THE HASHEMITE KINGDOM OF JORDAN
MINISTRY OF PLANNING
IN ASSOCIATION WITH
WATER AUTHORITY OF JORDAN

WATER RESOURCES STUDY
OF THE JAFR BASIN

INSTRUCTION MANUAL FOR FEM GROUNDWATER SIMULATION

(VERSION 3.0)

MARCH 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

PART 1

PART 2

PART 3

PART 4

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CONTENTS

UNISSF

(Unified Normal and Inverse Sub-Surface Flow Analysis Program)

Century Research Center Corporation, organized and existing under lows of Japan with the principal office at 3-6-2, Nihonbashi-honcho, Chuo-ku, Tokyo, Japan has developed and is the owner of computer program "UNISSF".

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COMPUTER : VAX8200 MODEL 821BA-YJ

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REFERENCES

Century Research Center Corporation, Japan, "Unified Normal and Inverse Sub-Surface Flow Analysis Program, User's Manual"

Japan International Cooperation Agency (JICA), Water Authority of Jordan, March 1990, "Water Resources Study of the Jafr Basin, Final Report"

PART 1 GENERAL

PART 1 GENERAL

CONTENTS

CHAPTER I
INTRODUCTION

The **UNISSF** program is designed to analyze the behavior of ground water in the multi-layered aquifer system in both confined condition and unconfined condition. The function of this program is to solve the unknown head and unknown flow in the region of analysis under the given boundary conditions and initial conditions by Finite Element Method (FEM), which is widely used in numerical analysis to solve the partial equation either steady or non-steady. The **UNISSF** also comprises the programs for graphic and plotting to demonstrate both the input data and the calculation results on the graphic display and/or the plotter. It is an advantage of the **UNISSF** to examine the input data and the calculation results by using these sub-programs. Graphic display and/or plotting system comprise the following drawing system;

- Mesh grid map (With element number and/or node number)
- Geological structure contour map (Bottom and/or top of the aquifer unit)
- Geological and/or groundwater profile at any time step
- Piezometric contour map at any time step
- Drawdown contour map at any time step

Those drawings on the color graphic display are effectively used to calibrate the simulation models in both steady state and non-steady state.

CHAPTER II
GENERAL FEATURE OF THE UNISSF PROGRAM

1. Composition of the UNISSF

The UNISSF is composed of the following 5 programs :

(1)	UNISSF2/G	:	Mesh-generator program
(2)	UNISSF2	:	Quasi-three-dimensional groundwater analysis program
(3)	UNISSF2/P	:	Post-processing program
(4)	DISPLAY	:	Graphic program
(5)	XYPLOT	:	Plotting program

2. Features

(1) UNISSF2/G (Mesh-generator program)

The UNISSF2/G is a program intended to automatically generate geometrical data (node coordinates, element connection, geological data), and it possess graphic and plotter output option.

1) Mesh data is entered automatically or manually.
2) Geological data necessary for each node is generated automatically.
3) Mesh and Geological data is checked by display graphic or plotter.

(3) UNISSF2 (Quasi-three-dimensional groundwater analysis program)

The UNISSF2 is a quasi-three-dimensional groundwater analysis program, and on the basis of Dupuit's hypothesis, groundwater flow in the three-dimensional ground is determinate by the Finite Element Method (FEM).

(4) UNISSF2/P (Post-processing program)

The UNISSF2/P is a program intended to deliver the output of the results calculated by the UNISSF2.

(5) DISPLAY

The DISPLAY is a program to show graphic outputs of calculated results by the UNISSF2 Input mesh diagram and generated geological contour diagram are also shown by this program.

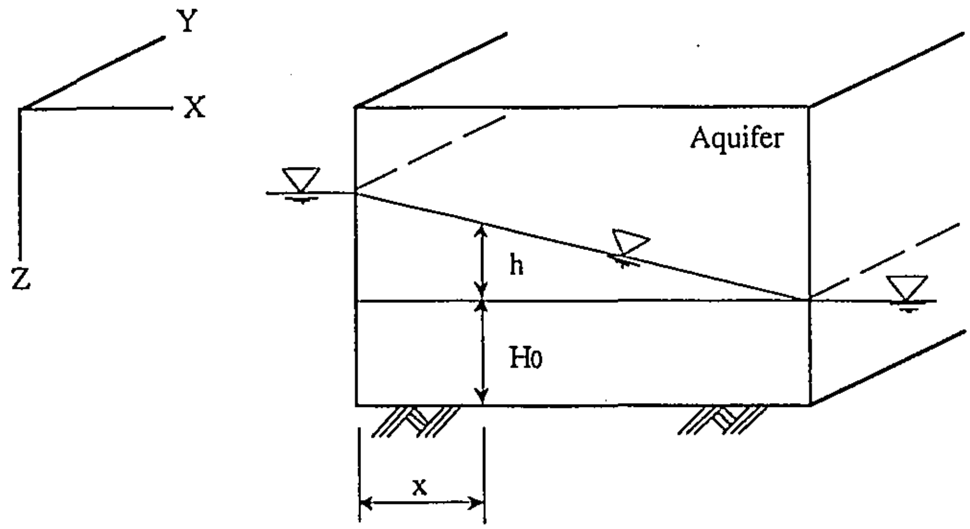
(6) XYPLOT

The XYPLOT is a program to show plot outputs of calculated results by the UNISSF2. Input mesh diagram and generated geological contour diagram are also shown by this program.

CHAPTER III
MATHEMATICAL SOLUTION

1. Dominant Equation

The dominant equation is based on the **Dupuit's hypothesis**. This hypothesis means the direction of groundwater infiltration flow is mainly on the horizontal plane, that is, the perpendicular components of flow is so small as compared with horizontal components as to be ignored.



Using Dupuit's hypothesis, continuous equation of three-dimensional groundwater flow is, from $V_z=0$, as follows;

$$S\frac{\partial h}{\partial t} + \frac{\partial}{\partial x}\{ (H_0 + h)V_x \} + \frac{\partial}{\partial y}\{ (H_0 + h)V_y \} = q \qquad (1)$$

where,	S	: coefficient of storage
	V_x, V_y, V_z	: apparent flow velocity in x, y, z directions
	q	: discharge/recharge per unit time
	t	: time
	h	: deference of head from H_0

On the other hand, Darcy's kinetic equation is as follows;

$$V_x = -K_x\frac{\partial h}{\partial x}, \qquad V_y = -K_y\frac{\partial h}{\partial y}, \qquad V_z = -K_z\frac{\partial h}{\partial z} \qquad (2)$$

where, K_x, K_y , K_z: coefficient of infiltration capacity in x, y, z directions

From equation (1) and (2), following equation (3) is obtained.

$$S\frac{\partial h}{\partial t} = \frac{\partial}{\partial x}\{ K_x(H0 + h)\frac{\partial h}{\partial x} \} + \frac{\partial}{\partial y}\{ K_y(H0 + h)\frac{\partial h}{\partial y} \} + q$$

$$= \frac{\partial}{\partial x}\{ T_x(h)\frac{\partial h}{\partial x} \} + \frac{\partial}{\partial y}\{ T_y(h)\frac{\partial h}{\partial y} \} + q \qquad (3)$$

where, T_x, T_y : coefficient of transmissivity in x, y directions

The equation (3) is the dominant equation of two dimensional groundwater flow. The equation (3) is approximately established in each element of the FEM mesh.

2. The Quasi-three-dimensional Analysis

The analysis by the equation (3) can be applied for multi-layered system so that it is called the **quasi-three dimensional analysis.** In this analysis, coefficient of transmissivity (T) and coefficient of storage (S) are considered as the function of piezometric head. It is able to analyze not only confined aquifer but also unconfined aquifer, even transference between both conditions. That is different from the conventional horizontal two-dimensional groundwater analysis.

The coefficient of transmissivity (T) is defined as follows;

$$T = \sum_{i=0}^{n} K_i b_i$$

where, K_i : coefficient of infiltration capacity of i-layer

b_i : thickness of i-layer

Meanwhile, the coefficient of storage (S) is defined as follows;

confined aquifer

$$T = \sum_{i=0}^{n} Ss_i \, b_i$$

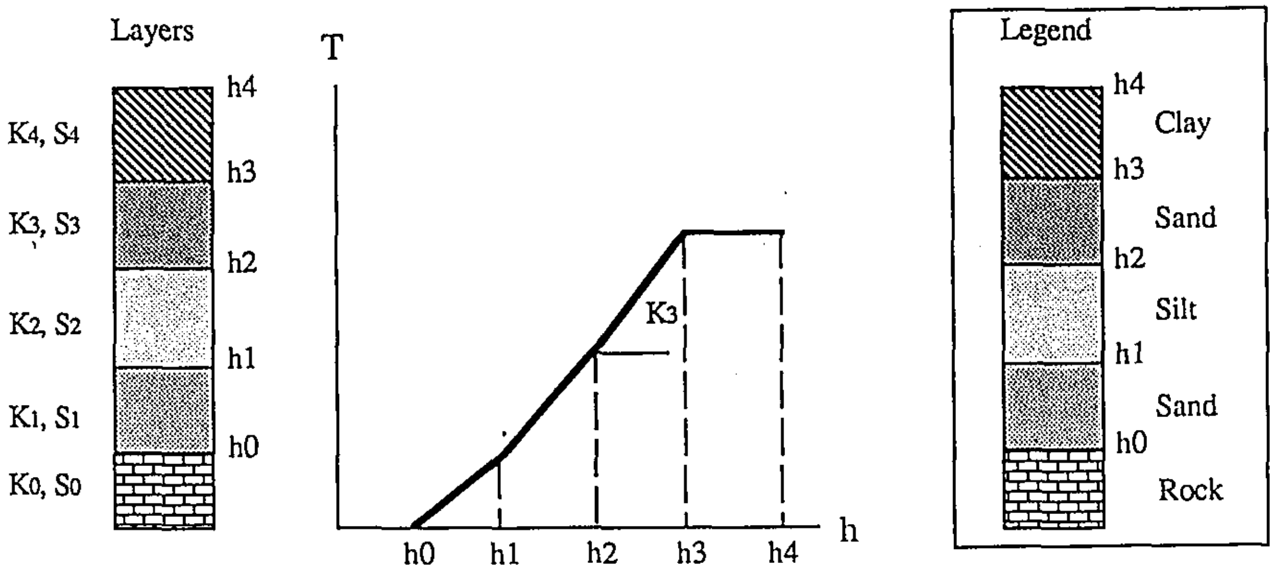
where, Ss_i : coefficient of specific storage i-layer

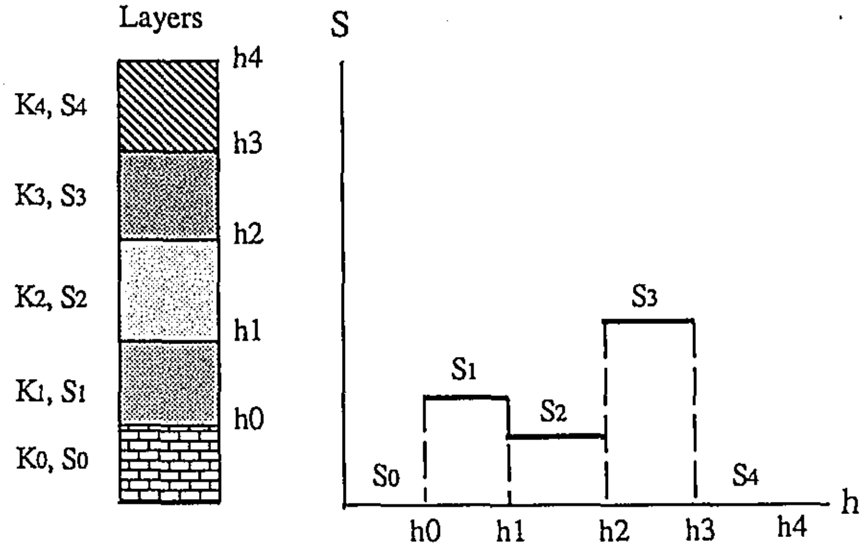
b_i : thickness of i-layer

unconfined aquifer

Defined as the volume of water discharged from the gap in the soil of unit volume (= effective porosity) due to lowering of piezometric level

The coefficient of transmissivity and the coefficient of storage, regarding as the function of groundwater level can be expressed as follows;





If the piezometric head is more than h3, the aquifer system is confined. T and S are expressed as the linear parameters of the equation (3).

$$T = K_0b_0 + K_1b_1 + K_2b_2 + K_3b_3 \ \ (= \text{constant})$$
$$S = Ss_1b_1 + Ss_2b_2 + Ss_3b_3 \ (= \text{constant})$$

If the piezometric head is less than h3, the aquifer system is unconfined. T and S are expressed as the non-linear parameters of the equation (3). S is nearly equal to the specific yield (= effective porosity) of the layer in which the piezomtric surface exists.

$$T = K_0b_0 + K_1b_1 + K_2b_2 + K_3(h - h_2) \quad (h_2 < h < h_3)$$

$S = S_3 \qquad (S = S_y + Ss_b, \quad S_y >> Ss_b)$

If the groundwater surface is further lowered to the basement ($h = h_0$), T and S become zero.

3. Theoretical solutions

Theoretical solutions of the equation (3) is obtained under some initial conditions and boundary conditions.

Initial Conditions : $h(x_i,0) = h(x_i)$

Boundary Conditions
- boundary with known head : $h(x_i,t) = h_b(x_i,t)$
- boundary with known discharge/recharge : $Q(x_i,t) = Q_b(x_i,t)$

4. Mathematical formulation

The equation (3) is formulated to be solved by numerical solution. Firstly, the following equation (4) is formulated from the equation (3) by using remainder R.

$$R = \frac{\partial}{\partial x}\{ T_x(h)\frac{\partial h}{\partial x}\} + \frac{\partial}{\partial y}\{ T_y(h)\frac{\partial h}{\partial y}\} + q - S\frac{\partial h}{\partial t} \qquad (4)$$

The optimal approximate solution is obtained by minimizing the remainder R for the all elements of FEM mesh. It is called the **weighted remainder method.** The weight is defined as 'the shape function', which is due to the shape of each element, by the **Gallarkin method.** After that, the following equation (5) is obtained.

$$\iint_s R\, [N]\, ds = 0 \qquad (5)$$

where, $[N]$: shape function (matrix)

When the equation (5) is solved, the following linearized and differentiated equation (6) is obtained.

$$\left(\frac{1}{\Delta t}[C]+[K]\right)\{h\}_{t+\Delta t}=\{F\}_{t+\Delta t}+\frac{1}{\Delta t}[C]\{h\}_t \qquad (6)$$

where,

$[C]$	: matrix of the value related to the coefficient of storage
$[K]$	: matrix of the value related to the coefficient of transmissivity
$\{F\}$	: matrix of the value related to discharge/recharge
$\{h\}$	: matrix of piezometric head
t	: time
Δt	: time step

The equation (6) is the expression of the simultaneous linear equation for h.

5. Skyline method

Generally, the equation (6) is solved by the Gauss' elimination method, but in consideration of saving the computer memory and increasing calculation speed, the **skyline method** is employed in this analysis. The skyline method is a kind of the **band matrix method**, but it is different from the ordinary one as follows;

1) Data is handled in row unit.
2) The correspondence of the band width is variable in each row.
3) The equation is formed by the sum of product.

Calculation

[a] { x } = [b]   [a], [b]   ---- (n x n) matrix
{ x }   ---- (n x 1) matrix

i) LU splitting

k = 2, 3, ... , n

j = 1, 2, ... , k-1

$$a^*_{jk} = a_{jk} - \sum_{i=1}^{j-1} a'_{ij}\, a^*_{ik}$$

$$a'_{jk} = a^*_{jk} / a'_{ij}$$

$$a'_{kk} = a_{kk} - \sum_{i=1}^{k-1} a'_{ik}\, a^*_{ik}$$

where, a^*_{ik} : the value before dividing by pivot a'_{ii}
(equivalent to component of 'U' of LU splitting)

a'_{ik} : the value after dividing by pivot a'_{ii}
(equivalent to component of 'L' of LU splitting)

ii) Allotment of memory

a_{11}	a_{21}	a_{31}						
	a_{22}	a_{32}				a_{72}		
		a_{33}		a_{53}		a_{73}		
			a_{44}	0		0		
				a_{55}	a_{65}	a_{75}		
					a_{66}	0	a_{86}	
						a_{77}	a_{87}	a_{97}
							a_{88}	a_{98}
								a_{99}

Coefficient Matrix

$\Rightarrow$

a_{11}	a_{21}	a_{22}	a_{31}	a_{32}	a_{33}	a_{44}	a_{53}	0	a_{55}	a_{65}	a_{66}

Array in Computer Memory

iii) Calculation of the right side of the equation

(Foward elimination)

$k = 2, 3, \ldots\ldots, n$

$$b'_k = (b_k - \sum_{i=1}^{k-1} L_{ki}\, b'_i) / L_{kk}$$

(Regressive substitution)

$k = n, n-1, \ldots\ldots, 2$

$x_k = b'_k$

$i = 1, 2, \ldots\ldots, k-1$

$b'_i \text{ (new)} = b'_i - U_{ki}\, x_k$

$x_1 = b_1 \text{ (final)}$

CHAPTER IV
GENERAL PROCEDURE OF GROUNDWATER SIMULATION

1. Data Preparation

(1) Region of analysis

The region of analysis are extended to hydrological boundary as far as possible, for example, river, lake, sea, and mountain ridge.

(2) Mesh

In the FEM analysis, the region to be analyzed is divided into the small portions called **'element'**,and vertexes of element are called **'node'**. The division is effected on a horizontal plan. The coordinates of node and element connection are defined for preparation of mesh data.

(3) Geological layer

In order to express the three-dimensional geological condition, the geological layer distribution in the vertical direction is given for each node.

(4) Hydrogeological conditions

The solutions of FEM analysis are obtained under the given hydrogeological conditions which are called **boundary conditions** and **initial conditions.**

1) Boundary condition

The boundary conditions mainly refer to piezometric head and flow at the outermost nodes of the region of analysis.

2) Initial condition

The initial conditions are given at all nodes. Either of the following two states is considered as initial condition in FEM analysis.

Static state (constant head, no water flow)
Steady state (constant head, constant flow)

(5) Aquifer constants

The following aquifer constants are defined for expression of transmissivity of the geological layers.

Coefficient of infiltration capacity (K)
Coefficient of storage (S)

2. Model Construction

Model, which is made up with the data in the region of analysis, is constructed to express the hydrogeological condition by the numerical data and to analyze that by numerical method with computer. The prepared data are entered to computer disk storage in accordance with the input data format of the program.

In the case of large scale model, **pre-processing** which is the data processing for mesh and geological data are performed in advance of numerical analysis to express the geometrical structures.

3 Steady State Calibration

(1) *Steady state analysis*

The condition of groundwater in the steady state is as follows.

constant piezometric head
constant groundwater flow
constant discharge/recharge

'Constant' means that the values are constant at each place and do not change by time.

To calculate unknown piezometric head under some boundary condition, the steady state condition is obtained. The steady state analysis is mostly executed at first in the groundwater analysis so as to estimate the existing condition of groundwater flow.

(2) Steady state model calibration

The piezometric surface in the region of analysis is obtained under some boundary condition, but the calculated results is needed to be compared with the actual groundwater flow condition. Prior to groundwater model analysis, physical features of aquifer system are to be examined to carry out a series of field investigations and analysis. The groundwater flow condition estimated by the model is needed to coincide with the actual condition. For this, the **model calibration** is performed by 'Trial and Error' until the calculated results become reasonable.

4. Non-steady State Calibration

(1) Non-steady state analysis

If the artificial abstraction, like pumping, is started at some steady state, the piezometric surface is gradually lowering, and finally the condition of groundwater becomes to another steady state with the artificial abstraction. This process is analyzed by the non-steady state analysis. The condition of groundwater is obtained by time until final steady state.

(2) Non-steady state model calibration

The non-steady state model calibration is performed to estimate the coefficient of storage (S) in the region of analysis. The drawdown of piezometric surface is due to the coefficient of storage.For example, the piezometric surface is as much lowering as lower coefficient of storage. The coefficient of storage of the model is adjusted by comparing calculated drawdown with actual drawdown.at the monitoring well in the region.

5. Model Simulation

After the model is reasonably calibrated, the piezometric surface in future is predicted by using the model. The purpose of the prediction is mainly to estimate the appropriate scale of the abstraction in the region. The groundwater condition in future is predicted for the several cases of abstractions, including the existing and the newly planned, by using the simulation model.

PART 2 TRAINING

PART 2 TRAINING

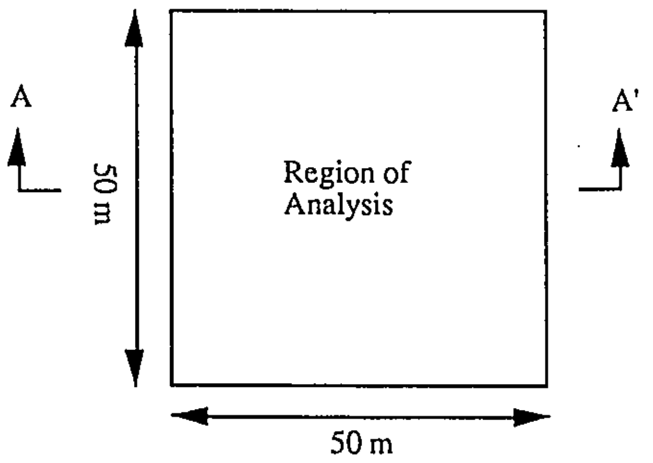
CONTENTS

CHAPTER I
EXAMPLE 1 : Steady state analysis in confined aquifer (1)

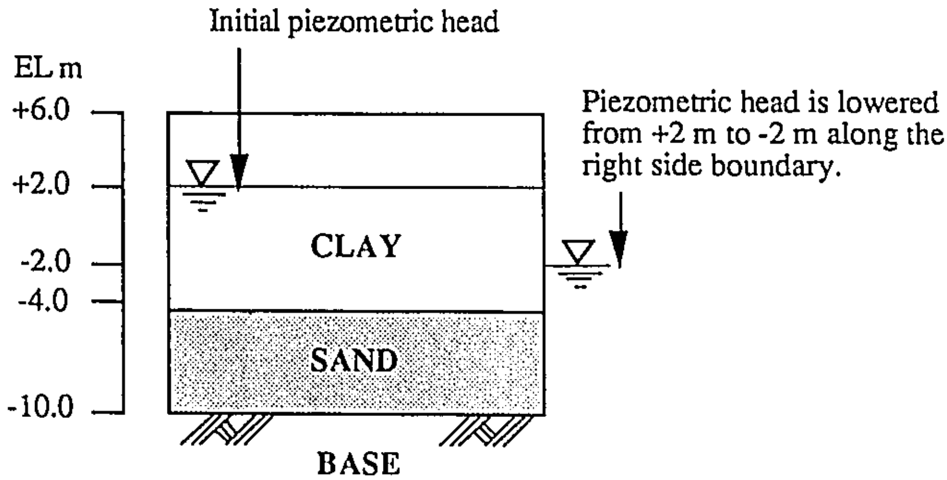
1. Data Preparation

Calculation of the piezometric head in the confined aquifer, after lowering the piezometric head along the right side boundary from +2 m to - 2 m.

Plane

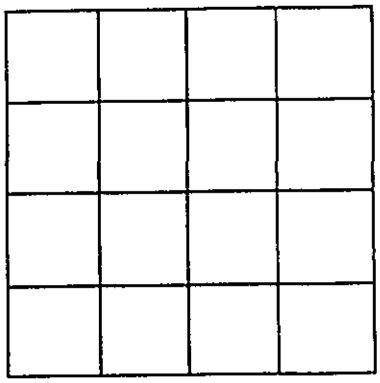


Section A-A'

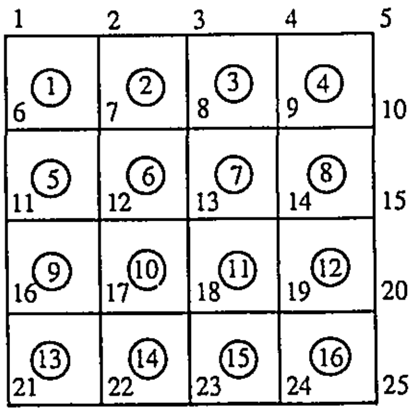


(1) Mesh data

1) Mesh diagram



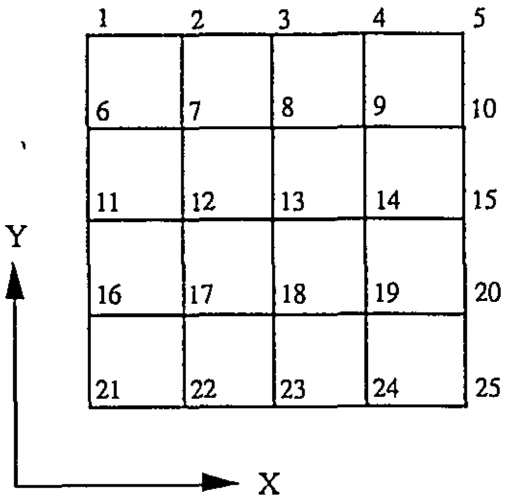
2) Node number and element number



1 - 25 Node number

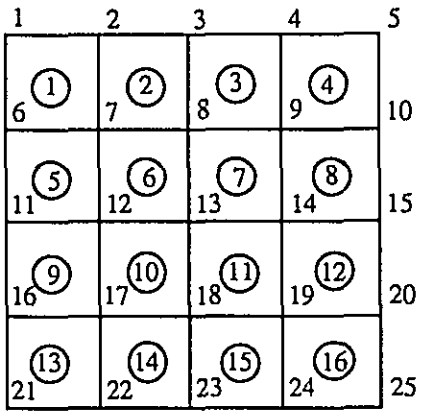
① - ⑯ Element number

3) Node coordinates



Node no.	Coordinates X	Coordinates Y
1	0.0	50.0
2	12.5	50.0
3	25.0	50.0
.	.	.
.	.	.
.	.	.
24	37.5	0.0
25	50.0	0.0

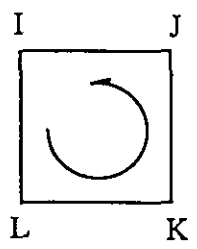
4) Element connection



1 - 25 Node number

(1) - (16) Element number

Element no.	Node no. of element I	J	K	L
1	1	6	7	2
2	2	7	3	8
3	3	8	9	4
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
15	18	23	24	19
16	19	24	25	20

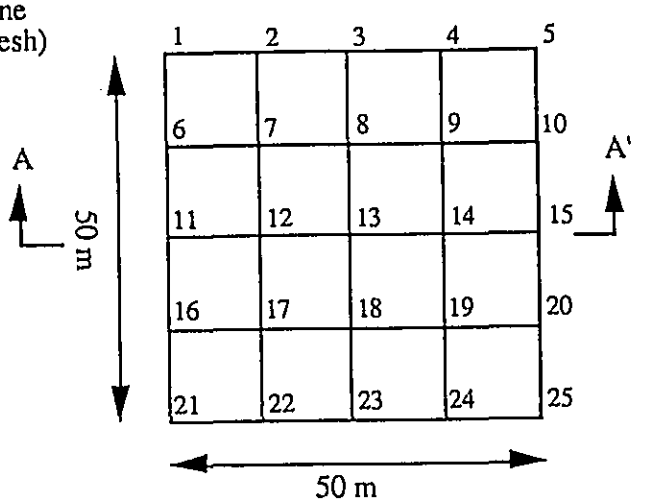


Node numbers of element are given counter-clockwise

(2) Geological data and aquifer constants

1) Symbol of layers

Plane (Mesh)



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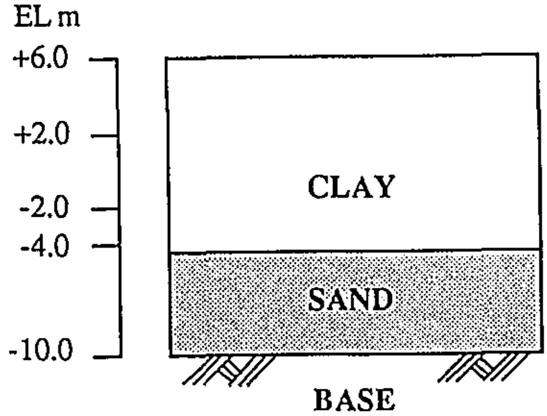
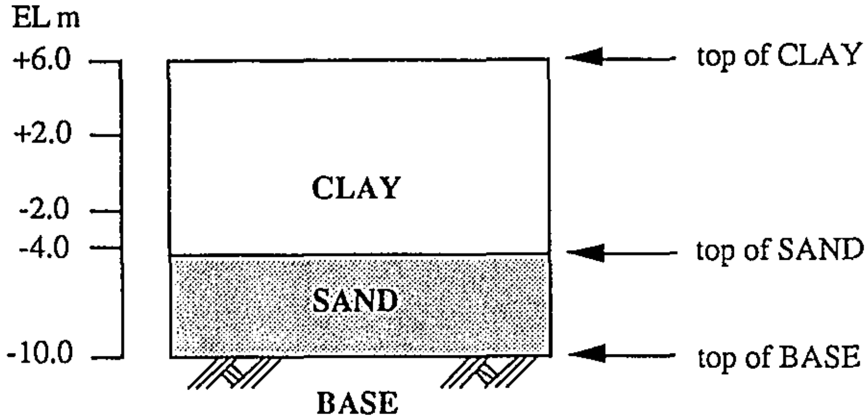


2) Elevation at top of each layers for each node



Node no.	Top of layer (EL m)		
	BASE	SAND	CLAY
1	-10	-4	2
2	-10	-4	2
3	-10	-4	2
.	.	.	.
.	.	.	.
.	.	.	.
24	-10	-4	2
25	-10	-4	2

3) Aquifer constants

The pair of K and S is given for each symbolized layer (except BASE).

K: coefficient of infiltration capacity
S : coefficient of storage

Layer	K (m/day)	S
CLAY	1.0×10^{-7} /1	1.0×10^{-7} /2
SAND	20	0.3 /3

Note : /1 The top layer is assumed to be impervious in the analysis of confined aquifer.

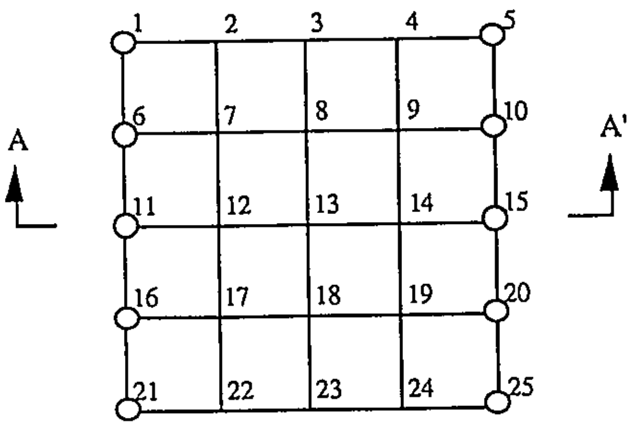
/2 Coefficient of storage of layer 'SAND' in confined aquifer

/3 Coefficient of storage of layer 'SAND' in unconfined aquifer

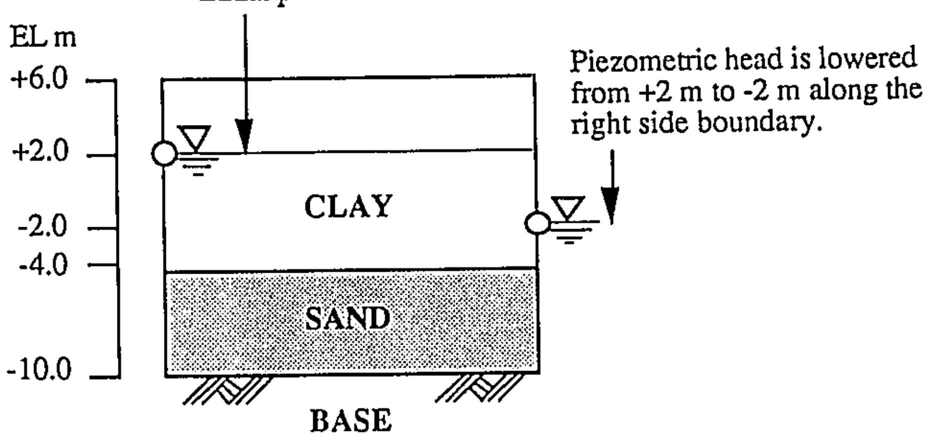
(3) **Boundary condition**

Plane

O Specified head boundary



Section A-A'



Left side boundary

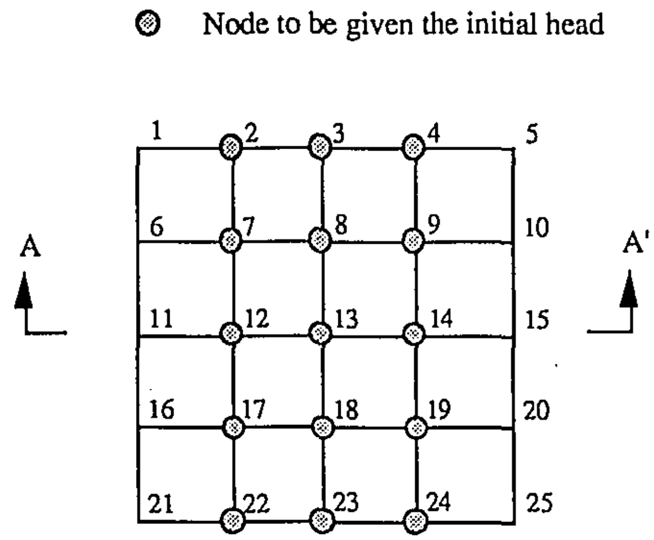
Node no.	Head (EL m)
1	2.0
6	2.0
11	2.0
16	2.0
21	2.0

Right side boundary

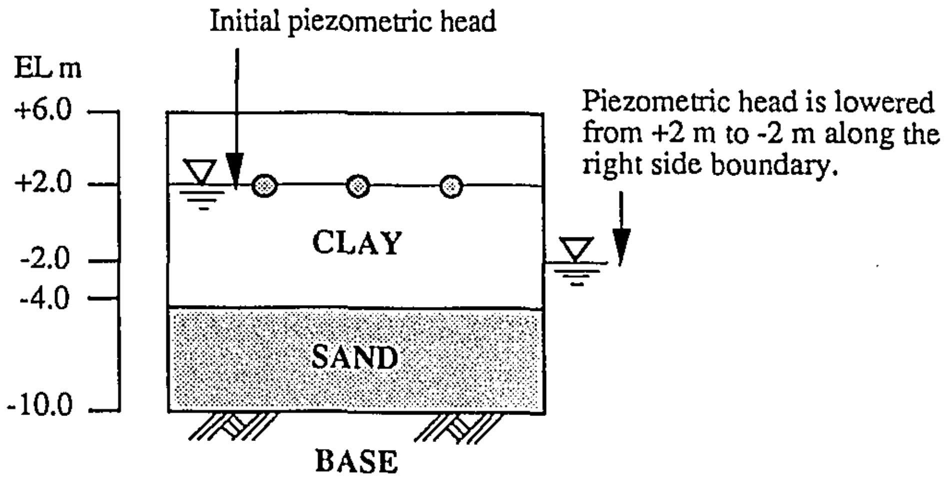
Node no.	Head (EL m)
5	-2.0
10	-2.0
15	-2.0
20	-2.0
25	-2.0

(4) Initial condition

Plane



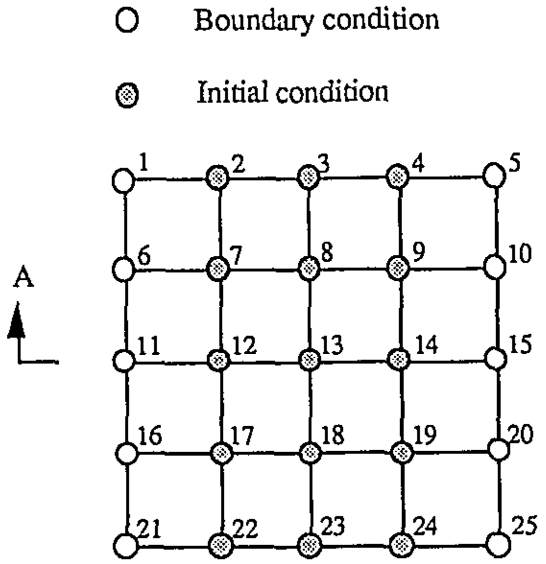
Section A-A'



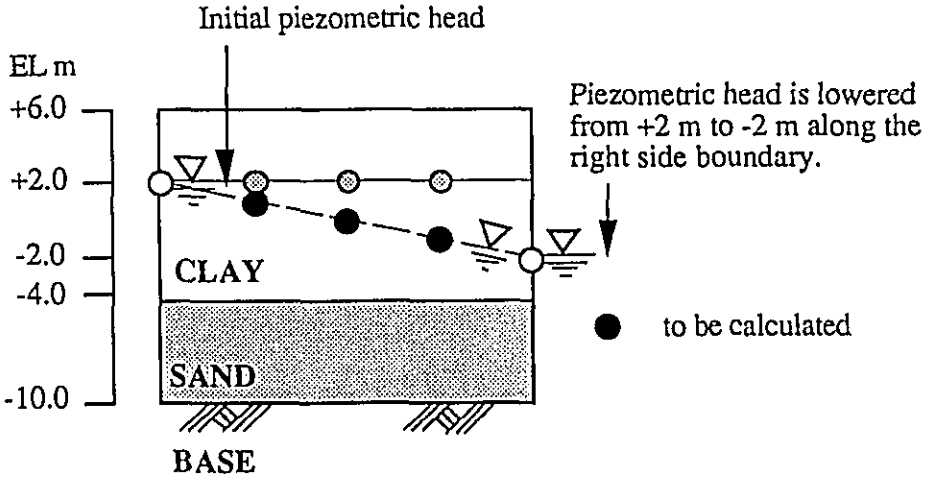
Node no.	Head (EL m)
2	2.0
3	2.0
4	2.0
7	2.0
8	2.0
9	2.0

Node no.	Head (EL m)
12	2.0
13	2.0
14	2.0
22	2.0
23	2.0
24	2.0

Plane



Section A-A'



2. Data Input

(1) Getting start

The prepared data is enter into the data file on the disk storage of the VAX computer system. Data input and operation of programs are performed at the terminal of VAX. If the **'TEKTRONIX'** is available, the graphic output is shown on the display. Before starting, it is necessary to get the **directory**, **username**, **password**, and **account** on VAX.

1) Login to VAX8200 at the terminal

1- check the connection of power cable
2- check the connection of communication cable from VAX8200
3- power switch on

4- Enter username > (USERNAME) [enter]
5- Local > C FALAJ [enter]

6- username : (USERNAME) [enter]
7- password : (PASSWORD) [enter]

2) Copy the file LOGIN.COM

$ COPY DUA0:[JICA]LOGIN.COM [] [enter]
$ @LOGIN [enter]

Note: This process is only for the first time. It is not necessary from the next login.

3) Logout from VAX

$ LO [enter]

(2) Editing the data file

1) $ ED EXA1.DAT [enter] (create the data file)
2) Input data for Example 1

```
SETTING,  CHEC,  100.
TITLE
  EXAMPLE 1  STEADY STATE ANALYSIS IN CONFINED AQUIFER
SYSTEM
1ST    , 25 , 16 , 4 , 25 , 2
2ND    ,  2 , 10., 0 ,  0 , 0
3RD    ,  0 ,  0 , 0 ,  0 , 0 , 0
4TH    ,  0 ,  0
*
*      --- MESH DATA ---
*
NODE ,           1 ,   0.0 ,  50.0
NODE ,           2 ,  12.5 ,  50.0
NODE ,           3 ,  25.0 ,  50.0
NODE ,           4 ,  37.5 ,  50.0
NODE ,           5 ,  50.0 ,  50.0
NODE ,           6 ,   0.0 ,  37.5
NODE ,           7 ,  12.5 ,  37.5
NODE ,           8 ,  25.0 ,  37.5
NODE ,           9 ,  37.5 ,  37.5
NODE ,          10 ,  50.0 ,  37.5
NODE ,          11 ,   0.0 ,  25.0
NODE ,          12 ,  12.5 ,  25.0
NODE ,          13 ,  25.0 ,  25.0
NODE ,          14 ,  37.5 ,  25.0
NODE ,          15 ,  50.0 ,  25.0
NODE ,          16 ,   0.0 ,  12.5
NODE ,          17 ,  12.5 ,  12.5
NODE ,          18 ,  25.0 ,  12.5
NODE ,          19 ,  37.5 ,  12.5
NODE ,          20 ,  50.0 ,  12.5
NODE ,          21 ,   0.0 ,   0.0
NODE ,          22 ,  12.5 ,   0.0
NODE ,          23 ,  25.0 ,   0.0
NODE ,          24 ,  37.5 ,   0.0
NODE ,          25 ,  50.0 ,   0.0
ELEM ,      1 ,      6 ,      7 ,      2 ,      1
ELEM ,      2 ,      7 ,      8 ,      3 ,      2
ELEM ,      3 ,      8 ,      9 ,      4 ,      3
ELEM ,      4 ,      9 ,     10 ,      5 ,      4
ELEM ,      5 ,     11 ,     12 ,      7 ,      6
ELEM ,      6 ,     12 ,     13 ,      8 ,      7
ELEM ,      7 ,     13 ,     14 ,      9 ,      8
ELEM ,      8 ,     14 ,     15 ,     10 ,      9
ELEM ,      9 ,     16 ,     17 ,     12 ,     11
ELEM ,     10 ,     17 ,     18 ,     13 ,     12
ELEM ,     11 ,     18 ,     19 ,     14 ,     13
ELEM ,     12 ,     19 ,     20 ,     15 ,     14
ELEM ,     13 ,     21 ,     22 ,     17 ,     16
ELEM ,     14 ,     22 ,     23 ,     18 ,     17
ELEM ,     15 ,     23 ,     24 ,     19 ,     18
ELEM ,     16 ,     24 ,     25 ,     20 ,     19
MEND
*
*     --- UNIT ---
```

```
*
UNIT  , ME , DAY , 10 ,  0.01
*
* BOUNDARY CONDITION
*
INIP  ,   1  ,  1  ,  1 ,   2.0
INIP  ,   6  ,  6  ,  1 ,   2.0
INIP  ,  11  , 11  ,  1 ,   2.0
INIP  ,  16  , 16  ,  1 ,   2.0
INIP  ,  21  , 21  ,  1 ,   2.0
INIP  ,   5  ,  5  ,  1 ,  -2.0
INIP  ,  10  , 10  ,  1 ,  -2.0
INIP  ,  15  , 15  ,  1 ,  -2.0
INIP  ,  20  , 20  ,  1 ,  -2.0
INIP  ,  25  , 25  ,  1 ,  -2.0
NCON  ,   1  ,  1  ,  1 ,   HF
NCON  ,   6  ,  6  ,  1 ,   HF
NCON  ,  11  , 11  ,  1 ,   HF
NCON  ,  16  , 16  ,  1 ,   HF
NCON  ,  21  , 21  ,  1 ,   HF
NCON  ,   5  ,  5  ,  1 ,   HF
NCON  ,  10  , 10  ,  1 ,   HF
NCON  ,  15  , 15  ,  1 ,   HF
NCON  ,  20  , 20  ,  1 ,   HF
NCON  ,  25  , 25  ,  1 ,   HF
*
* INITIAL CONDITION
*
INIP  ,   2  ,  2  ,  1 ,   2.0
INIP  ,   3  ,  3  ,  1 ,   2.0
INIP  ,   4  ,  4  ,  1 ,   2.0
INIP  ,   7  ,  7  ,  1 ,   2.0
INIP  ,   8  ,  8  ,  1 ,   2.0
INIP  ,   9  ,  9  ,  1 ,   2.0
INIP  ,  12  , 12  ,  1 ,   2.0
INIP  ,  13  , 13  ,  1 ,   2.0
INIP  ,  14  , 14  ,  1 ,   2.0
INIP  ,  17  , 17  ,  1 ,   2.0
INIP  ,  18  , 18  ,  1 ,   2.0
INIP  ,  19  , 19  ,  1 ,   2.0
INIP  ,  22  , 22  ,  1 ,   2.0
INIP  ,  23  , 23  ,  1 ,   2.0
INIP  ,  24  , 24  ,  1 ,   2.0
*
*    --- STEADY STATE ---
*
CONT , STEADY
*
*    --- AQUIFER CONSTANTS ---
LAYE , 2
SAND , 20.  , 0.3
CLAY , 1.0E-07, 1.0E-07
*
*    --- GEOLOGICAL DATA ---
*
GEOL ,  1 ,  1 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL ,  2 ,  2 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL ,  3 ,  3 ,  1 ,  2
BASE ,  SAND     CLAY
```

```
 -10.,  -4.0   , 6.0
GEOL ,  4 ,  4 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL ,  5 ,  5 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL ,  6 ,  6 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL ,  7 ,  7 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL ,  8 ,  8 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL ,  9 ,  9 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 10 , 10 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 11 , 11 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 12 , 12 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 13 , 13 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 14 , 14 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 15 , 15 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 16 , 16 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 17 , 17 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 18 , 18 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 19 , 19 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 20 , 20 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 21 , 21 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 22 , 22 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 23 , 23 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 24 , 24 ,  1 ,  2
BASE ,  SAND    CLAY
```

```
 -10.,   -4.0    , 6.0
GEOL , 25 , 25 ,  1 ,   2
BASE ,  SAND     CLAY
 -10.,   -4.0    , 6.0
*
ENDD
```

4) Press **PF4** function key
5) Command : **exit** [enter] (data to be saved) or
   Command : **quit** [enter] (data not to be saved / data not to be changed)

3. Data Check and Calculation

(1) Data check

1) $ UNISSF [enter]

2) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> M [enter] ('M' for UNISSF2)

3) RESTART ? (Y/N) N [enter]

4) FILE NAME(?.dat) EXA1 [enter]

.
.
.
(checking the data)
.
.
.

FORTRAN STOP

UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> E [enter] ('E' for end)

5) $ ED EXA1.PRN [enter] (print output to be checked)

6) Press PF4 function key (at the end of check)
7) Command : QUIT [enter]

(2) Calculation by UNISSF2

1) **$ ED EXA1.DAT** [enter]

   1st line of the data to be changed

```
SETTING, CHEC,  100
    |
    v
SETTING, RUN ,  100
          ^
          |
```

   (RUN + one blank)

2) Press **PF4** function key   (at the end of edit)
3) Command : **EXIT** [enter]   (save the data)

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> **M** [enter]   ('M' for UNISSF2)

6) RESTART ? (Y/N) **N** [enter]

7) FILE NAME(?.dat) **EXA1** [enter]

   .
   .
   .
   (calculating)
   .
   .
   .

   FORTRAN STOP

   UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> **E** [enter]   ('E' for end)

8) **$ ED EXA1.PRN** [enter]   (print output to be checked)

9) Press **PF4** function key   (at the end of check)
10) Command : **QUIT** [enter]

4. Post Processing by UNISSF2/P

(1) Creation of the data file for plot control

1) $ ED PLOT1.DAT [enter]

2) Input data

```
START    1      TP
SUBTITLE
         EXAMPLE 1
NNUM     ON
ENUM     ON
DIVI     OFF
DOWN     OFF
MESH     OFF
MPLOT
FPRIN    ON
SCALE    A4
CONT     10
PLOT     ALL
REWIND
VERT     SET       1
11       15
VERT     1
LPLOT    ALL
END
```

3) Press **PF4** function key (at the end of edit)
4) Command : **EXIT** [enter] (save the data)

(2) Post processing

1) **$ UNISSF** [enter]

2)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
END         < E >
```

PLEASE ENTER ----> **P** [enter] ('P' for UNISSF2/P)

3) RESTART ? (Y/N) **N** [enter]

4) FILE NAME(?.dat) **PLOT1** [enter]
5) FILE NAME(FT10) **EXA1.FT10** [enter]
6) FILE NAME(FT11) **EXA1.FT11** [enter]

.
.
.
(processing)
.
.
.

FORTRAN STOP

UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter] ('E' for end)

7) **$ ED EXA1.PRN** [enter] (print output to be checked)

8) Press **PF4** function key (at the end of check)
9) Command : **QUIT** [enter]

5. Graphic and Plotting

(1) Graphic on TEKTRONIX terminal

1) Press **SET UP** key
2) * **CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) $ **UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **D** [enter] ('D' for **DISPLAY**)

6) FILE NAME : **FOR040.DAT** [enter]

7) press **CLEAR** key

(graphic 1) (Press [enter] to show the next graphic)
(graphic 2) (Press 'E' for end of graphic)
.
.
.

8) At the end of graphic (no graphic on display), Press **CLEAR** key

9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter] ('E' for end)

10) Press **SET UP** key
11) * **CODE ANSI** [enter]
12) Press **SET UP** key, and [enter]

(2) Plotting

1) Plotter set up
2) Paper set
3) Press '**On-line**' soft key
4) $ **UNISSF** [enter]
5) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> X [enter] ('X' for XYPLOT)

6) FILE NAME : FOR040.DAT [enter]

   .
   .
   .
   (plotting)
   .
   .
   .

7) If there are more than 2 drawings, the plotting is stopped and the message '**HALT RECIEVED...**' is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press '**On-line**' soft key.
8) At the end of plotting, the message 'PLOT COMPLETE' is shown in the plotter window.
9) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> E [enter]

6. Output

(1) Print output by UNISSF2

UNISSF-2 VER. 3.5

```
1.......10........20........30........40........50........60........70........80

SETTING,  RUN ,  100.
TITLE
  EXAMPLE 1  STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM
1ST   , 25 , 16 , 4 , 25 , 2
2ND   ,  2 , 10., 0 ,  0 , 0
3RD   ,  0 , 0  , 0 ,  0 , 0 , 0
4TH   ,  0 , 0
*
*     --- MESH ---
*
NODE ,          1 ,   0.0 ,  50.0
NODE ,          2 ,  12.5 ,  50.0
NODE ,          3 ,  25.0 ,  50.0
NODE ,          4 ,  37.5 ,  50.0
NODE ,          5 ,  50.0 ,  50.0
NODE ,          6 ,   0.0 ,  37.5
NODE ,          7 ,  12.5 ,  37.5
NODE ,          8 ,  25.0 ,  37.5
NODE ,          9 ,  37.5 ,  37.5
NODE ,         10 ,  50.0 ,  37.5
NODE ,         11 ,   0.0 ,  25.0
NODE ,         12 ,  12.5 ,  25.0
NODE ,         13 ,  25.0 ,  25.0
NODE ,         14 ,  37.5 ,  25.0
NODE ,         15 ,  50.0 ,  25.0
NODE ,         16 ,   0.0 ,  12.5
NODE ,         17 ,  12.5 ,  12.5
NODE ,         18 ,  25.0 ,  12.5
NODE ,         19 ,  37.5 ,  12.5
NODE ,         20 ,  50.0 ,  12.5
NODE ,         21 ,   0.0 ,   0.0
NODE ,         22 ,  12.5 ,   0.0
NODE ,         23 ,  25.0 ,   0.0
NODE ,         24 ,  37.5 ,   0.0
NODE ,         25 ,  50.0 ,   0.0
ELEM ,     1 ,     6 ,     7 ,     2 ,     1
ELEM ,     2 ,     7 ,     8 ,     3 ,     2
ELEM ,     3 ,     8 ,     9 ,     4 ,     3
ELEM ,     4 ,     9 ,    10 ,     5 ,     4
```

```
40    ELEM ,    5 ,   11 ,   12 ,    7 ,    6
41    ELEM ,    6 ,   12 ,   13 ,    8 ,    7
42    ELEM ,    7 ,   13 ,   14 ,    9 ,    8
43    ELEM ,    8 ,   14 ,   15 ,   10 ,    9
44    ELEM ,    9 ,   16 ,   17 ,   12 ,   11
45    ELEM ,   10 ,   17 ,   18 ,   13 ,   12
46    ELEM ,   11 ,   18 ,   19 ,   14 ,   13
47    ELEM ,   12 ,   19 ,   20 ,   15 ,   14
48    ELEM ,   13 ,   21 ,   22 ,   17 ,   16
49    ELEM ,   14 ,   22 ,   23 ,   18 ,   17
50    ELEM ,   15 ,   23 ,   24 ,   19 ,   18
```

```
1.......10........20........30........40........50........60........70........80

ELEM ,    16 ,    24 ,    25 ,    20 ,    19
MEND
*
*    --- UNIT ---
*
UNIT  , ME , DAY , 10 ,  0.01
*
*    --- BOUNDARY CONDITION ---
*
INIP  ,  1  ,  1  ,  1 ,   2.0
INIP  ,  6  ,  6  ,  1 ,   2.0
INIP  , 11  , 11  ,  1 ,   2.0
INIP  , 16  , 16  ,  1 ,   2.0
INIP  , 21  , 21  ,  1 ,   2.0
INIP  ,  5  ,  5  ,  1 ,  -2.0
INIP  , 10  , 10  ,  1 ,  -2.0
INIP  , 15  , 15  ,  1 ,  -2.0
INIP  , 20  , 20  ,  1 ,  -2.0
INIP  , 25  , 25  ,  1 ,  -2.0
NCON  ,  1  ,  1  ,  1 ,   HF
NCON  ,  6  ,  6  ,  1 ,   HF
NCON  , 11  , 11  ,  1 ,   HF
NCON  , 16  , 16  ,  1 ,   HF
NCON  , 21  , 21  ,  1 ,   HF
NCON  ,  5  ,  5  ,  1 ,   HF
NCON  , 10  , 10  ,  1 ,   HF
NCON  , 15  , 15  ,  1 ,   HF
NCON  , 20  , 20  ,  1 ,   HF
NCON  , 25  , 25  ,  1 ,   HF
*
*    --- INITIAL CONDITION ---
*
INIP  ,  2 ,   2 ,   1 ,   2.0
INIP  ,  3 ,   3 ,   1 ,   2.0
INIP  ,  4 ,   4 ,   1 ,   2.0
INIP  ,  7 ,   7 ,   1 ,   2.0
INIP  ,  8 ,   8 ,   1 ,   2.0
INIP  ,  9 ,   9 ,   1 ,   2.0
INIP  , 12 ,  12 ,   1 ,   2.0
```

```
INIP  , 13 ,  13 ,   1 ,   2.0
INIP  , 14 ,  14 ,   1 ,   2.0
INIP  , 17 ,  17 ,   1 ,   2.0
INIP  , 18 ,  18 ,   1 ,   2.0
INIP  , 19 ,  19 ,   1 ,   2.0
INIP  , 22 ,  22 ,   1 ,   2.0
INIP  , 23 ,  23 ,   1 ,   2.0
INIP  , 24 ,  24 ,   1 ,   2.0
*
*    --- STEADY STATE ---
*
```

```
1.......10........20........30........40........50........60........70........80

CONT , STEADY
*
*    --- AQUIFER CONSTANTS ---
*
LAYE ,  2
SAND ,  20.    , 0.3
CLAY ,  1.0E-07, 1.0E-07
*
*     --- GEOLOGICAL DATA ---
*
GEOL , 1 ,  1 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL , 2 ,  2 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL , 3 ,  3 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL , 4 ,  4 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL , 5 ,  5 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL , 6 ,  6 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL , 7 ,  7 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL , 8 ,  8 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL , 9 ,  9 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,10 , 10 , 1 , 2
BASE ,  SAND ,  CLAY
```

```
 -10.,  -4.0 ,  6.0
GEOL ,11 , 11 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,12 , 12 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,13 , 13 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,14 , 14 , 1 , 2
```

```
1.......10........20........30........40........50........60........70........80

BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,15 , 15 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,16 , 16 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,17 , 17 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,18 , 18 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,19 , 19 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,20 , 20 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,21 , 21 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,22 , 22 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,23 , 23 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,24 , 24 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
GEOL ,25 , 25 , 1 , 2
BASE ,  SAND ,  CLAY
 -10.,  -4.0 ,  6.0
*
ENDD
```

EXAMPLE 1 STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM

****** S T R A T I G R A P H Y ******

MAT 1		MAT 2		MAT 3		MAT 4		MAT 5	
CLAY	10.000	CLAY	10.000	CLAY	10.000	CLAY	10.000	CLAY	10.000
SAND	6.000	SAND	6.000	SAND	6.000	SAND	6.000	SAND	6.000

MAT 6		MAT 7		MAT 8		MAT 9		MAT 10	
CLAY	10.000	CLAY	10.000	CLAY	10.000	CLAY	10.000	CLAY	10.000
SAND	6.000	SAND	6.000	SAND	6.000	SAND	6.000	SAND	6.000

MAT 11		MAT 12		MAT 13		MAT 14		MAT 15	
CLAY	10.000	CLAY	10.000	CLAY	10.000	CLAY	10.000	CLAY	10.000
SAND	6.000	SAND	6.000	SAND	6.000	SAND	6.000	SAND	6.000

MAT 16		MAT 17		MAT 18		MAT 19		MAT 20	
CLAY	10.000	CLAY	10.000	CLAY	10.000	CLAY	10.000	CLAY	10.000
SAND	6.000	SAND	6.000	SAND	6.000	SAND	6.000	SAND	6.000

EXAMPLE 1 STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM

****** S T R A T I G R A P H Y ******

MAT 21		MAT 22		MAT 23		MAT 24		MAT 25	
CLAY	10.000	CLAY	10.000	CLAY	10.000	CLAY	10.000	CLAY	10.000
SAND	6.000	SAND	6.000	SAND	6.000	SAND	6.000	SAND	6.000

EXAMPLE 1 STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM

NODE	X	Y	P	Q	QLMT	BASE	SURFACE	COND	MAT
1	0.0000E+00	5.0000E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00	HF	1
2	1.2500E+01	5.0000E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		2
3	2.5000E+01	5.0000E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		3
4	3.7500E+01	5.0000E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		4
5	5.0000E+01	5.0000E+01	-2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00	HF	5
6	0.0000E+00	3.7500E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00	HF	6
7	1.2500E+01	3.7500E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		7
8	2.5000E+01	3.7500E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		8
9	3.7500E+01	3.7500E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		9
10	5.0000E+01	3.7500E+01	-2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00	HF	10
11	0.0000E+00	2.5000E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00	HF	11
12	1.2500E+01	2.5000E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		12
13	2.5000E+01	2.5000E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		13
14	3.7500E+01	2.5000E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		14
15	5.0000E+01	2.5000E+01	-2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00	HF	15
16	0.0000E+00	1.2500E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00	HF	16
17	1.2500E+01	1.2500E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		17
18	2.5000E+01	1.2500E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		18
19	3.7500E+01	1.2500E+01	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		19
20	5.0000E+01	1.2500E+01	-2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00	HF	20
21	0.0000E+00	0.0000E+00	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00	HF	21
22	1.2500E+01	0.0000E+00	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		22
23	2.5000E+01	0.0000E+00	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		23
24	3.7500E+01	0.0000E+00	2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00		24
25	5.0000E+01	0.0000E+00	-2.0000E+00	0.0000E+00	-1.0000E+01	-1.0000E+01	6.0000E+00	HF	25

EXAMPLE 1 STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM

ELEM	I	J	K	L	CAPACITY	NO OF RAIN
1	6	7	2	1	0.000	0
2	7	8	3	2	0.000	0
3	8	9	4	3	0.000	0
4	9	10	5	4	0.000	0
5	11	12	7	6	0.000	0
6	12	13	8	7	0.000	0
7	13	14	9	8	0.000	0
8	14	15	10	9	0.000	0
9	16	17	12	11	0.000	0
10	17	18	13	12	0.000	0
11	18	19	14	13	0.000	0
12	19	20	15	14	0.000	0
13	21	22	17	16	0.000	0
14	22	23	18	17	0.000	0
15	23	24	19	18	0.000	0
16	24	25	20	19	0.000	0

```
                              CP-TIME IS    0.0000E+00  SEC. FOR INPUTS OR PREPARATION OF CAL.

TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   0  WAS  3.00000E+00  AT NODE     24
TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   1  WAS  6.66134E-16  AT NODE     17
TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   2  WAS  6.66134E-16  AT NODE     17

FLUX INFO     TIME =  0.0000E+00     INFLOW =  4.8000E+02  OUTFLOW = -4.8000E+02  FLUX =  0.0000E+00  TOTAL FLUX =  0.0000E+00
```

EXAMPLE 1 STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM

TIME = 0.0000E+00   TIME STEP = 0

***** I N I T I A L   S T E A D Y   S T A T E *****

NODE	HEAD LEVEL	PRESSURE HEAD (BASE LINE)	Q	NODE	HEAD LEVEL	PRESSURE HEAD (BASE LINE)	Q
1	2.0000	12.0000	0.6000E+02				
2	1.0000	11.0000					
3	0.0000	10.0000					
4	-1.0000	9.0000					
5	-2.0000	8.0000	-0.6000E+02				
6	2.0000	12.0000	0.1200E+03				
7	1.0000	11.0000					
8	0.0000	10.0000					
9	-1.0000	9.0000					
10	-2.0000	8.0000	-0.1200E+03				
11	2.0000	12.0000	0.1200E+03				
12	1.0000	11.0000					
13	0.0000	10.0000					
14	-1.0000	9.0000					
15	-2.0000	8.0000	-0.1200E+03				
16	2.0000	12.0000	0.1200E+03				
17	1.0000	11.0000					
18	0.0000	10.0000					
19	-1.0000	9.0000					
20	-2.0000	8.0000	-0.1200E+03				
21	2.0000	12.0000	0.6000E+02				
22	1.0000	11.0000					
23	0.0000	10.0000					
24	-1.0000	9.0000					
25	-2.0000	8.0000	-0.6000E+02				

EXAMPLE 1 STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM TIME = 0.000

***** I N I T I A L S T E A D Y S T A T E *****

ELEM	X	Y	VX	VY	V	ANG
1	6.2500	43.7500	0.96000E+01	0.47684E-05	0.96000E+01	0.000
2	18.7500	43.7500	0.96000E+01	0.19073E-05	0.96000E+01	0.000
3	31.2500	43.7500	0.96000E+01	-0.95367E-06	0.96000E+01	0.000
4	43.7500	43.7500	0.96000E+01	0.00000E+00	0.96000E+01	0.000
5	6.2500	31.2500	0.96000E+01	0.47684E-05	0.96000E+01	0.000
6	18.7500	31.2500	0.96000E+01	0.19073E-05	0.96000E+01	0.000
7	31.2500	31.2500	0.96000E+01	-0.95367E-06	0.96000E+01	0.000
8	43.7500	31.2500	0.96000E+01	0.00000E+00	0.96000E+01	0.000
9	6.2500	18.7500	0.96000E+01	0.47684E-05	0.96000E+01	0.000
10	18.7500	18.7500	0.96000E+01	0.19073E-05	0.96000E+01	0.000
11	31.2500	18.7500	0.96000E+01	-0.95367E-06	0.96000E+01	0.000
12	43.7500	18.7500	0.96000E+01	0.00000E+00	0.96000E+01	0.000
13	6.2500	6.2500	0.96000E+01	0.47684E-05	0.96000E+01	0.000
14	18.7500	6.2500	0.96000E+01	0.19073E-05	0.96000E+01	0.000
15	31.2500	6.2500	0.96000E+01	-0.95367E-06	0.96000E+01	0.000
16	43.7500	6.2500	0.96000E+01	0.00000E+00	0.96000E+01	0.000

```
EXAMPLE 1  STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM

                                        ***** (UNIT11) TIME   0.0000E+00

                                        ***** (UNIT12) TIME   0.0000E+00

                              ----- E N D   O F   J O B -----
```

(2) Print output by UNISSF2/P

```
1.......10........20........30........40........50........60........70........80

START   1      TP
SUBTITLE
         EXAMPLE 1
NNUM     ON
ENUM     ON
DIVI     OFF
DOWN     OFF
MESH     OFF
MPLOT
FPRIN    ON
SCALE    A4
CONT     10
PLOT     ALL
REWIND
VERT     SET       1
1     5
VERT     1
LPLOT    ALL
END
```

```
EXAMPLE 1  STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM

      EXAMPLE 1

       ** PLOT INPUT FIG. **

       ** PLOT NODAL POINT NUMBER **

       ** PLOT ELEMENT NUMBER **

EXAMPLE 1  STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM

      EXAMPLE 1

       TIME =    0.000E+00

       ** PLOT VALUE **

       ** CONTOUR PLOT VALUE **

            1:    -2.000  2:    -1.600  3:    -1.200  4:    -0.800  5:    -0.400
            6:     0.000  7:     0.400  8:     0.800  9:     1.200 10:     1.600
           11:     2.000

EXAMPLE 1  STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM

      EXAMPLE 1

       TIME =    0.000E+00

       ** PLOT VERTICAL FIG. **

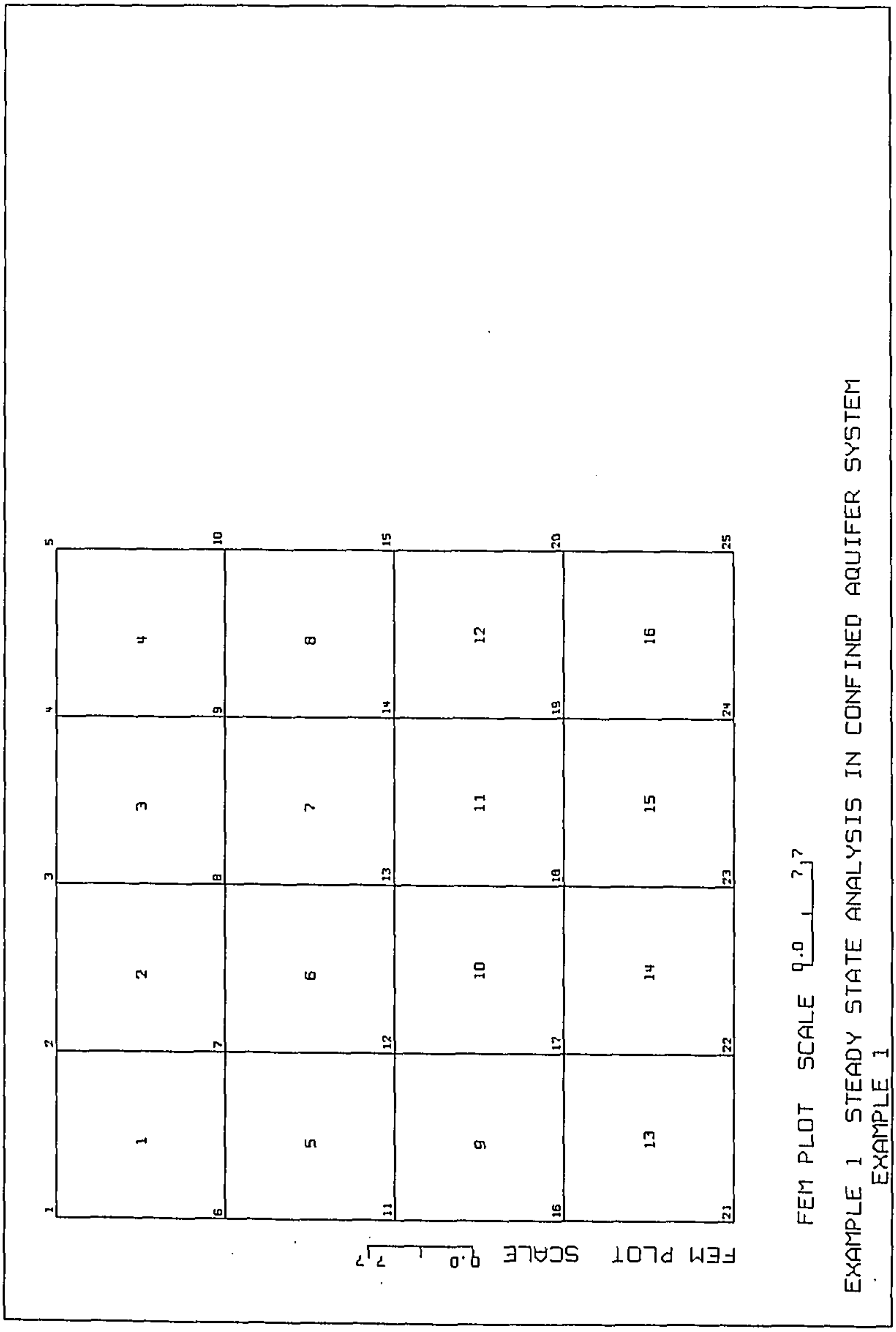
       ** PLOT VERTICAL FIG. NUMBER     1 **

           NODAL POINT

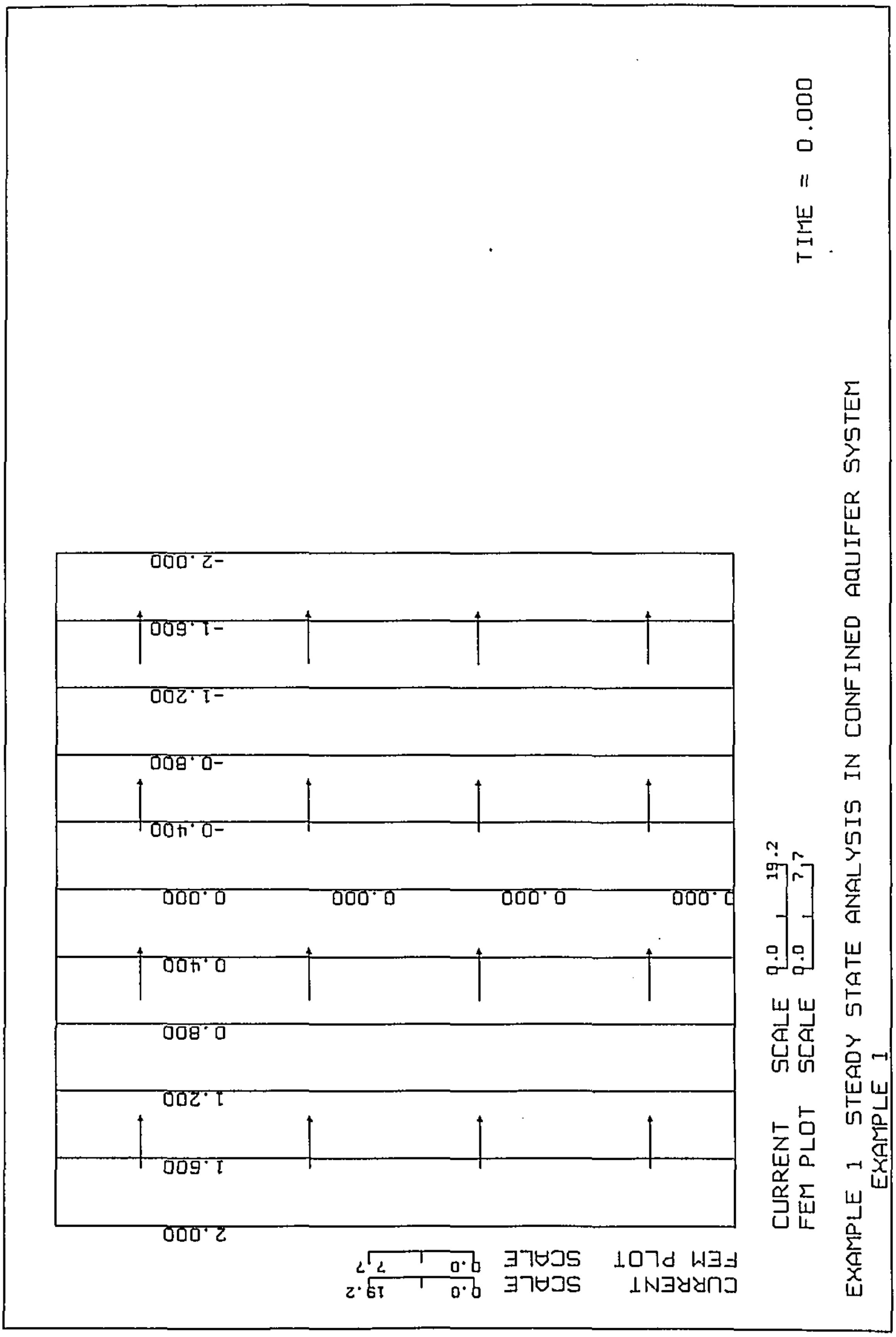
                1      2      3      4      5
```

(3) Plot output

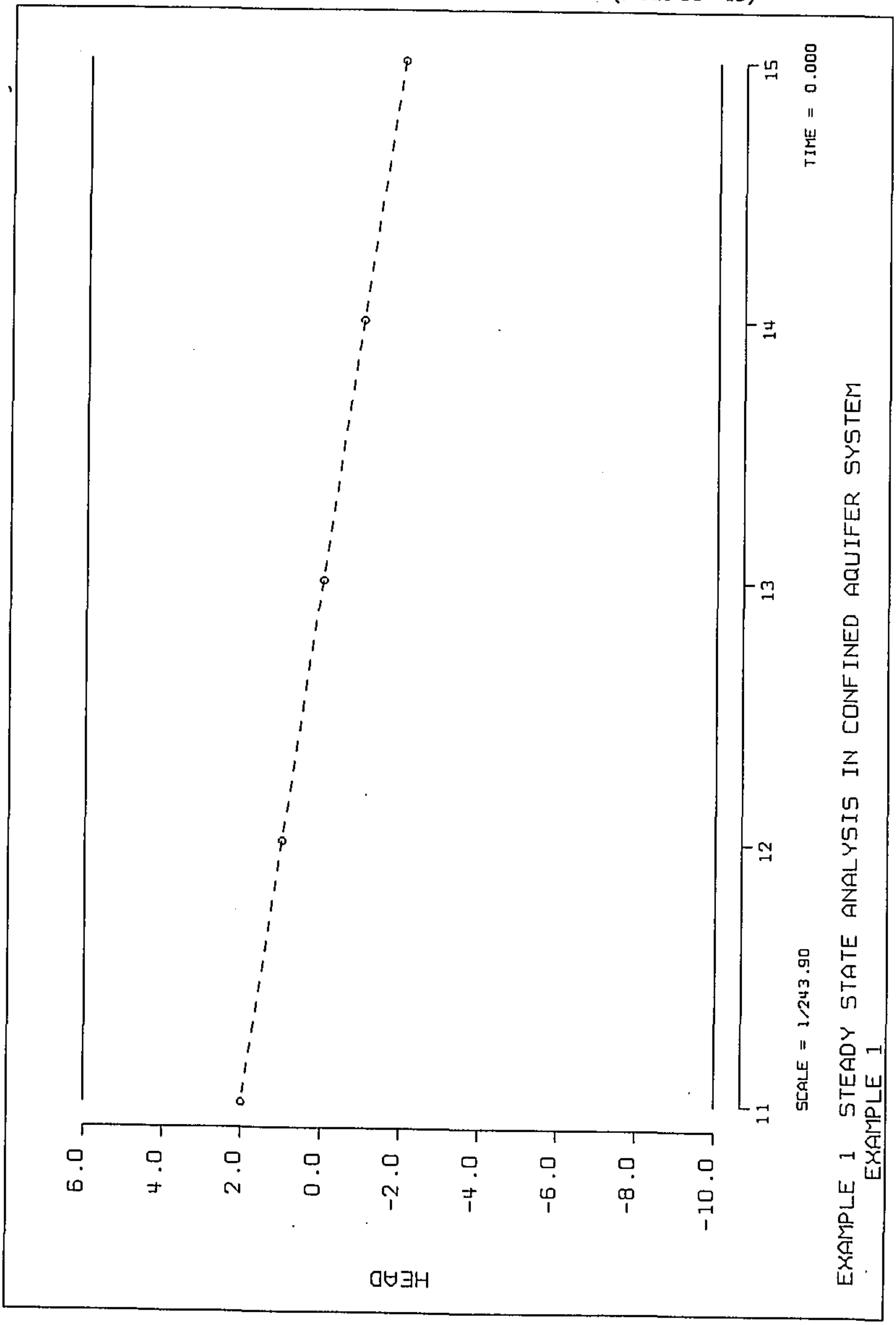
Mesh



Piezometric Surface and Flow Vector



Profile of Piezometric Surface
(Node 11 - 15)

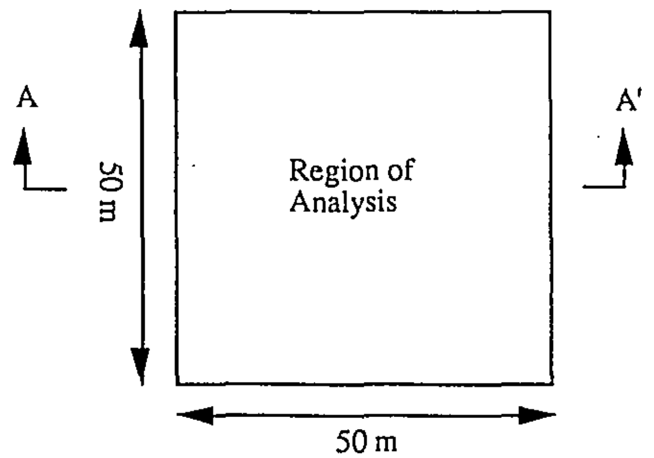


CHAPTER II
Example 2 : Non-steady state analysis in unconfined aquifer

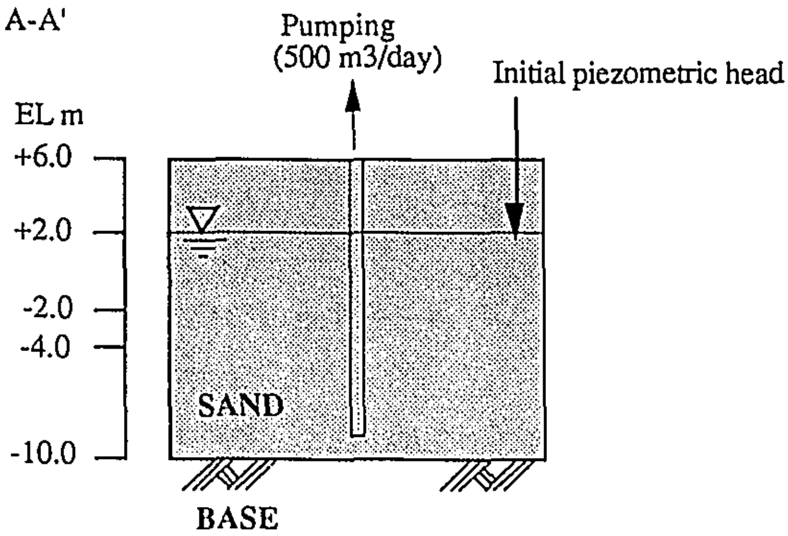
1. Data Preparation

Calculation of the piezometric head in the confined aquifer with 500 m^3/day of pumping at the center of the region.

Plane



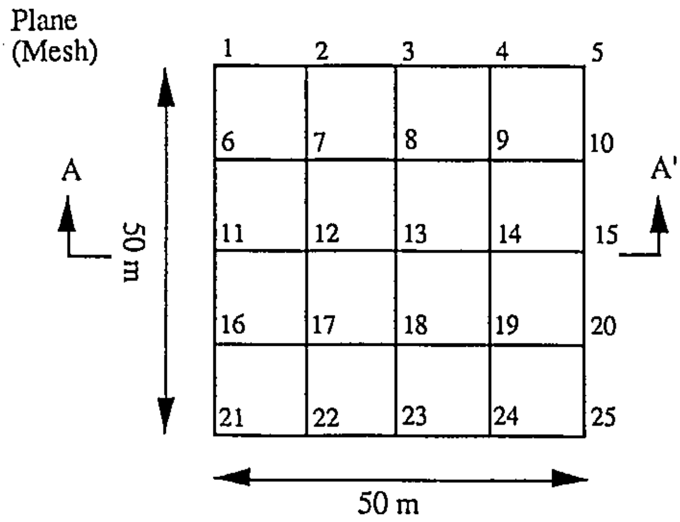
Section A-A'

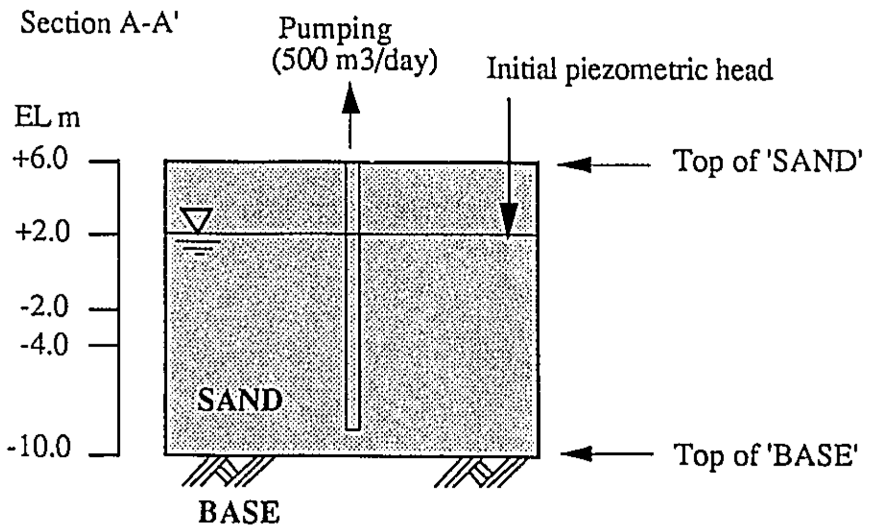


(1) **Mesh Data**

Same as Example 1

(2) **Geological Data and Aquifer Constants**





Elevation at the top of each layer

Node no.	Top of layer BASE	Top of layer SAND
1	-10	6
2	-10	6
3	-10	6
.	.	.
.	.	.
.	.	.
24	-10	6
25	-10	6

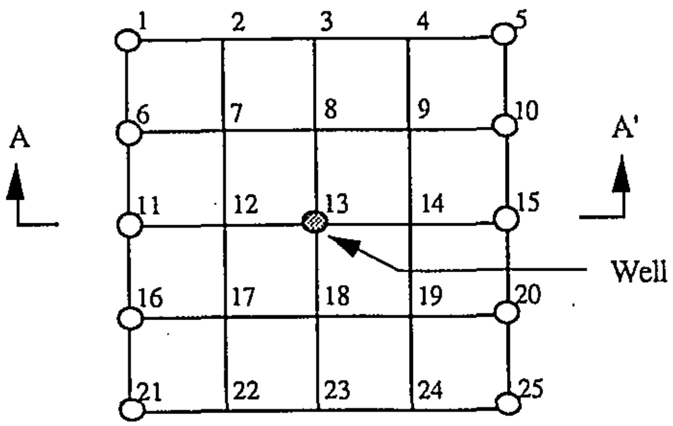
Aquifer Constants

Layer	K (m/day)	S
SAND	20	0.3

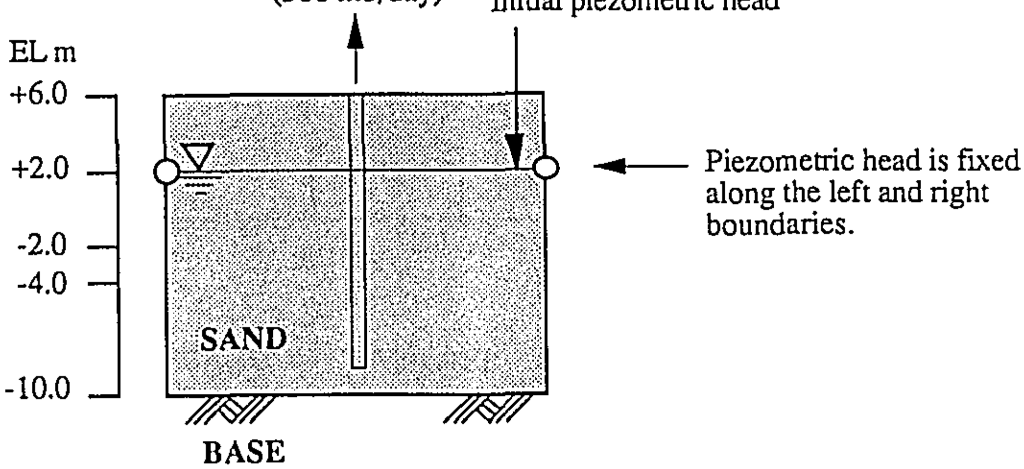
(3) Boundary Conditions

Plane

○ Specified head boundary



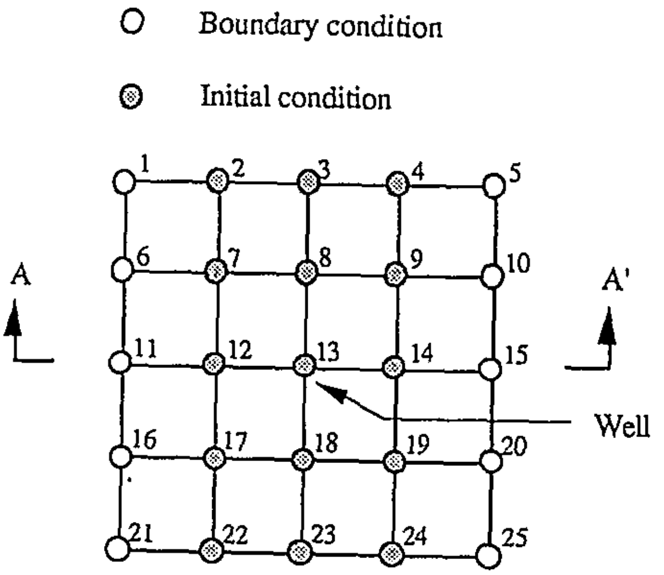
Section A-A'

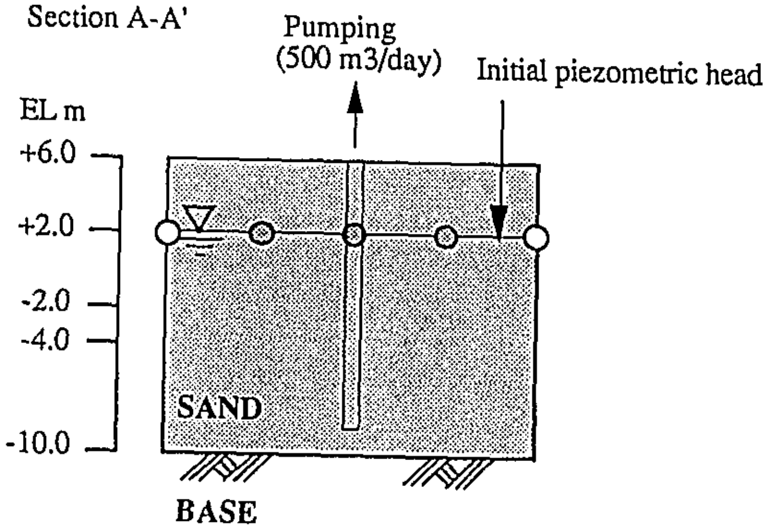


Left side boundary		Right side boundary		Well	
Node no.	Head (EL m)	Node no.	Head (EL m)	Node no.	Pumping (m3/day)
1	2.0	5	2.0	13	500
6	2.0	10	2.0		
11	2.0	15	2.0		
16	2.0	20	2.0		
21	2.0	25	2.0		

(4) Initial condition

Plane

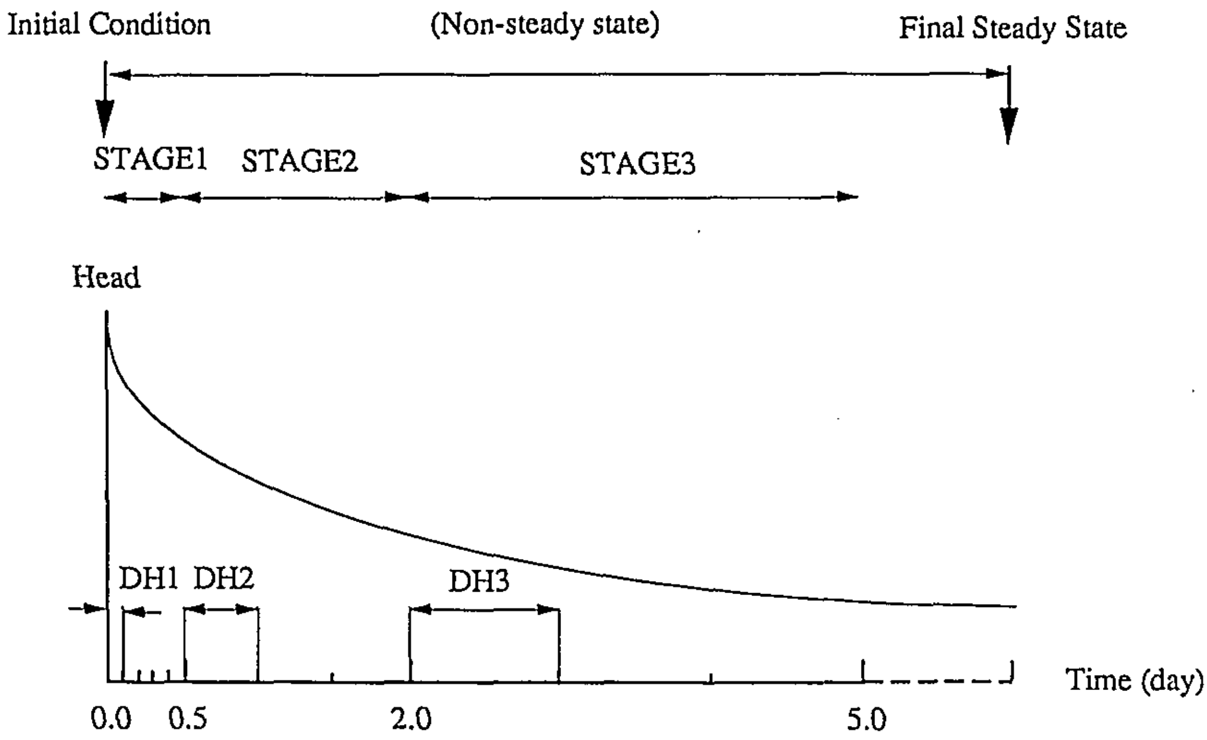




Node no.	Head (EL m)
2	2.0
3	2.0
4	2.0
.	.
.	.
.	.
22	2.0
23	2.0
24	2.0

(5) Time stage and step

FEM Calculation for non-steady analysis is proceeded by time-step, which is a short time length divided from the total calculation time. The time step is possible to give stage-wise. The time step DT1, DT2 and DT3 are given to the STAGE1,STAGE2 and STAGE3 respectively. In general, time step is needed to be short in the early stage and longer in the later stage to save the calculation time.



STAGE	TIME STEP	End of STAGE
1	DT1 = 0.1	T = 0.5
2	DT2 = 0.5	T = 2.0
3	DT3 = 1.0	T = 5.0

(6) Output time

Print and plot outputs are obtained by specifying the output time.

(Example)

Stage	Time	Time Step	
1	0.0	0	(Initial Condition)
1	0.1	1	
1	0.2	2	Output
1	0.3	3	
1	0.4	4	
1	0.5	5	
2	1.0	6	Output
2	1.5	7	
2	2.0	8	
3	3.0	9	
3	4.0	10	
3	5.0	11	Output (Final Steady State)

Time 0.2, 2.0 and 5.0 are specified in the input data by using 'PRTIME' and 'PLTIME' command.

2. Data Input

(1) Editing the data file

1) **$ ED EXA2.DAT** [enter] (create the data file)
2) Input data for Example 2

```
SETTING,  CHEC,  100.
TITLE
  EXAMPLE 2  NON-STEADY STATE ANALYSIS
1ST   , 25 , 16 , 4 , 25 , 2
2ND   ,  2 , 10., 0 ,  0 , 0
3RD   ,  0 ,  0 , 0 ,  0 , 0 , 0
4TH   ,  0 ,  0
*
*     --- MESH DATA ---
*
NODE ,          1 ,  0.0 ,  50.0
NODE ,          2 , 12.5 ,  50.0
NODE ,          3 , 25.0 ,  50.0
NODE ,          4 , 37.5 ,  50.0
NODE ,          5 , 50.0 ,  50.0
NODE ,          6 ,  0.0 ,  37.5
NODE ,          7 , 12.5 ,  37.5
NODE ,          8 , 25.0 ,  37.5
NODE ,          9 , 37.5 ,  37.5
NODE ,         10 , 50.0 ,  37.5
NODE ,         11 ,  0.0 ,  25.0
NODE ,         12 , 12.5 ,  25.0
NODE ,         13 , 25.0 ,  25.0
NODE ,         14 , 37.5 ,  25.0
NODE ,         15 , 50.0 ,  25.0
NODE ,         16 ,  0.0 ,  12.5
NODE ,         17 , 12.5 ,  12.5
NODE ,         18 , 25.0 ,  12.5
NODE ,         19 , 37.5 ,  12.5
NODE ,         20 , 50.0 ,  12.5
NODE ,         21 ,  0.0 ,   0.0
NODE ,         22 , 12.5 ,   0.0
NODE ,         23 , 25.0 ,   0.0
NODE ,         24 , 37.5 ,   0.0
NODE ,         25 , 50.0 ,   0.0
ELEM ,     1 ,      6 ,      7 ,      2 ,      1
ELEM ,     2 ,      7 ,      8 ,      3 ,      2
ELEM ,     3 ,      8 ,      9 ,      4 ,      3
ELEM ,     4 ,      9 ,     10 ,      5 ,      4
ELEM ,     5 ,     11 ,     12 ,      7 ,      6
ELEM ,     6 ,     12 ,     13 ,      8 ,      7
ELEM ,     7 ,     13 ,     14 ,      9 ,      8
ELEM ,     8 ,     14 ,     15 ,     10 ,      9
ELEM ,     9 ,     16 ,     17 ,     12 ,     11
ELEM ,    10 ,     17 ,     18 ,     13 ,     12
ELEM ,    11 ,     18 ,     19 ,     14 ,     13
ELEM ,    12 ,     19 ,     20 ,     15 ,     14
ELEM ,    13 ,     21 ,     22 ,     17 ,     16
ELEM ,    14 ,     22 ,     23 ,     18 ,     17
ELEM ,    15 ,     23 ,     24 ,     19 ,     18
ELEM ,    16 ,     24 ,     25 ,     20 ,     19
```

```
MEND
*
*    --- UNIT ---
*
UNIT  , ME , DAY , 10 ,  0.01
*
*    --- TIME STEP ---
*
TIME, 3
STEP, 1, 0.1, 0.5
STEP, 2, 0.5, 2.0
STEP, 3, 1.0, 5.0
*
*    --- BOUNDARY CONDITION ---
*
INIP  ,   1  ,  1  ,  1 ,   2.0
INIP  ,   6  ,  6  ,  1 ,   2.0
INIP  ,  11  , 11  ,  1 ,   2.0
INIP  ,  16  , 16  ,  1 ,   2.0
INIP  ,  21  , 21  ,  1 ,   2.0
INIP  ,   5  ,  5  ,  1 ,   2.0
INIP  ,  10  , 10  ,  1 ,   2.0
INIP  ,  15  , 15  ,  1 ,   2.0
INIP  ,  20  , 20  ,  1 ,   2.0
INIP  ,  25  , 25  ,  1 ,   2.0
NCON  ,   1  ,  1  ,  1 ,   HF
NCON  ,   6  ,  6  ,  1 ,   HF
NCON  ,  11  , 11  ,  1 ,   HF
NCON  ,  16  , 16  ,  1 ,   HF
NCON  ,  21  , 21  ,  1 ,   HF
NCON  ,   5  ,  5  ,  1 ,   HF
NCON  ,  10  , 10  ,  1 ,   HF
NCON  ,  15  , 15  ,  1 ,   HF
NCON  ,  20  , 20  ,  1 ,   HF
NCON  ,  25  , 25  ,  1 ,   HF
*
NCON  ,  13  , 13  ,  1 ,   QF
INIQ  ,  13,   13  ,  1 ,   -500
*
*    --- INITIAL CONDITION ---
*
INIP  ,   2  ,  2  ,  1 ,   2.0
INIP  ,   3  ,  3  ,  1 ,   2.0
INIP  ,   4  ,  4  ,  1 ,   2.0
INIP  ,   7  ,  7  ,  1 ,   2.0
INIP  ,   8  ,  8  ,  1 ,   2.0
INIP  ,   9  ,  9  ,  1 ,   2.0
INIP  ,  12  , 12  ,  1 ,   2.0
INIP  ,  13  , 13  ,  1 ,   2.0
INIP  ,  14  , 14  ,  1 ,   2.0
INIP  ,  17  , 17  ,  1 ,   2.0
INIP  ,  18  , 18  ,  1 ,   2.0
INIP  ,  19  , 19  ,  1 ,   2.0
INIP  ,  22  , 22  ,  1 ,   2.0
INIP  ,  23  , 23  ,  1 ,   2.0
INIP  ,  24  , 24  ,  1 ,   2.0
*
*    --- STEADY STATE ---
*
CONT , STEADY
*
*    --- AQUIFER CONSTANTS ---
LAYE , 2
```

Time stage and step (Non-steady)

Well : Node 13

```
SAND , 20.  , 0.3
CLAY , 1.0E-07, 1.0E-07
*
*    --- GEOLOGICAL DATA ---
*
GEOL ,  1 ,  1 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL ,  2 ,  2 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL ,  3 ,  3 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL ,  4 ,  4 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL ,  5 ,  5 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL ,  6 ,  6 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL ,  7 ,  7 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL ,  8 ,  8 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL ,  9 ,  9 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 10 , 10 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 11 , 11 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 12 , 12 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 13 , 13 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 14 , 14 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 15 , 15 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 16 , 16 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 17 , 17 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 18 , 18 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 19 , 19 ,  1 ,  2
BASE ,  SAND     CLAY
 -10.,  -4.0    , 6.0
GEOL , 20 , 20 ,  1 ,  2
```

```
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 21 , 21 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 22 , 22 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 23 , 23 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 24 , 24 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
GEOL , 25 , 25 ,  1 ,  2
BASE ,  SAND    CLAY
 -10.,  -4.0   , 6.0
*
PRTIME, 0.5, 1.0, 2.0, 4.0          Outputs are to be obtained
PLTIME, 0.5, 1.0, 2.0, 4.0          at specified times.
*
ENDD
```

4) *Press PF4 function key*
5) Command : **exit** [enter] (data to be saved) or
Command : **quit** [enter] (data not to be saved / data not to be changed)

3. Data Check and Calculation

(1) Data check

1) $ **UNISSF** [enter]

2) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> M [enter] ('M' for UNISSF2)

3) RESTART ? (Y/N) N [enter]

4) FILE NAME(?.dat) **EXA2** [enter]

.
.
.
(checking the data)
.
.
.

FORTRAN STOP

UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> E [enter] ('E' for end)

5) **$ ED EXA2.PRN** [enter] (print output to be checked)

6) Press **PF4** function key (at the end of check)
7) Command : **QUIT** [enter]

(2) Calculation by UNISSF2

1) $ ED EXA2.DAT [enter]

1st line of the data to be changed

```
SETTING, CHEC,  100
      |
      v
SETTING, RUN ,  100
          ^
          |
   (RUN + one blank)
```

2) Press PF4 function key (at the end of edit)
3) Command : EXIT [enter] (save the data)

4) $ UNISSF [enter]

5)
```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

PLEASE ENTER ----> M [enter] ('M' for UNISSF2)

6) RESTART ? (Y/N) N [enter]

7) FILE NAME(?.dat) EXA2 [enter]

.
.
.
(calculating)
.
.
.

FORTRAN STOP

```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

PLEASE ENTER ----> E [enter] ('E' for end)

8) $ ED EXA2.PRN [enter] (print output to be checked)

9) Press PF4 function key (at the end of check)
10) Command : QUIT [enter]

4. Post Processing by UNISSF2/P

(1) Creation of the data file for plot control

1) **$ ED PLOT2.DAT** [enter]

2) Input data

```
START    1        TP
SUBTITLE
         EXAMPLE 2
NNUM     ON
ENUM     ON
DIVI     OFF
DOWN     OFF
MESH     OFF
MPLOT
FPRIN    ON
SCALE    A4
CONT     10
PLOT     ALL
REWIND
VERT     SET       1
11       15
VERT     1
LPLOT    ALL
END
```

3) Press **PF4** function key (at the end of edit)
4) Command : **EXIT** [enter] (save the data)

(2) Post processing

1) **$ UNISSF** [enter]

2) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> P [enter] ('P' for UNISSF2/P)

3) RESTART ? (Y/N) N [enter]

4) FILE NAME(?.dat) **PLOT2** [enter]
5) FILE NAME(FT10) **EXA2.FT10** [enter]
6) FILE NAME(FT11) **EXA2.FT11** [enter]

.
.
.
(processing)
.
.
.

FORTRAN STOP

UNISSF2	< M >
UNISSF2/G	< G >
UNISSF2/P	< P >
DISPLAY	< D >
XYPLOT	< X >
END	< E >

PLEASE ENTER ----> **E** [enter] ('E' for end)

7) $ **ED PLOT2.PRN** [enter] (print output to be checked)

8) Press **PF4** function key (at the end of check)

9) Command : **QUIT** [enter]

5. Graphic and Plotting

(1) Graphic on TEKTRONIX terminal

1) Press **SET UP** key
2) * **CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) **$ UNISSF** [enter]

5)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
END         < E >
```

PLEASE ENTER ----> **D** [enter] ('D' for DISPLAY)

6) FILE NAME : **FOR040.DAT** [enter]

7) press **CLEAR** key

(graphic 1) (Press [enter] to show the next graphic)
(graphic 2) (Press 'E' for end of graphic)
.
.
.

8) At the end of graphic (no graphic on display), Press **CLEAR** key

9)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
END         < E >
```

PLEASE ENTER ----> **E** [enter] ('E' for end)

10) Press **SET UP** key
11) * **CODE ANSI** [enter]
12) Press **SET UP** key, and [enter]

(2) Plotting

1) Plotter set up
2) Paper set
3) Press 'On-line' soft key

4) $ UNISSF [enter]

5)
```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

PLEASE ENTER ----> X [enter] ('X' for XYPLOT)

6) FILE NAME : FOR040.DAT [enter]

.
.
.

(plotting)

.
.
.

7) If there are more than 2 drawings, the plotting is stopped and the message 'HALT RECIEVED...' is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press 'On-line' soft key.

8) At the end of plotting, the message 'PLOT COMPLETE' is shown in the plotter window.

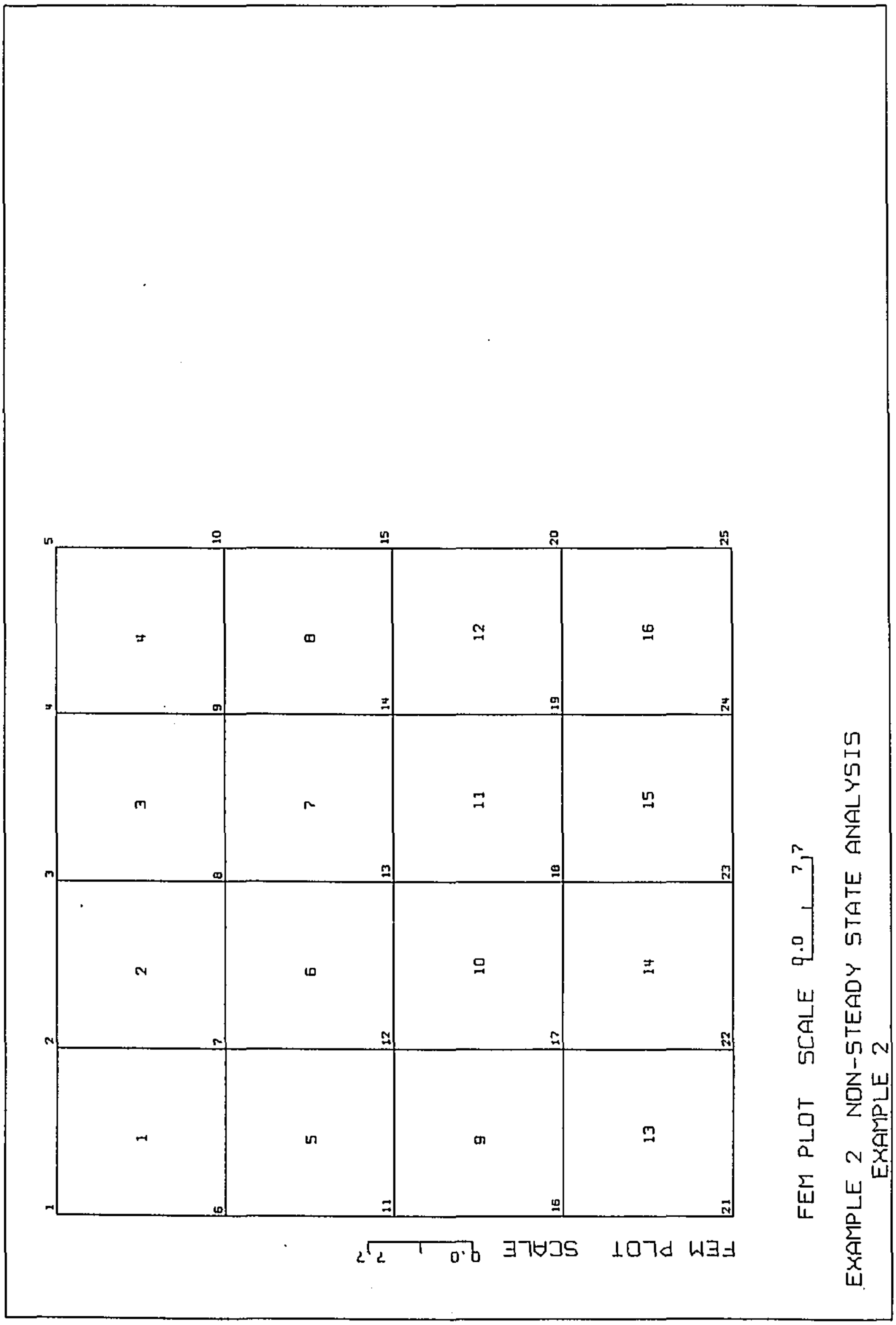
9)
```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

PLEASE ENTER ----> E [enter]

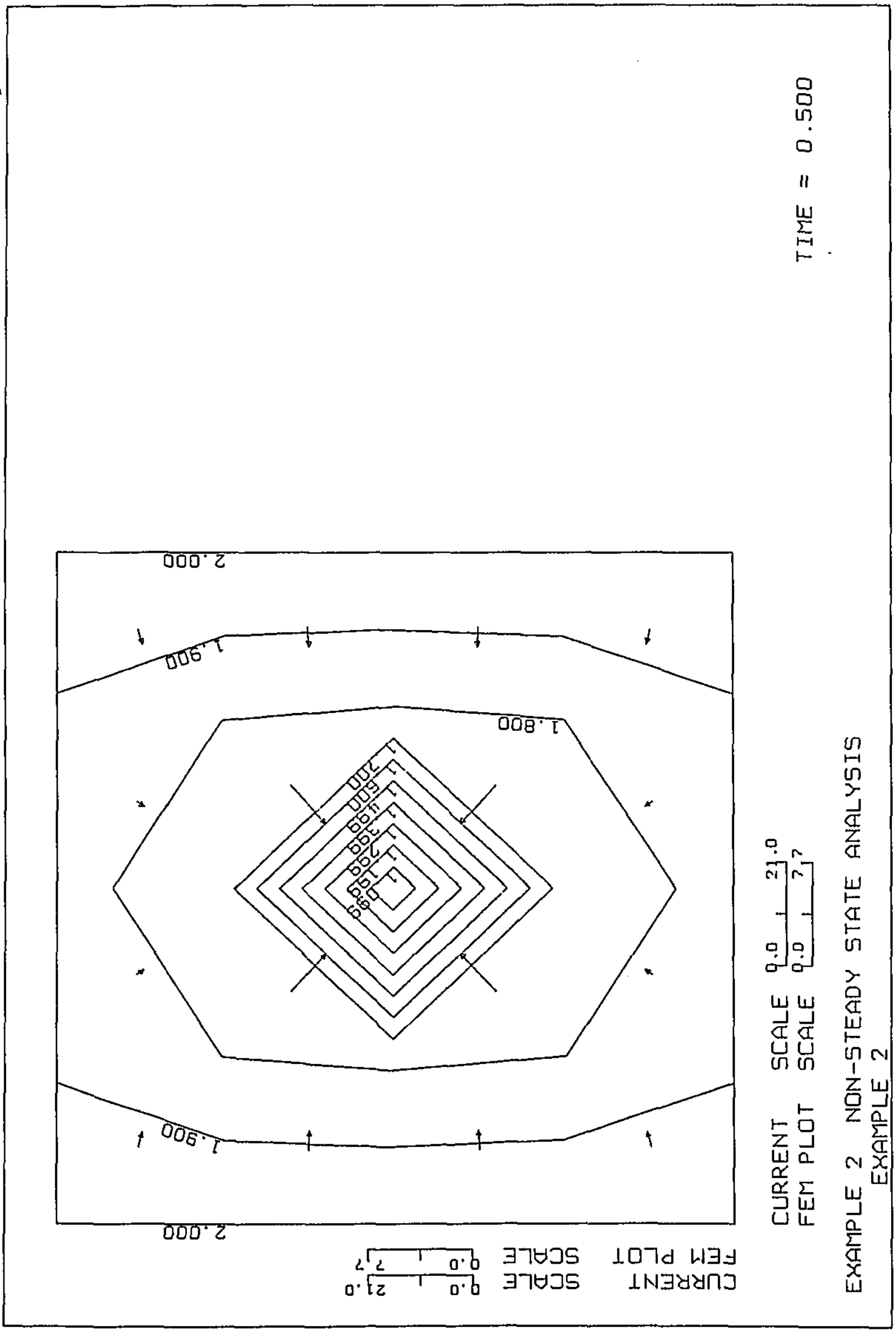
6. Output

(Plot output only)

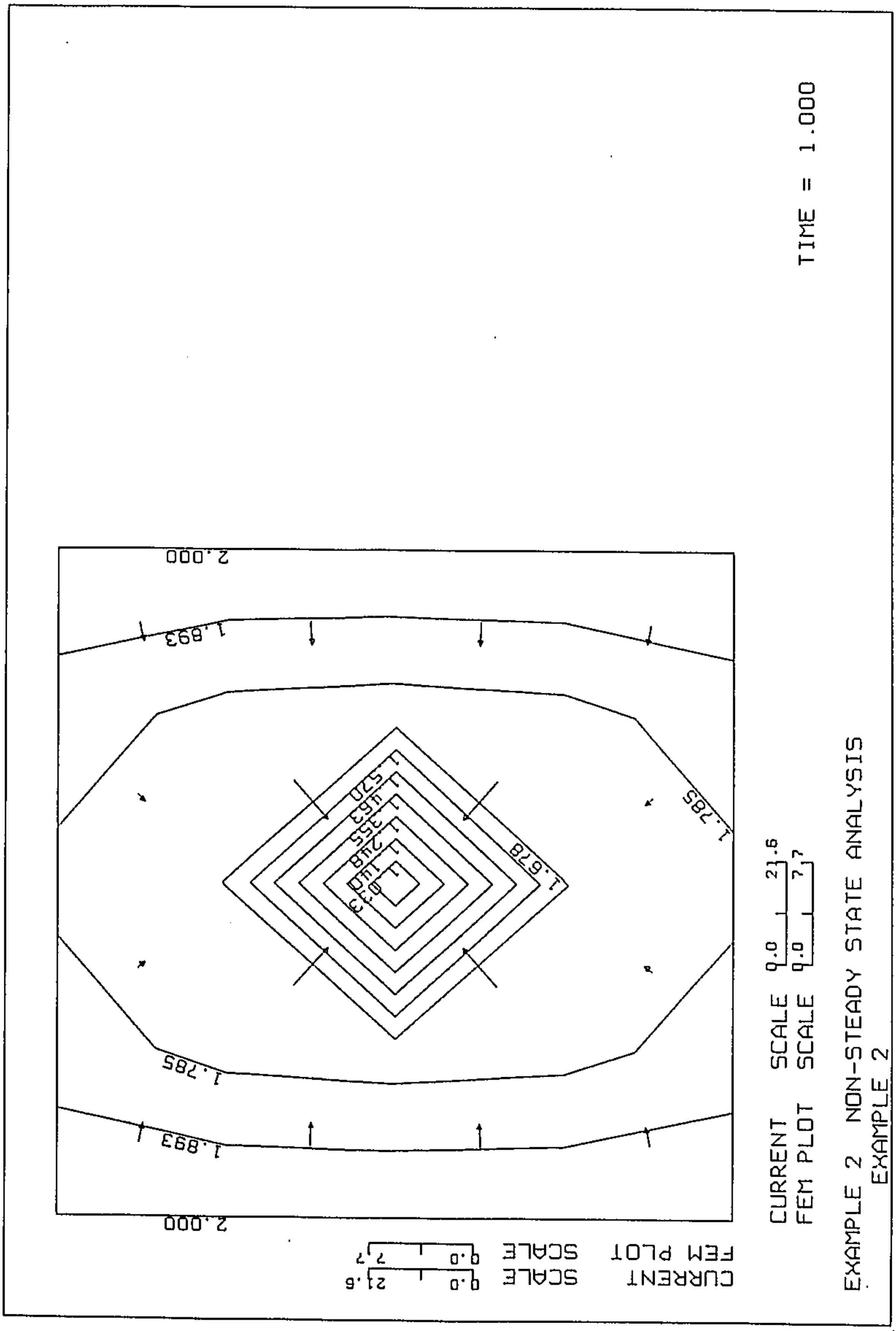
Mesh



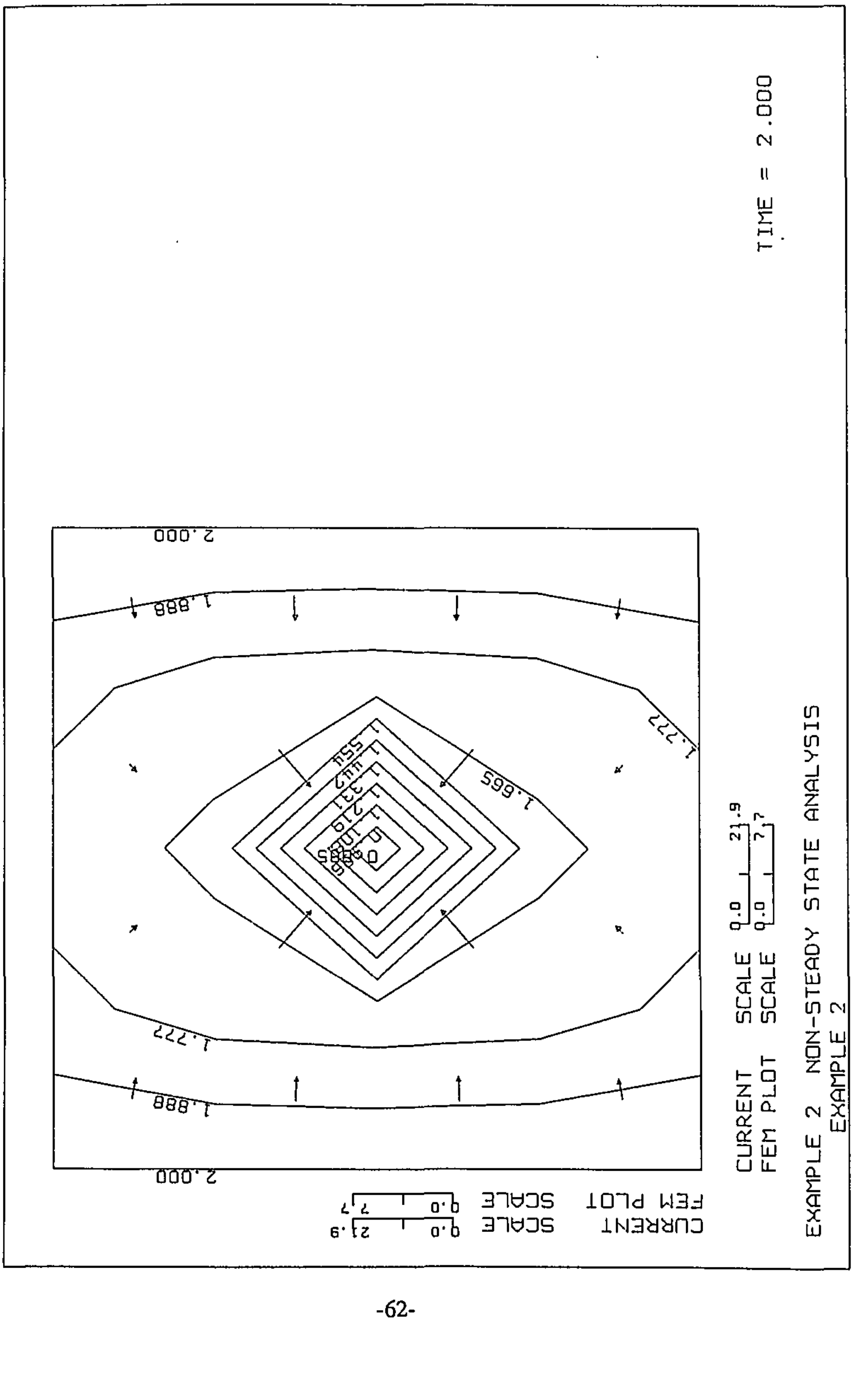
Piezometric Surface and Flow Vector



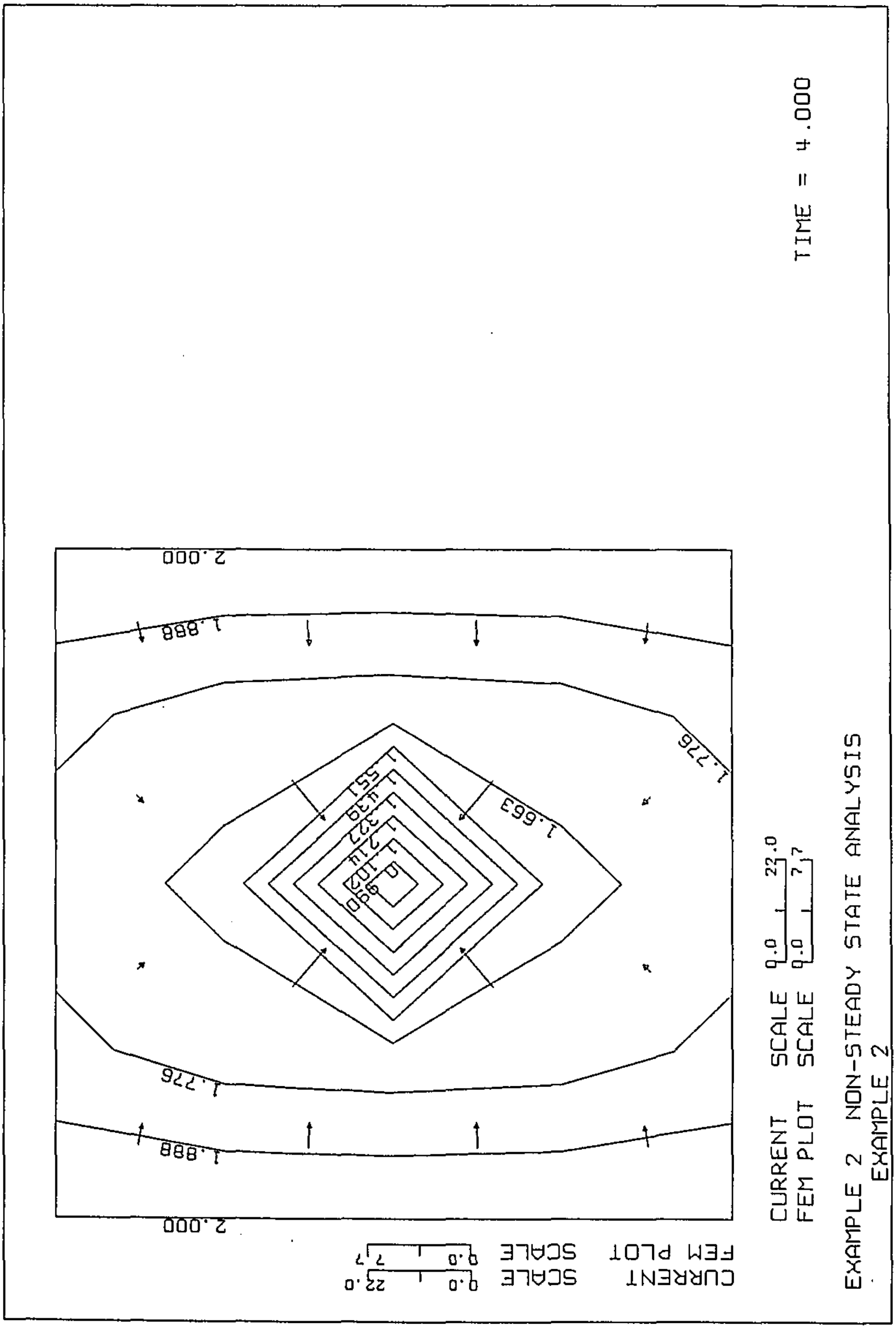
Piezometric Surface and Flow Vector



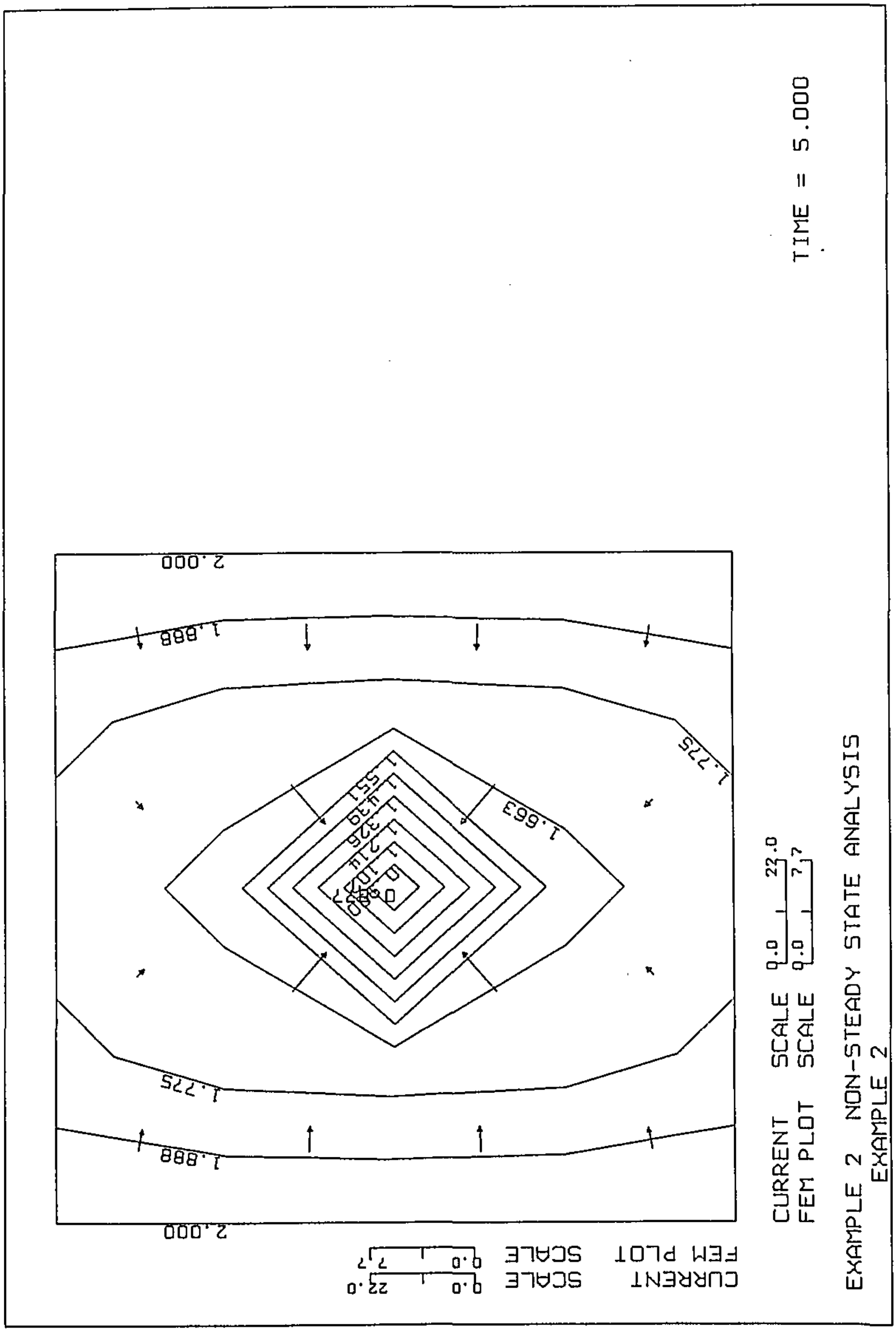
Piezometric Surface and Flow Vector



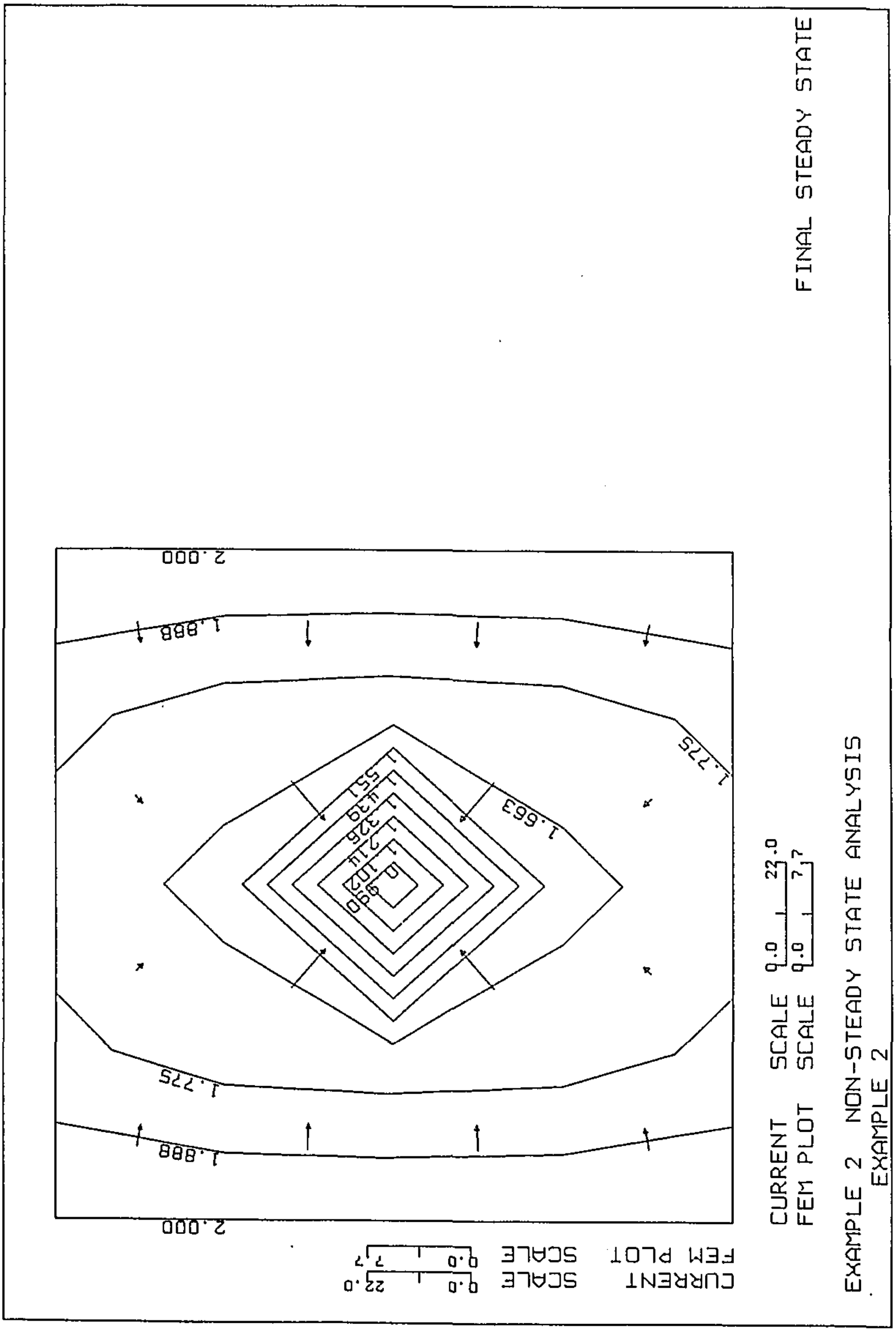
Piezometric Surface and Flow Vector



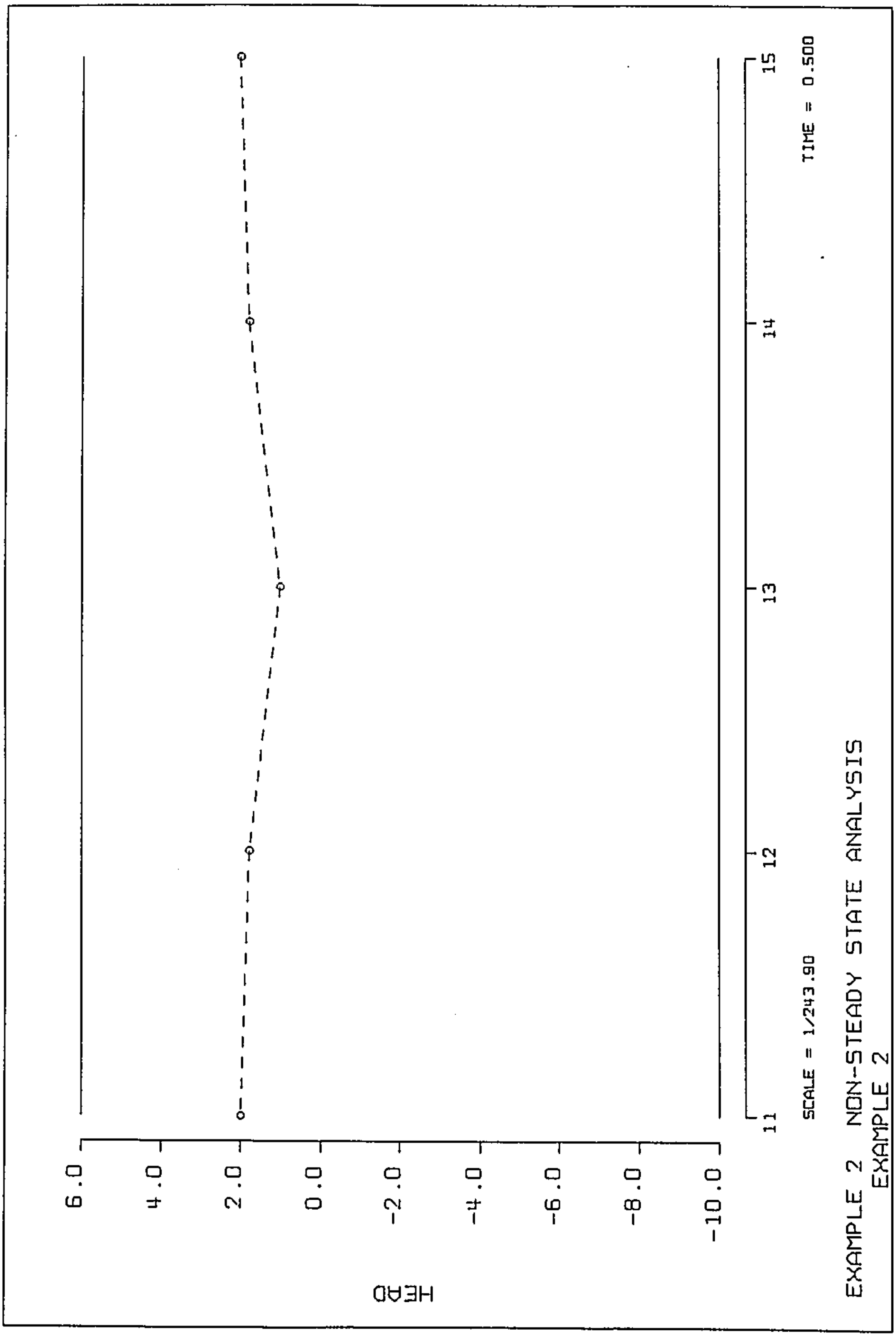
Piezometric Surface and Flow Vector



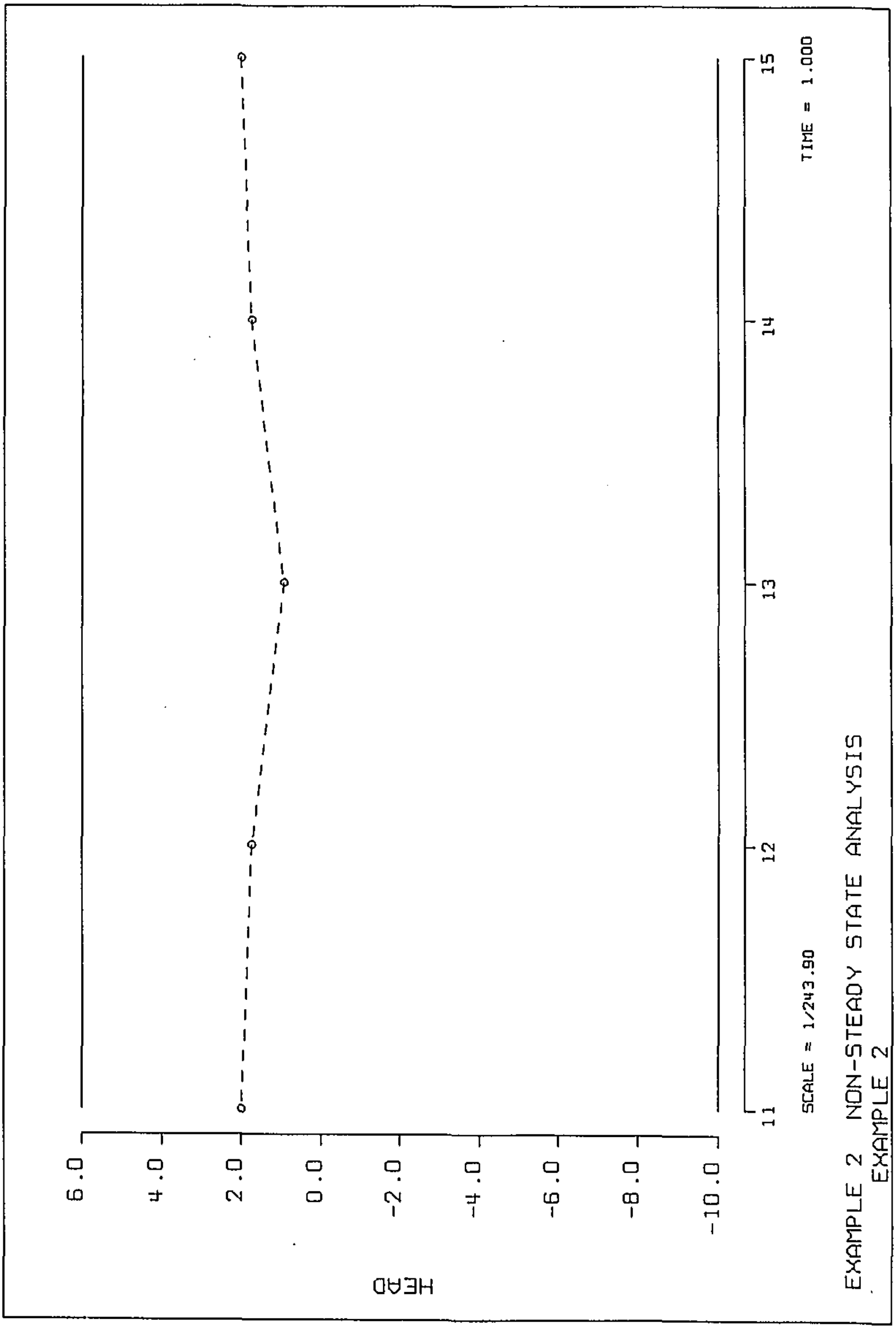
Piezometric Surface and Flow Vector



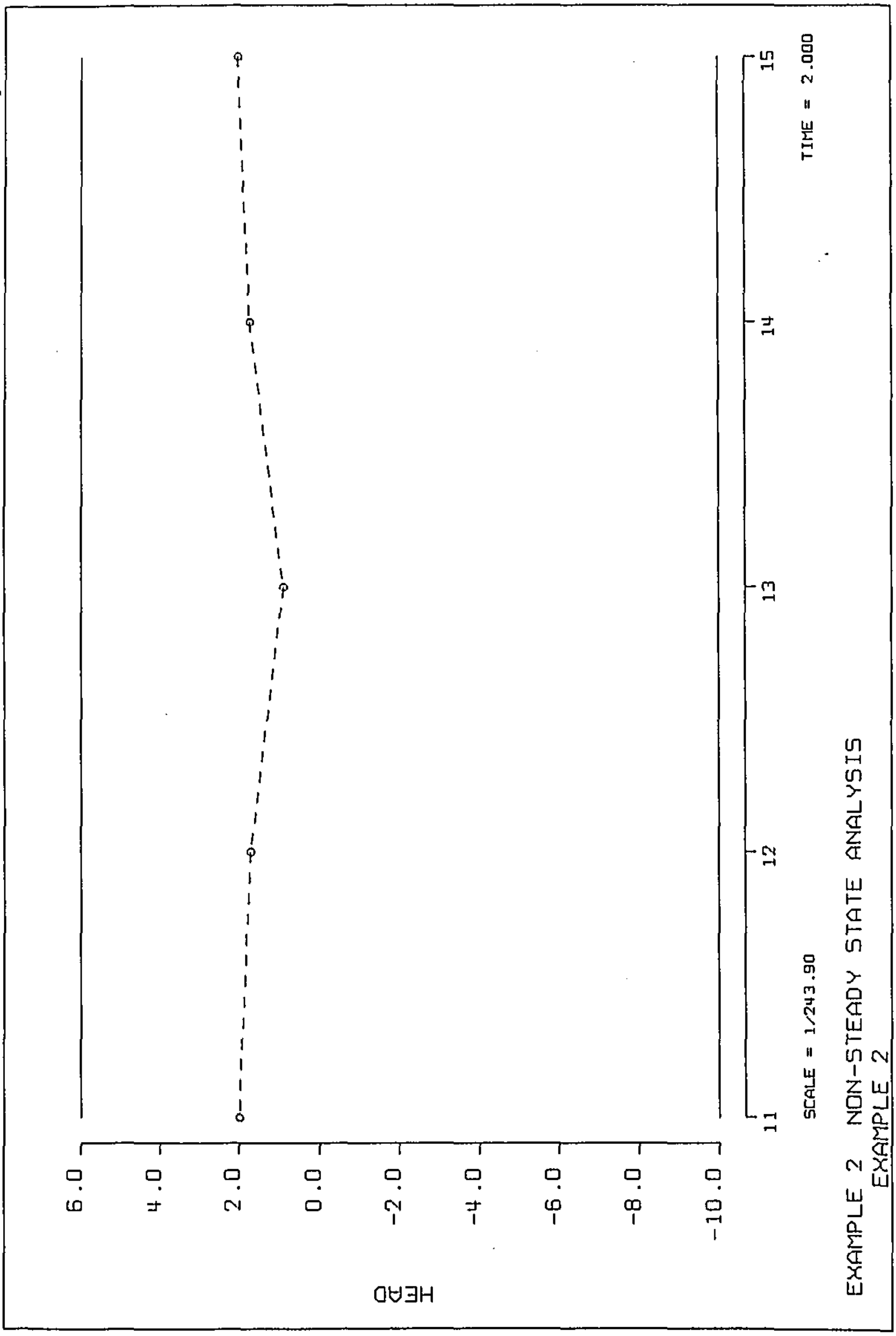
Profile of Piezometric Surface (Node 11 - 15)



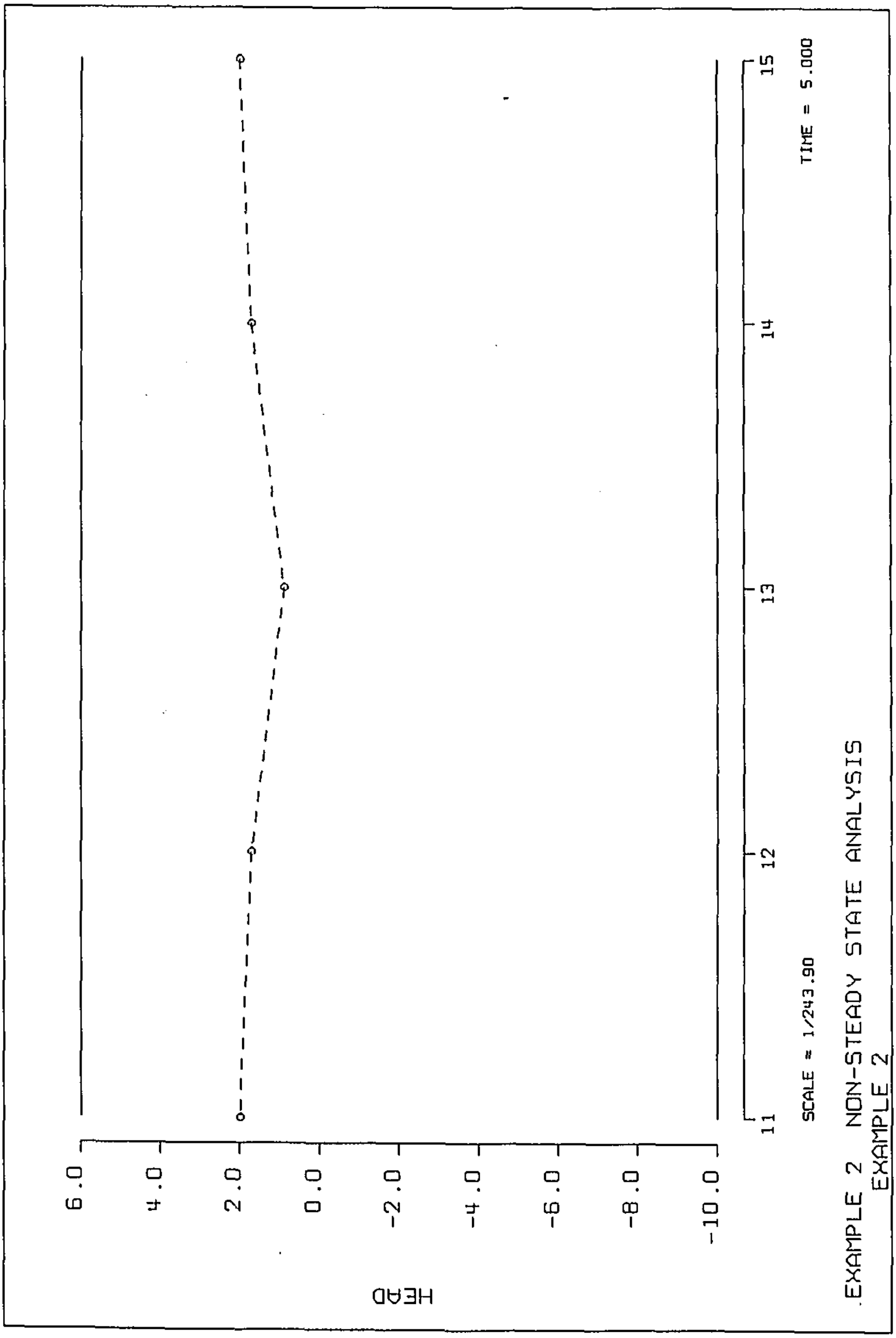
Profile of Piezometric Surface (Node 11 - 15)



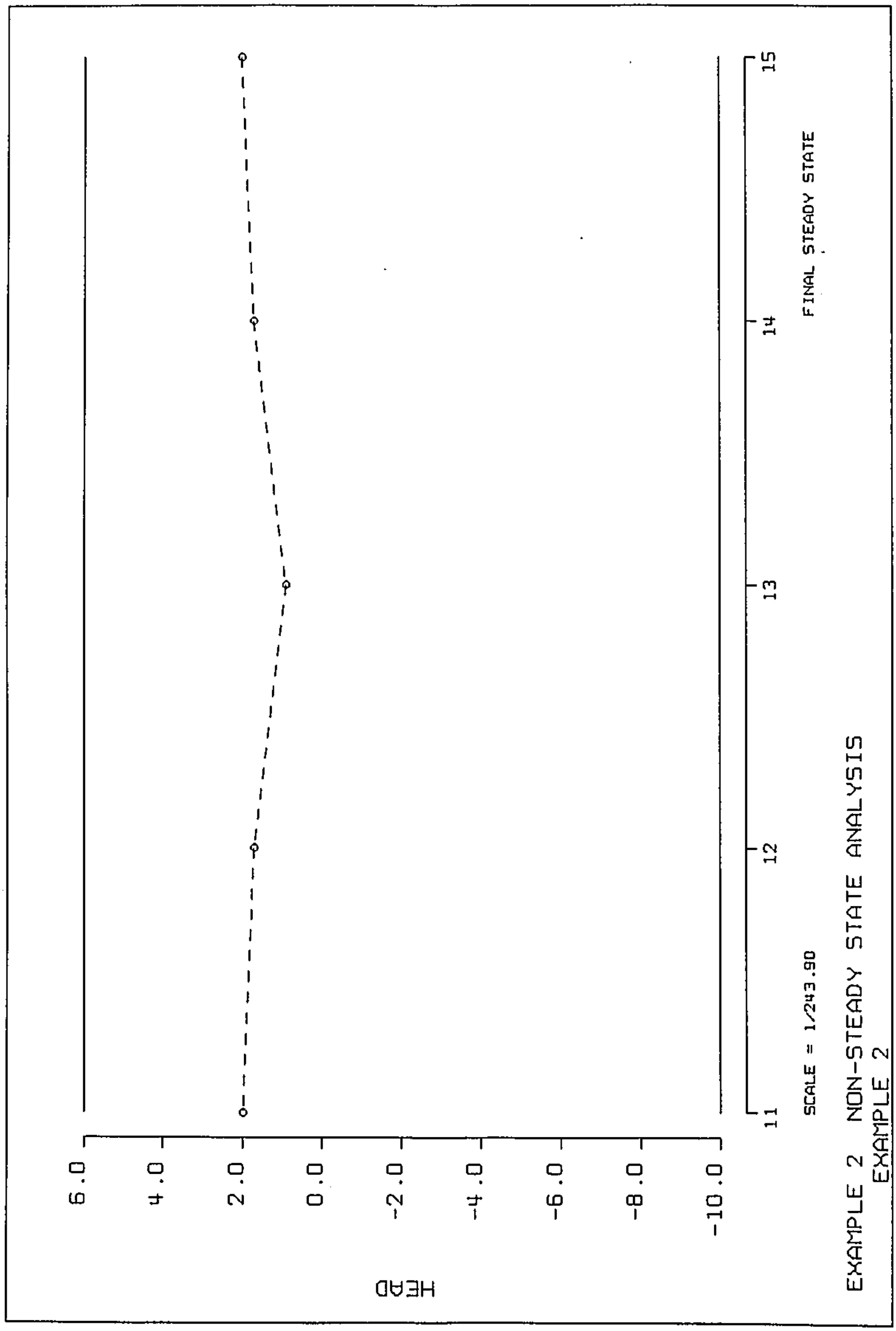
Profile of Piezometric Surface (Node 11 - 15)



Profile of Piezometric Surface (Node 11 - 15)



Profile of Piezometric Surface (Node 11 - 15)

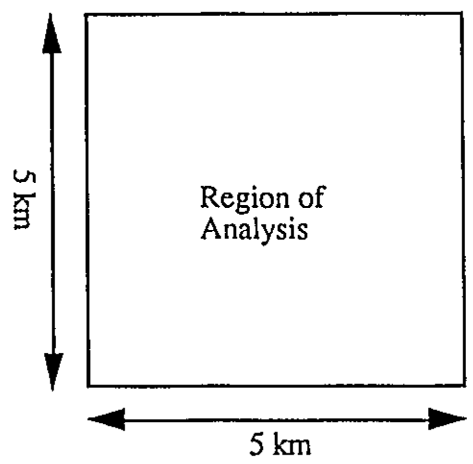


CHAPTER III
Example 3 : Steady state analysis in confined aquifer (2)

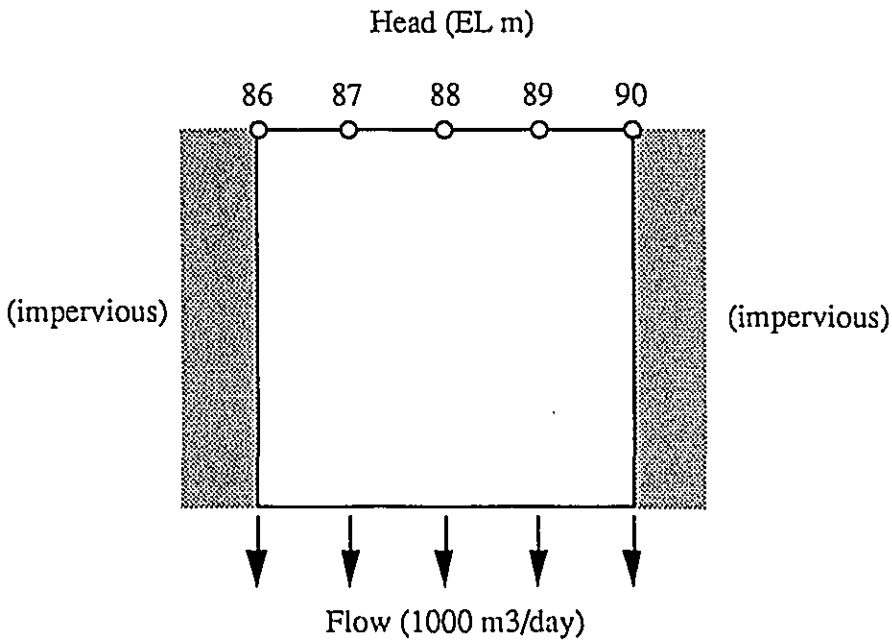
1. Data Preparation

Calculation of the piezometric head in the confined aquifer under the given boundary condition

Plane

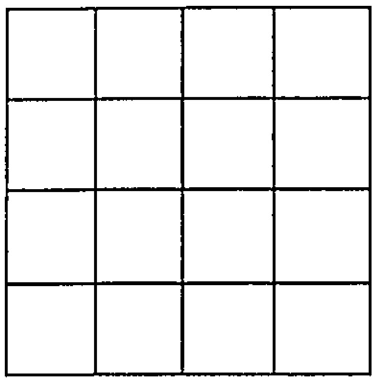


Boundary condition

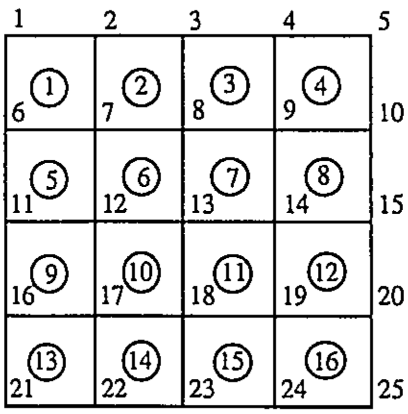


(1) Mesh data

1) Mesh diagram



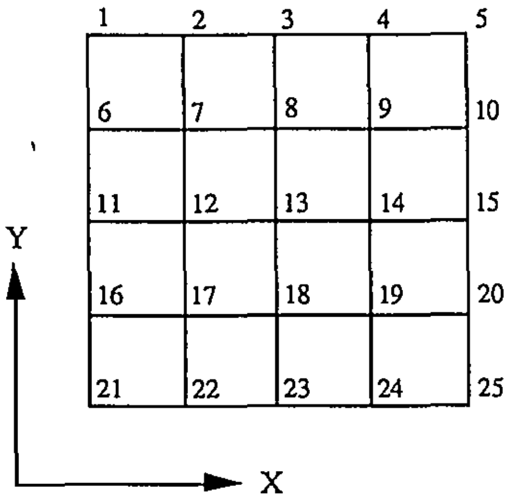
2) Node number and element number



1 - 25 Node number

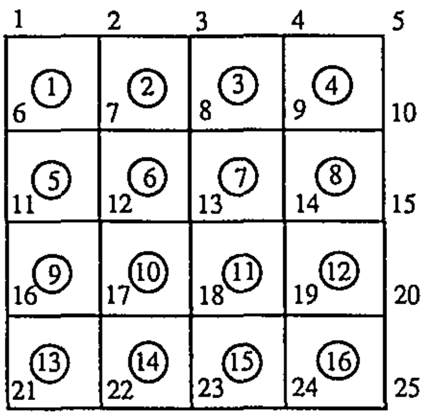
① - ⑯ Element number

3) Node coordinates



Node no.	Coordinates X	Coordinates Y
1	0	5000
2	1250	5000
3	2500	5000
.	.	.
.	.	.
.	.	.
24	3750	0
25	5000	0

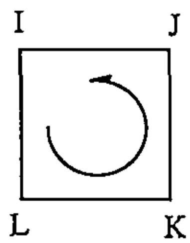
4) Element connection



1 - 25 Node number

① - ⑯ Element number

Element no.	Node no. of element I	J	K	L
1	1	6	7	2
2	2	7	3	8
3	3	8	9	4
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
15	18	23	24	19
16	19	24	25	20

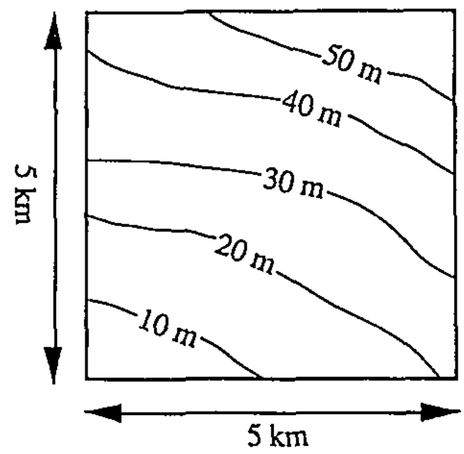


Node numbers of element are given counter-clockwise

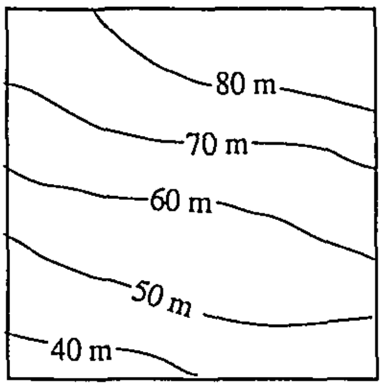
(2) Geological data and aquifer constants

1) Symbol of layers and elevation at top of each layers for each node

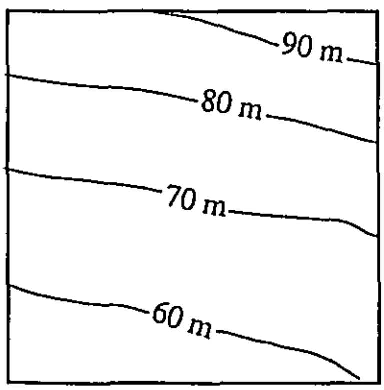
Elevation Contour



BASE
(Bottom of Aquifer /
Top of Basement)



AQUI
(Top of Aquifer)

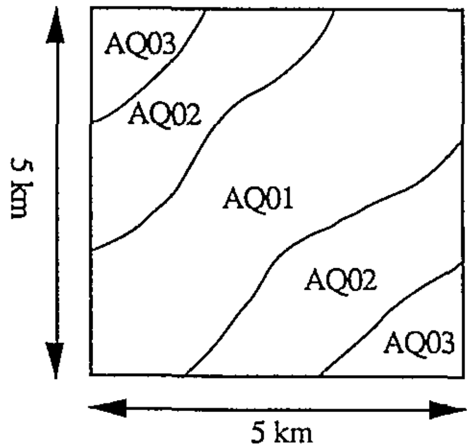


SURF
(Ground Surface)

Node	Top of BASE (EL m)	Top of AQUI (EL m)	Top of SURF (EL m)
1	44	75	85
2	48	80	88
3	53	84	91
4	56	87	93
5	60	90	95
6	36	68	78
7	38	73	78
8	40	77	80
9	44	79	82
10	50	81	85
11	24	57	68
12	26	60	69
13	28	61	71
14	31	63	73
15	38	67	74
16	12	46	60
17	15	50	62
18	19	52	63
19	24	54	65
20	30	57	66
21	5	37	55
22	8	39	56
23	11	40	58
24	17	44	59
25	21	45	61

2) Aquifer constants

Trasmissivity Map



Symbol	K (m/day)	S
AQ01	10.0	0.3
AQ02	5.0	0.2
AQ03	2.0	0.1

Node	Symbol	K (m/day)	S
1	AQ03	2.0	0.1
2	AQ03	2.0	0.1
3	AQ02	5.0	0.2
4	AQ01	10.0	0.3
5	AQ01	10.0	0.3
6	AQ03	2.0	0.1
7	AQ02	5.0	0.2
8	AQ01	10.0	0.3
9	AQ01	10.0	0.3
10	AQ01	10.0	0.3
11	AQ02	5.0	0.2
12	AQ01	10.0	0.3
13	AQ01	10.0	0.3
14	AQ01	10.0	0.3
15	AQ02	5.0	0.2
16	AQ01	10.0	0.3

17	AQ01	10.0	0.3
18	AQ02	5.0	0.2
19	AQ02	5.0	0.2
20	AQ01	2.0	0.1
21	AQ01	10.0	0.3
22	AQ01	10.0	0.3
23	AQ02	5.0	0.2
24	AQ03	2.0	0.1
25	AQ03	2.0	0.1

Input Data :

Layer	K (m/day)	S
SURF	1.0×10^{-7} /1	1.0×10^{-7} /2
AQ01	10	0.3 /3
AQ02	5	0.2 /3
AQ03	2	0.1 /3

Note : /1 The top layer is assumed to be impervious in the analysis of confined aquifer.

/2 Coefficient of storage of layer 'AQxx' in confined aquifer

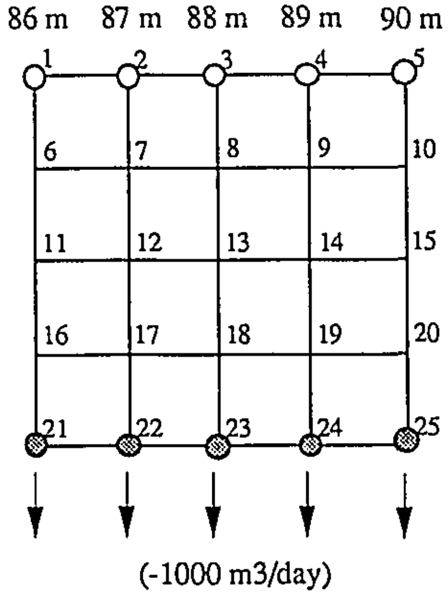
/3 Coefficient of storage of layer 'AQxx' in unconfined aquifer

(3) **Boundary condition**

Plane

○ Specified head boundary

● Specified flow boundary



Node	Specified Head (EL m)	Node	Specified Flow (m3/day)
1	86	21	-600
2	87	22	-600
3	88	23	-400
4	89	24	-200
5	90	25	-200

(4) **Initial condition**

Assumed initial condition : (Top of 'BASE') + 30 m

2. Data Input

(1) Editing the data file

1) **$ ED EXA3.DAT** [enter] (create the data file)
2) Input data for Example 3

```
SETTING,  CHEC,  100.
TITLE
  EXAMPLE 3  STEADY STATE ANALYSIS IN CONFINED AQUIFER SYSTEM
1ST    , 25 , 16 , 4 , 25 , 2
2ND    ,  4 , 0  , 0 ,  0 , 0
3RD    ,  0 , 0  , 0 ,  0 , 0 , 0
4TH    ,  0 , 0
*
*      --- MESH ---
*
NODE ,           1 ,     0 ,  5000
NODE ,           2 ,  1250 ,  5000
NODE ,           3 ,  2500 ,  5000
NODE ,           4 ,  3750 ,  5000
NODE ,           5 ,  5000 ,  5000
NODE ,           6 ,     0 ,  3750
NODE ,           7 ,  1250 ,  3750
NODE ,           8 ,  2500 ,  3750
NODE ,           9 ,  3750 ,  3750
NODE ,          10 ,  5000 ,  3750
NODE ,          11 ,     0 ,  2500
NODE ,          12 ,  1250 ,  2500
NODE ,          13 ,  2500 ,  2500
NODE ,          14 ,  3750 ,  2500
NODE ,          15 ,  5000 ,  2500
NODE ,          16 ,     0 ,  1250
NODE ,          17 ,  1250 ,  1250
NODE ,          18 ,  2500 ,  1250
NODE ,          19 ,  3750 ,  1250
NODE ,          20 ,  5000 ,  1250
NODE ,          21 ,     0 ,     0
NODE ,          22 ,  1250 ,     0
NODE ,          23 ,  2500 ,     0
NODE ,          24 ,  3750 ,     0
NODE ,          25 ,  5000 ,     0
ELEM ,      1 ,      6 ,      7 ,      2 ,      1
ELEM ,      2 ,      7 ,      8 ,      3 ,      2
ELEM ,      3 ,      8 ,      9 ,      4 ,      3
ELEM ,      4 ,      9 ,     10 ,      5 ,      4
ELEM ,      5 ,     11 ,     12 ,      7 ,      6
ELEM ,      6 ,     12 ,     13 ,      8 ,      7
ELEM ,      7 ,     13 ,     14 ,      9 ,      8
ELEM ,      8 ,     14 ,     15 ,     10 ,      9
ELEM ,      9 ,     16 ,     17 ,     12 ,     11
ELEM ,     10 ,     17 ,     18 ,     13 ,     12
ELEM ,     11 ,     18 ,     19 ,     14 ,     13
ELEM ,     12 ,     19 ,     20 ,     15 ,     14
ELEM ,     13 ,     21 ,     22 ,     17 ,     16
ELEM ,     14 ,     22 ,     23 ,     18 ,     17
ELEM ,     15 ,     23 ,     24 ,     19 ,     18
```

```
ELEM ,    16 ,     24 ,     25 ,     20 ,     19
MEND
*
*    --- UNIT ---
*
UNIT  , ME , DAY , 10 ,  0.01
*
*    --- BOUNDARY CONDITION ---
*
INIP  ,  1  ,  1  ,  1 ,    86
INIP  ,  2  ,  2  ,  1 ,    87
INIP  ,  3  ,  3  ,  1 ,    88
INIP  ,  4  ,  4  ,  1 ,    89
INIP  ,  5  ,  5  ,  1 ,    90
INIQ  , 21  , 21  ,  1 ,  -600
INIQ  , 22  , 22  ,  1 ,  -600
INIQ  , 23  , 23  ,  1 ,  -400
INIQ  , 24  , 24  ,  1 ,  -200
INIQ  , 25  , 25  ,  1 ,  -200
NCON  ,  1  ,  1  ,  1 ,   HF
NCON  ,  2  ,  2  ,  1 ,   HF
NCON  ,  3  ,  3  ,  1 ,   HF
NCON  ,  4  ,  4  ,  1 ,   HF
NCON  ,  5  ,  5  ,  1 ,   HF
NCON  , 21  , 21  ,  1 ,   QF
NCON  , 22  , 22  ,  1 ,   QF
NCON  , 23  , 23  ,  1 ,   QF
NCON  , 24  , 24  ,  1 ,   QF
NCON  , 25  , 25  ,  1 ,   QF
*
*    --- INITIAL CONDITION ---
*
INIP  ,  6 ,   6 ,   1 ,   66
INIP  ,  7 ,   7 ,   1 ,   68
INIP  ,  8 ,   8 ,   1 ,   70
INIP  ,  9 ,   9 ,   1 ,   74
INIP  , 10 ,  10 ,   1 ,   80
INIP  , 11 ,  11 ,   1 ,   54
INIP  , 12 ,  12 ,   1 ,   56
INIP  , 13 ,  13 ,   1 ,   58
INIP  , 14 ,  14 ,   1 ,   61
INIP  , 15 ,  15 ,   1 ,   68
INIP  , 16 ,  16 ,   1 ,   42
INIP  , 17 ,  17 ,   1 ,   45
INIP  , 18 ,  18 ,   1 ,   49
INIP  , 19 ,  19 ,   1 ,   54
INIP  , 20 ,  20 ,   1 ,   60
INIP  , 20 ,  20 ,   1 ,   35
INIP  , 22 ,  22 ,   1 ,   38
INIP  , 23 ,  23 ,   1 ,   41
INIP  , 24 ,  24 ,   1 ,   47
INIP  , 25 ,  25 ,   1 ,   51
*
*    --- STEADY STATE ---
*
CONT , STEADY
*
*    --- AQUIFER CONSTANTS ---
*
LAYE ,  4
AQ01 ,  10.0   , 0.3
AQ02 ,   5.0   , 0.2
AQ03 ,   2.0   , 0.1
```

```
SURF ,  1.0E-07, 1.0E-07
*
*     --- GEOLOGICAL DATA ---
*
GEOL , 1 ,  1 , 1 , 2
BASE ,  AQ03 ,  SURF
  44 ,     75 ,    85
GEOL , 2 ,  2 , 1 , 2
BASE ,  AQ03 ,  SURF
  48 ,     80 ,    88
GEOL , 3 ,  3 , 1 , 2
BASE ,  AQ02 ,  SURF
  53 ,     84 ,    91
GEOL , 4 ,  4 , 1 , 2
BASE ,  AQ01 ,  SURF
  56 ,     87 ,    93
GEOL , 5 ,  5 , 1 , 2
BASE ,  AQ01 ,  SURF
  60 ,     90 ,    95
GEOL , 6 ,  6 , 1 , 2
BASE ,  AQ03 ,  SURF
  36 ,     68 ,    78
GEOL , 7 ,  7 , 1 , 2
BASE ,  AQ02 ,  SURF
  38 ,     73 ,    78
GEOL , 8 ,  8 , 1 , 2
BASE ,  AQ01 ,  SURF
  40 ,     77 ,    80
GEOL , 9 ,  9 , 1 , 2
BASE ,  AQ02 ,  SURF
  44 ,     79 ,    82
GEOL ,10 , 10 , 1 , 2
BASE ,  AQ01 ,  SURF
  50 ,     81 ,    85
GEOL ,11 , 11 , 1 , 2
BASE ,  AQ01 ,  SURF
  24 ,     57 ,    68
GEOL ,12 , 12 , 1 , 2
BASE ,  AQ01 ,  SURF
  26 ,     60 ,    69
GEOL ,13 , 13 , 1 , 2
BASE ,  AQ01 ,  SURF
  28 ,     61 ,    71
GEOL ,14 , 14 , 1 , 2
BASE ,  AQ01 ,  SURF
  31 ,     63 ,    73
GEOL ,15 , 15 , 1 , 2
BASE ,  AQ02 ,  SURF
  38 ,     67 ,    74
GEOL ,16 , 16 , 1 , 2
BASE ,  AQ01 ,  SURF
  12 ,     46 ,    60
GEOL ,17 , 17 , 1 , 2
BASE ,  AQ01 ,  SURF
  15 ,     50 ,    62
GEOL ,18 , 18 , 1 , 2
BASE ,  AQ02 ,  SURF
  19 ,     52 ,    63
GEOL ,19 , 19 , 1 , 2
BASE ,  AQ02 ,  SURF
  24 ,     54 ,    65
GEOL ,20 , 20 , 1 , 2
BASE ,  AQ01 ,  SURF
```

```
  30 ,    57 ,    66
GEOL ,21 , 21 , 1 , 2
BASE ,  AQ01 ,  SURF
   5 ,    37 ,    55
GEOL ,22 , 22 , 1 , 2
BASE ,  AQ01 ,  SURF
   8 ,    39 ,    56
GEOL ,23 , 23 , 1 , 2
BASE ,  AQ02 ,  SURF
  11 ,    40 ,    58
GEOL ,24 , 24 , 1 , 2
BASE ,  AQ03 ,  SURF
  17 ,    44 ,    59
GEOL ,25 , 25 , 1 , 2
BASE ,  AQ03 ,  SURF
  21 ,    45 ,    61
*
ENDD
```

4) Press **PF4** function key

5) Command : **exit** [enter] (data to be saved) or
Command : **quit** [enter] (data not to be saved / data not to be changed)

3. Data Check and Calculation

(1) Data check

1) $ **UNISSF** [enter]

2) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **M** [enter] ('M' for UNISSF2)

3) RESTART ? (Y/N) **N** [enter]

4) FILE NAME(?.dat) **EXA3** [enter]

.
.
.
(checking the data)
.
.
.

FORTRAN STOP

UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter] ('E' for end)

5) $ **ED EXA3.PRN** [enter] (print output to be checked)

6) Press **PF4** function key (at the end of check)
7) Command : **QUIT** [enter]

(2) Calculation by UNISSF2

1) **$ ED EXA3.DAT** [enter]

   1st line of the data to be changed

```
SETTING, CHEC,  100
    |
    v
SETTING, RUN ,  100
          ^
          |
   (RUN + one blank)
```

2) Press **PF4** key (at the end of edit)
3) Command : **EXIT** [enter] (save the data)

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> **M** [enter] ('M' for UNISSF2)

6) RESTART ? (Y/N) **N** [enter]

7) FILE NAME(?.dat) **EXA3** [enter]

   .
   .
   .
   (calculating)
   .
   .
   .

   FORTRAN STOP

   UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> **E** [enter] ('E' for end)

8) **$ ED EXA3.PRN** [enter] (print output to be checked)

9) Press **PF4** function key (at the end of check)
10) Command : **QUIT** [enter]

4. Post Processing by UNISSF2/P

(1) Creation of the data file for plot control

1) **$ ED PLOT3.DAT** [enter]

2) Input data

```
START    1      TP
SUBTITLE
         EXAMPLE 3
NNUM     ON
ENUM     ON
DIVI     OFF
DOWN     OFF
MESH     OFF
MPLOT
FPRIN    ON
SCALE    A4
CONT     MANU
76, 78, 80, 82, 84, 86, 88, 90
PLOT     ALL
REWIND
END
```

3) Press **PF4** function key (at the end of edit)
4) Command : **EXIT** [enter] (save the data)

(2) Post processing

1) **$ UNISSF** [enter]

2) UNISSF2 <M>
UNISSF2/G <G>
UNISSF2/P <P>
DISPLAY <D>
XYPLOT <X>
END <E>

PLEASE ENTER ----> **P** [enter] ('P' for UNISSF2/P)

3) RESTART ? (Y/N) **N** [enter]

4) FILE NAME(?.dat) **PLOT3** [enter]
5) FILE NAME(FT10) **EXA3.FT10** [enter]
6) FILE NAME(FT11) **EXA3.FT11** [enter]

.
.
.
(processing)
.
.
.

FORTRAN STOP

UNISSF2 <M>
UNISSF2/G <G>

UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter] ('E' for end)

7) $ **ED PLOT3.PRN** [enter] (print output to be checked)

8) Press **PF4** function key (at the end of check)
9) Command : **QUIT** [enter]

5. Graphic and Plotting

(1) Graphic on TEKTRONIX terminal

1) Press **SET UP** key
2) * **CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) **$ UNISSF** [enter]

5)

UNISSF2	< M >
UNISSF2/G	< G >
UNISSF2/P	< P >
DISPLAY	< D >
XYPLOT	< X >
END	< E >

PLEASE ENTER ----> **D** [enter] ('D' for **DISPLAY**)

6) FILE NAME : **FOR040.DAT** [enter]

7) press **CLEAR** key

(graphic 1) (Press [enter] to show the next graphic)
(graphic 2) (Press 'E' for end of graphic)
.
.
.

8) At the end of graphic (no graphic on display), Press **CLEAR** key

9)

UNISSF2	< M >
UNISSF2/G	< G >
UNISSF2/P	< P >
DISPLAY	< D >
XYPLOT	< X >
END	< E >

PLEASE ENTER ----> **E** [enter] ('E' for end)

10) Press **SET UP** key
11) * **CODE ANSI** [enter]
12) Press **SET UP** key, and [enter]

(2) Plotting

1) Plotter set up
2) Paper set
3) Press '**On-line**' soft key
4) $ UNISSF [enter]
5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

   PLEASE ENTER ----> X [enter] ('X' for XYPLOT)

6) FILE NAME : **FOR040.DAT** [enter]

   .
   .
   .
   (plotting)
   .
   .
   .

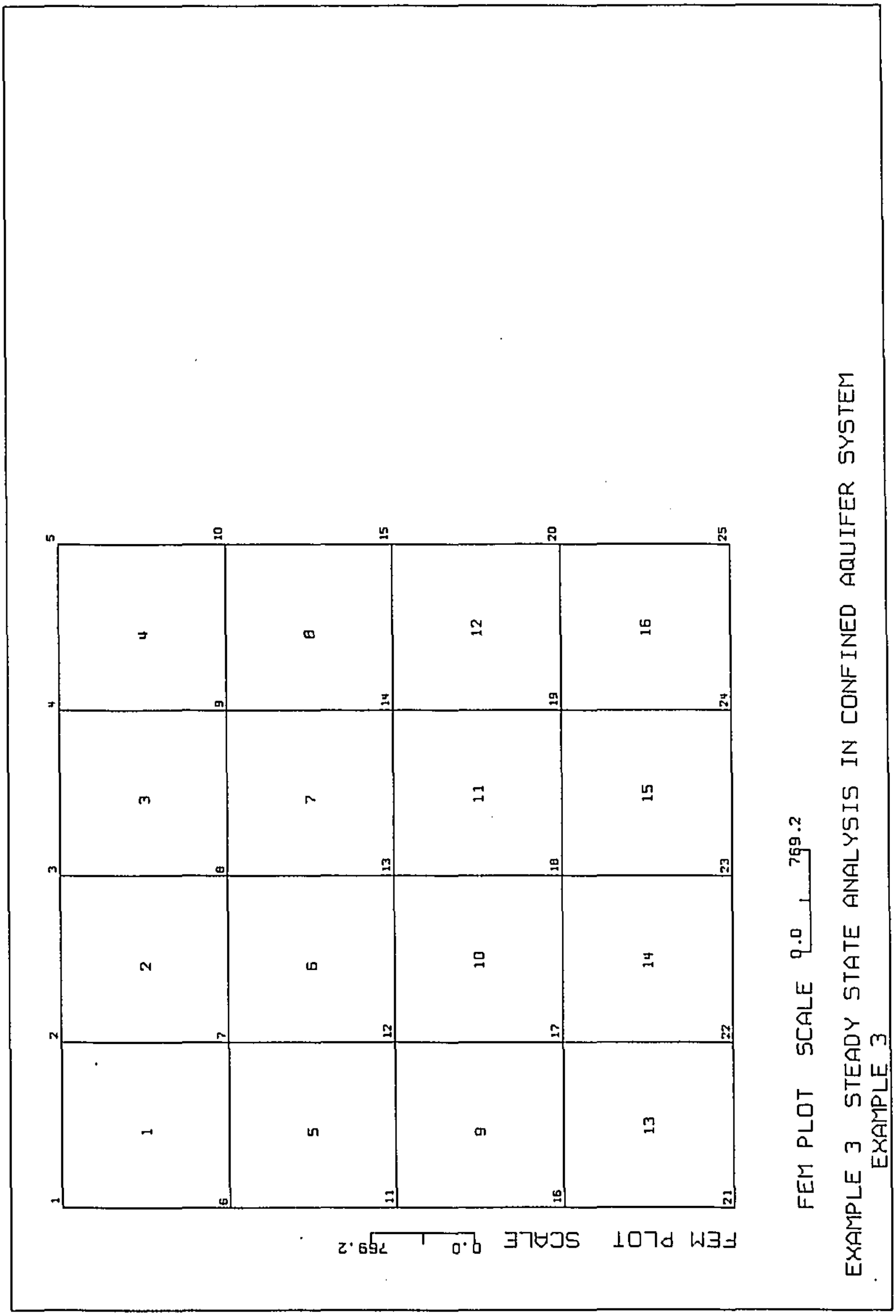
7) If there are more than 2 drawings, the plotting is stopped and the message '**HALT RECIEVED...**' is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press '**On-line**' soft key.
8) At the end of plotting, the message '**PLOT COMPLETE**' is shown in the plotter window.
9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

   PLEASE ENTER ----> E [enter]

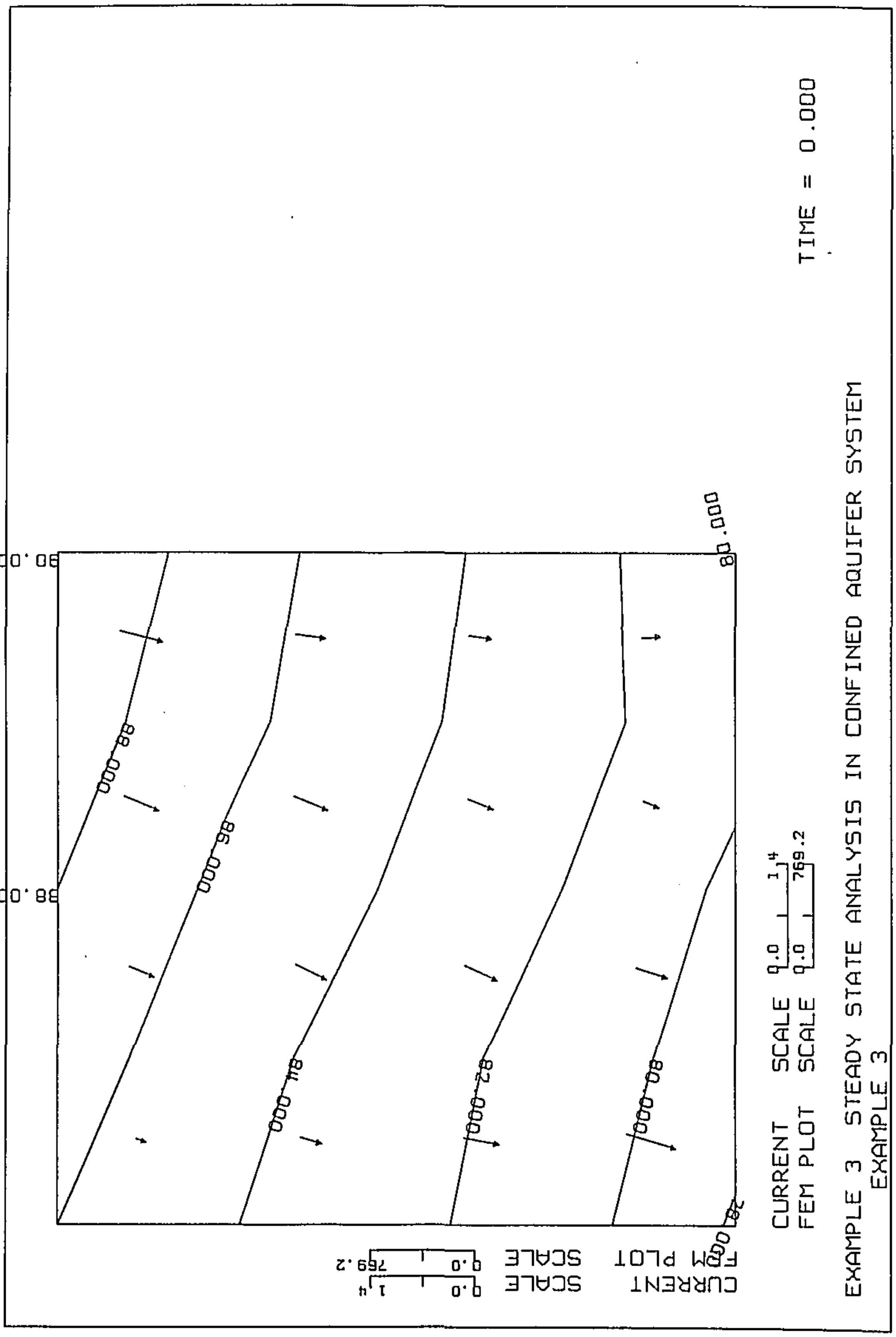
6. Output

(Plot output only)

Mesh



Piezometric Surface and Flow Vector

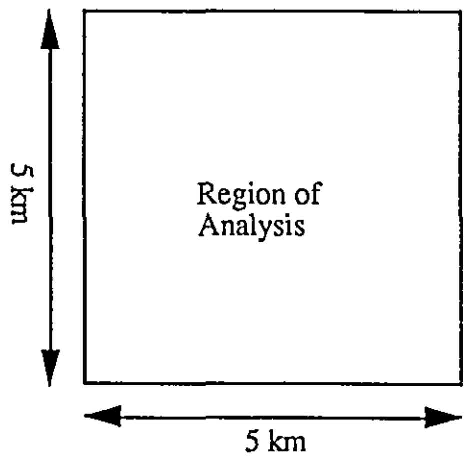


CHAPTER IV
Example 4 : Non-steady state analysis in confined aquifer

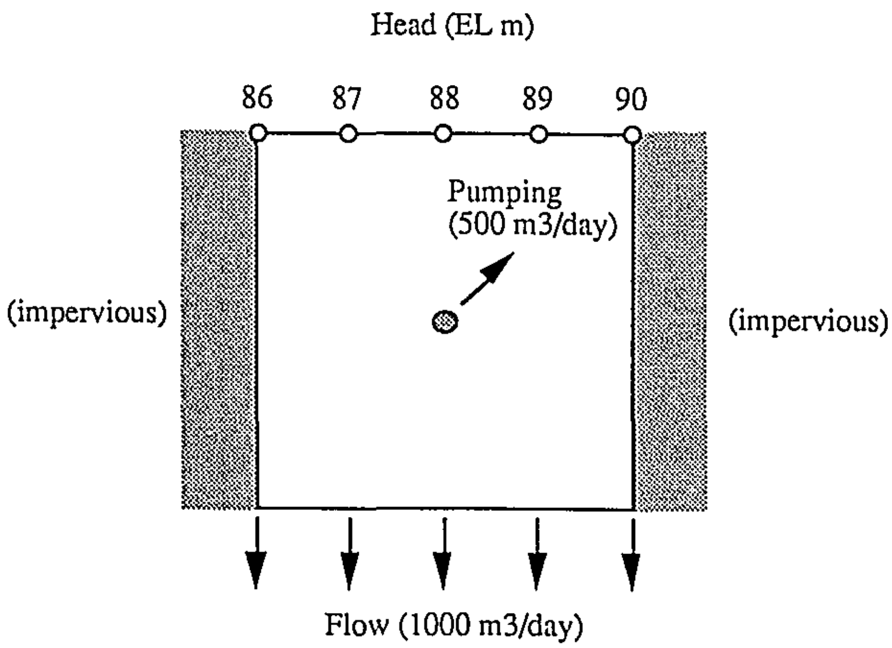
1. Data Preparation

Calculation of the piezometric head in the confined aquifer with 500 m^3/day of pumping starting from the steady state which is calculated at the EXAMPLE 3.

Plane



Boundary condition

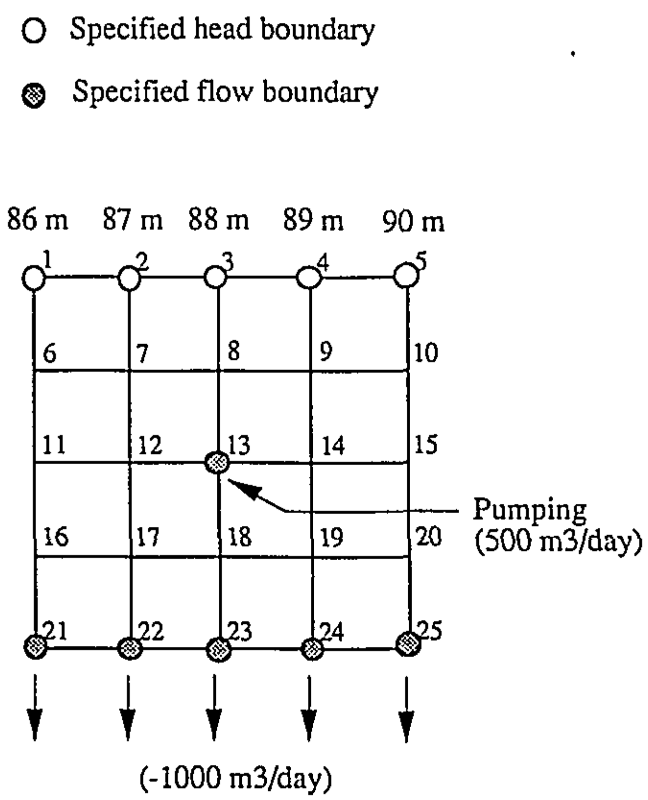


(1) **Mesh data**
Same as EXAMPLE 3

(2) **Geological data and aquifer constants**
Same as EXAMPLE 3

(3) **Boundary condition**

Plane



Node	Specified Head (EL m)	Node	Specified Flow (m3/day)
1	86	21	-600
2	87	22	-600
3	88	23	-400
4	89	24	-200
5	90	25	-200

Pumping : 500 m^3/day at node 13

(4) Initial condition

1) Initial condition for the steady state calculation (without pumping)
   Assumed initial condition : (Top of 'BASE') + 30 m

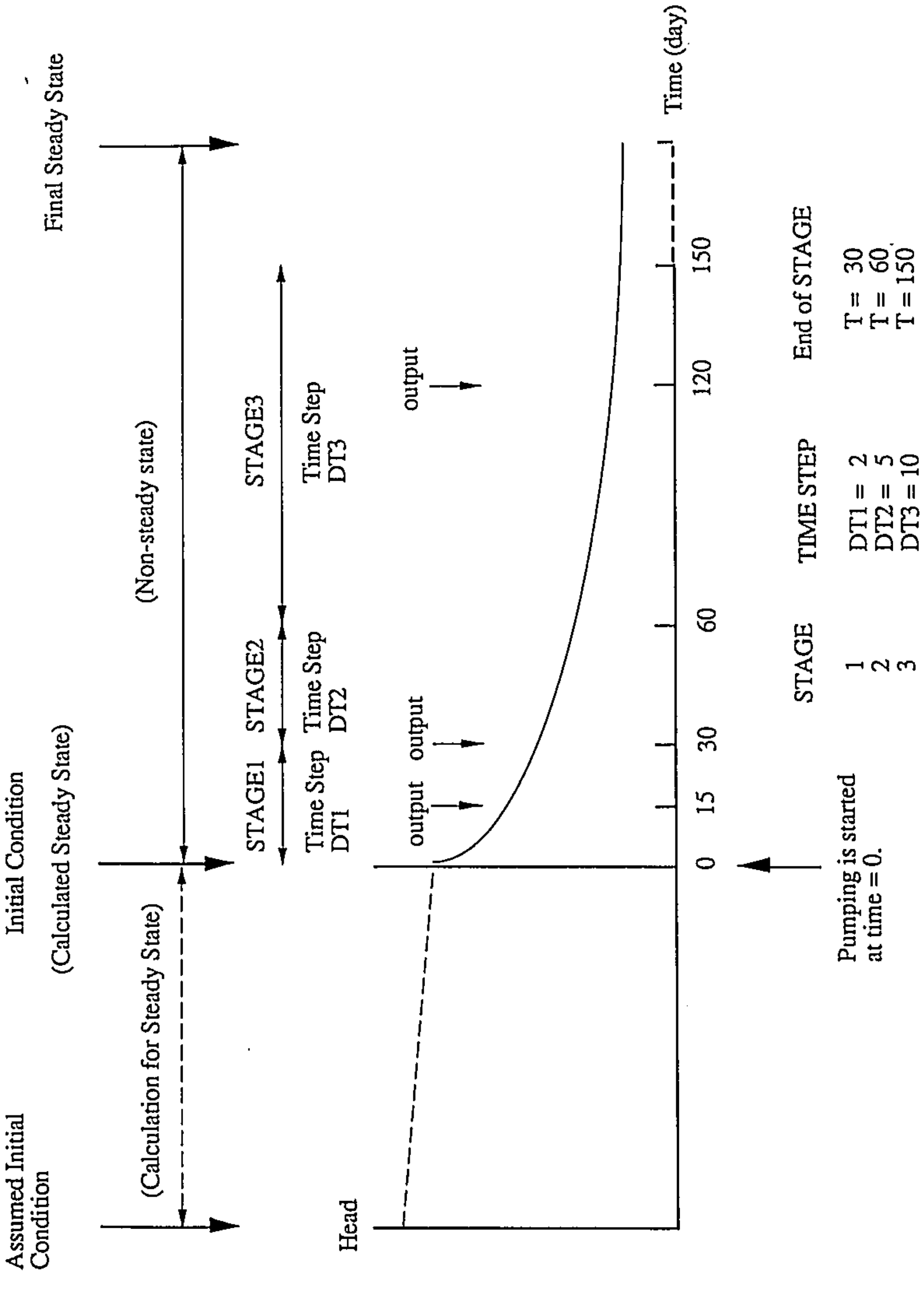
2) Initial condition for the non-steady state calculation (with pumping)
   Caluculated conditiion of steady state without pumping

(5) Time stage and step

FEM Calculation for non-steady analysis is proceeded by time-step, which is a short time length divided from the total calculation time. The time step is possible to give stage-wise. The time step DT1, DT2 and DT3 are given to the STAGE1,STAGE2 and STAGE3 respectively. In general, time step is needed to be short in the early stage and longer in the later stage to save the calculation time.

(6) Output time

Print and plot outputs are obtained by specifying the output time.


Assumed Initial Condition
(Calculation for Steady State)
Initial Condition
(Calculated Steady State)
(Non-steady state)
Final Steady State
STAGE1
Time Step DT1
STAGE2
Time Step DT2
STAGE3
Time Step DT3
output
output
output
Head
0
15
30
60
120
150
Time (day)
Pumping is started at time = 0.
STAGE
1
2
3
TIME STEP
DT1 = 2
DT2 = 5
DT3 = 10
End of STAGE
T = 30
T = 60
T = 150

2. Data Input

(1) Editing the data file

1) **$ ED EXA4.DAT** [enter] (create the data file)
2) Input data for Example 4

```
SETTING,  CHEC,  100.
TITLE
  EXAMPLE 4  NON-STEADY STATE ANALYSIS
1ST    , 25 , 16 , 4 , 25 , 2
2ND    ,  4 , 0  , 0 ,  0 , 0
3RD    ,  0 , 0  , 0 ,  0 , 0 , 0
4TH    ,  0 , 0
*
*      --- MESH ---
*
NODE ,            1 ,     0 ,  5000
NODE ,            2 ,  1250 ,  5000
NODE ,            3 ,  2500 ,  5000
NODE ,            4 ,  3750 ,  5000
NODE ,            5 ,  5000 ,  5000
NODE ,            6 ,     0 ,  3750
NODE ,            7 ,  1250 ,  3750
NODE ,            8 ,  2500 ,  3750
NODE ,            9 ,  3750 ,  3750
NODE ,           10 ,  5000 ,  3750
NODE ,           11 ,     0 ,  2500
NODE ,           12 ,  1250 ,  2500
NODE ,           13 ,  2500 ,  2500
NODE ,           14 ,  3750 ,  2500
NODE ,           15 ,  5000 ,  2500
NODE ,           16 ,     0 ,  1250
NODE ,           17 ,  1250 ,  1250
NODE ,           18 ,  2500 ,  1250
NODE ,           19 ,  3750 ,  1250
NODE ,           20 ,  5000 ,  1250
NODE ,           21 ,     0 ,     0
NODE ,           22 ,  1250 ,     0
NODE ,           23 ,  2500 ,     0
NODE ,           24 ,  3750 ,     0
NODE ,           25 ,  5000 ,     0
ELEM ,     1 ,     6 ,     7 ,     2 ,     1
ELEM ,     2 ,     7 ,     8 ,     3 ,     2
ELEM ,     3 ,     8 ,     9 ,     4 ,     3
ELEM ,     4 ,     9 ,    10 ,     5 ,     4
ELEM ,     5 ,    11 ,    12 ,     7 ,     6
ELEM ,     6 ,    12 ,    13 ,     8 ,     7
ELEM ,     7 ,    13 ,    14 ,     9 ,     8
ELEM ,     8 ,    14 ,    15 ,    10 ,     9
ELEM ,     9 ,    16 ,    17 ,    12 ,    11
ELEM ,    10 ,    17 ,    18 ,    13 ,    12
ELEM ,    11 ,    18 ,    19 ,    14 ,    13
ELEM ,    12 ,    19 ,    20 ,    15 ,    14
ELEM ,    13 ,    21 ,    22 ,    17 ,    16
ELEM ,    14 ,    22 ,    23 ,    18 ,    17
ELEM ,    15 ,    23 ,    24 ,    19 ,    18
ELEM ,    16 ,    24 ,    25 ,    20 ,    19
```

```
MEND
*
*    --- UNIT ---
*
UNIT  , ME , DAY , 10 ,  0.01
*
*    --- TIME STEP ---
TIME, 3
STEP, 1,  2,  30
STEP, 2,  5,  60
STEP, 3, 10, 150
*
*
*    --- BOUNDARY CONDITION ---
*
INIP  ,  1  ,  1  ,  1 ,    86
INIP  ,  2  ,  2  ,  1 ,    87
INIP  ,  3  ,  3  ,  1 ,    88
INIP  ,  4  ,  4  ,  1 ,    89
INIP  ,  5  ,  5  ,  1 ,    90
INIQ  , 21  , 21  ,  1 ,  -600
INIQ  , 22  , 22  ,  1 ,  -600
INIQ  , 23  , 23  ,  1 ,  -400
INIQ  , 24  , 24  ,  1 ,  -200
INIQ  , 25  , 25  ,  1 ,  -200
NCON  ,  1  ,  1  ,  1 ,    HF
NCON  ,  2  ,  2  ,  1 ,    HF
NCON  ,  3  ,  3  ,  1 ,    HF
NCON  ,  4  ,  4  ,  1 ,    HF
NCON  ,  5  ,  5  ,  1 ,    HF
NCON  , 21  , 21  ,  1 ,    QF
NCON  , 22  , 22  ,  1 ,    QF
NCON  , 23  , 23  ,  1 ,    QF
NCON  , 24  , 24  ,  1 ,    QF
NCON  , 25  , 25  ,  1 ,    QF
*
*    --- INITIAL CONDITION ---
*
INIP  ,  6 ,   6 ,   1 ,   66
INIP  ,  7 ,   7 ,   1 ,   68
INIP  ,  8 ,   8 ,   1 ,   70
INIP  ,  9 ,   9 ,   1 ,   74
INIP  , 10 ,  10 ,   1 ,   80
INIP  , 11 ,  11 ,   1 ,   54
INIP  , 12 ,  12 ,   1 ,   56
INIP  , 13 ,  13 ,   1 ,   58
INIP  , 14 ,  14 ,   1 ,   61
INIP  , 15 ,  15 ,   1 ,   68
INIP  , 16 ,  16 ,   1 ,   42
INIP  , 17 ,  17 ,   1 ,   45
INIP  , 18 ,  18 ,   1 ,   49
INIP  , 19 ,  19 ,   1 ,   54
INIP  , 20 ,  20 ,   1 ,   60
INIP  , 20 ,  20 ,   1 ,   35
INIP  , 22 ,  22 ,   1 ,   38
INIP  , 23 ,  23 ,   1 ,   41
INIP  , 24 ,  24 ,   1 ,   47
INIP  , 25 ,  25 ,   1 ,   51
*
*    --- STEADY STATE -> NON-STEADY STEATE ---
*
CONT , STUN
*
```

```
*    --- AQUIFER CONSTANTS ---
*
LAYE ,  4
AQ01 ,  10.0   , 0.3
AQ02 ,   5.0   , 0.2
AQ03 ,   2.0   , 0.1
SURF ,  1.0E-07, 1.0E-07
*
*     --- GEOLOGICAL DATA ---
*
GEOL , 1 ,  1 , 1 , 2
BASE ,  AQ03 ,  SURF
  44 ,    75 ,    85
GEOL , 2 ,  2 , 1 , 2
BASE ,  AQ03 ,  SURF
  48 ,    80 ,    88
GEOL , 3 ,  3 , 1 , 2
BASE ,  AQ02 ,  SURF
  53 ,    84 ,    91
GEOL , 4 ,  4 , 1 , 2
BASE ,  AQ01 ,  SURF
  56 ,    87 ,    93
GEOL , 5 ,  5 , 1 , 2
BASE ,  AQ01 ,  SURF
  60 ,    90 ,    95
GEOL , 6 ,  6 , 1 , 2
BASE ,  AQ03 ,  SURF
  36 ,    68 ,    78
GEOL , 7 ,  7 , 1 , 2
BASE ,  AQ02 ,  SURF
  38 ,    73 ,    78
GEOL , 8 ,  8 , 1 , 2
BASE ,  AQ01 ,  SURF
  40 ,    77 ,    80
GEOL , 9 ,  9 , 1 , 2
BASE ,  AQ02 ,  SURF
  44 ,    79 ,    82
GEOL ,10 , 10 , 1 , 2
BASE ,  AQ01 ,  SURF
  50 ,    81 ,    85
GEOL ,11 , 11 , 1 , 2
BASE ,  AQ01 ,  SURF
  24 ,    57 ,    68
GEOL ,12 , 12 , 1 , 2
BASE ,  AQ01 ,  SURF
  26 ,    60 ,    69
GEOL ,13 , 13 , 1 , 2
BASE ,  AQ01 ,  SURF
  28 ,    61 ,    71
GEOL ,14 , 14 , 1 , 2
BASE ,  AQ01 ,  SURF
  31 ,    63 ,    73
GEOL ,15 , 15 , 1 , 2
BASE ,  AQ02 ,  SURF
  38 ,    67 ,    74
GEOL ,16 , 16 , 1 , 2
BASE ,  AQ01 ,  SURF
  12 ,    46 ,    60
GEOL ,17 , 17 , 1 , 2
BASE ,  AQ01 ,  SURF
  15 ,    50 ,    62
GEOL ,18 , 18 , 1 , 2
BASE ,  AQ02 ,  SURF
```

```
  19 ,    52 ,    63
GEOL ,19 , 19 , 1 , 2
BASE ,  AQ02 ,  SURF
  24 ,    54 ,    65
GEOL ,20 , 20 , 1 , 2
BASE ,  AQ01 ,  SURF
  30 ,    57 ,    66
GEOL ,21 , 21 , 1 , 2
BASE ,  AQ01 ,  SURF
   5 ,    37 ,    55
GEOL ,22 , 22 , 1 , 2
BASE ,  AQ01 ,  SURF
   8 ,    39 ,    56
GEOL ,23 , 23 , 1 , 2
BASE ,  AQ02 ,  SURF
  11 ,    40 ,    58
GEOL ,24 , 24 , 1 , 2
BASE ,  AQ03 ,  SURF
  17 ,    44 ,    59
GEOL ,25 , 25 , 1 , 2
BASE ,  AQ03 ,  SURF
  21 ,    45 ,    61
*
*
PRTIME, 15, 30, 120
PLTIME, 15, 30, 120
*
*
NBTIME, 0
ENDD
NEWB  ,  1,    0
13, QF,  0,  SS,  0.0,  CG,  -500
```

Pumping at node 13
starting at time = 0

3. Data Check and Calculation

(1) Data check

1) **$ UNISSF** [enter]

2)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
END         < E >
```

PLEASE ENTER ----> **M** [enter] ('M' for UNISSF2)

3) RESTART ? (Y/N) **N** [enter]

4) FILE NAME(?.dat) **EXA4** [enter]

.
.
.
(checking the data)
.
.
.

FORTRAN STOP

```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
END         < E >
```

PLEASE ENTER ----> **E** [enter] ('E' for end)

5) **$ ED EXA4.PRN** [enter] (print output to be checked)

6) Press **PF4** function key (at the end of check)

7) Command : **QUIT** [enter]

(2) Calculation by UNISSF2

1) **$ ED EXA4.DAT** [enter]

   1st line of the data to be changed

```
SETTING, CHEC,  100
     |
     v
SETTING, RUN ,  100
          ^
          |
```

   (RUN + one blank)

2) Press **PF4** key (at the end of edit)
3) Command : **EXIT** [enter] (save the data)

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> **M** [enter] ('M' for UNISSF2)

6) RESTART ? (Y/N) **N** [enter]

7) FILE NAME(?.dat) **EXA4** [enter]

   .
   .
   .
   (calculating)
   .
   .
   .

   FORTRAN STOP

   UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> **E** [enter] ('E' for end)

8) **$ ED EXA4.PRN** [enter] (print output to be checked)

9) Press **PF4** function key (at the end of check)
10) Command : **QUIT** [enter]

4. Post Processing by UNISSF2/P (contour map of piezometric surface)

(1) Creation of the data file for plot control

1) **$ ED CONT4.DAT** [enter]

2) Input data

```
START    1      TP
SUBTITLE
          EXAMPLE 4
NNUM      ON
ENUM      ON
DIVI      OFF
DOWN      OFF
MESH      OFF
MPLOT
FPRIN     ON
SCALE     A4
CONT      MANU
76, 78, 80, 82, 84, 86, 88, 90
PLOT      ALL
REWIND
END
```

3) Press **PF4** function key (at the end of edit)
4) Command : **EXIT** [enter] (save the data)

(2) Post processing

1) **$ UNISSF** [enter]

2)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
END         < E >
```

PLEASE ENTER ----> **P** [enter] ('P' for UNISSF2/P)

3) RESTART ? (Y/N) **N** [enter]

4) FILE NAME(?.dat) **CONT4** [enter]
5) FILE NAME(FT10) **EXA4.FT10** [enter]
6) FILE NAME(FT11) **EXA4.FT11** [enter]

.
.
.
(processing)
.
.
.

FORTRAN STOP

UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter] ('E' for end)

7) $ **ED CONT4.PRN** [enter] (print output to be checked)

8) *Press* **PF4** *function key* (at the end of check)
9) Command : **QUIT** [enter]

5. Post Processing by UNISSF2/P (contour map of drawdown)

(1) Creation of the data file for plot control

1) **$ ED DOWN4.DAT** [enter]

2) Input data

```
START    1       TP
SUBTITLE
         EXAMPLE 4  (DRAWDOWN)
NNUM     ON
ENUM     ON
DIVI     ON
DOWN     ON
MESH     OFF
FPRIN    ON
SCALE    A4
CONT     MANU
-0.5, -1.0, -1.5, -2.0, -2.5
-3.0, -3.5, -4.0, -4.5, -5.0
PLOT     ALL
REWIND
END
```

3) Press **PF4** function key (at the end of edit)
4) Command : **EXIT** [enter] (save the data)

(2) Post processing

1) **$ UNISSF** [enter]

2)
```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

PLEASE ENTER ----> **P** [enter] ('P' for UNISSF2/P)

3) RESTART ? (Y/N) **N** [enter]

4) FILE NAME(?.dat) **DOWN4** [enter]
5) FILE NAME(FT10) **EXA4.FT10** [enter]
6) FILE NAME(FT11) **EXA4.FT11** [enter]

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.
.
(processing)
.
.
.

FORTRAN STOP

UNISSF2	< M >
UNISSF2/G	< G >
UNISSF2/P	< P >
DISPLAY	< D >
XYPLOT	< X >
END	< E >

PLEASE ENTER ----> **E** [enter] ('E' for end)

7) **$ ED DOWN4.PRN** [enter] (print output to be checked)

8) Press **PF4** *function key* (*at the end of check*)
9) Command : **QUIT** [enter]

6. Graphic and Plotting

(1) Graphic on TEKTRONIX terminal

1) Press **SET UP** key
2) *** CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **D** [enter] ('D' for **DISPLAY**)

6) FILE NAME : **FOR040.DAT** [enter]

7) press **CLEAR** key

(graphic 1) (Press [enter] to show the next graphic)
(graphic 2) (Press 'E' for end of graphic)
.
.
.

8) At the end of graphic (no graphic on display), Press **CLEAR** key

9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter] ('E' for end)

10) Press **SET UP** key
11) *** CODE ANSI** [enter]
12) Press **SET UP** key, and [enter]

(2) Plotting

1) Plotter set up
2) Paper set
3) Press **'On-line'** soft key

4) $ **UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **X** [enter] ('X' for **XYPLOT**)

6) FILE NAME : **FOR040.DAT** [enter]

.
.
.

(plotting)

.
.
.

7) If there are more than 2 drawings, the plotting is stopped and the message **'HALT RECIEVED...'** is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press **'On-line'** soft key.

8) At the end of plotting, the message **'PLOT COMPLETE'** is shown in the plotter window.

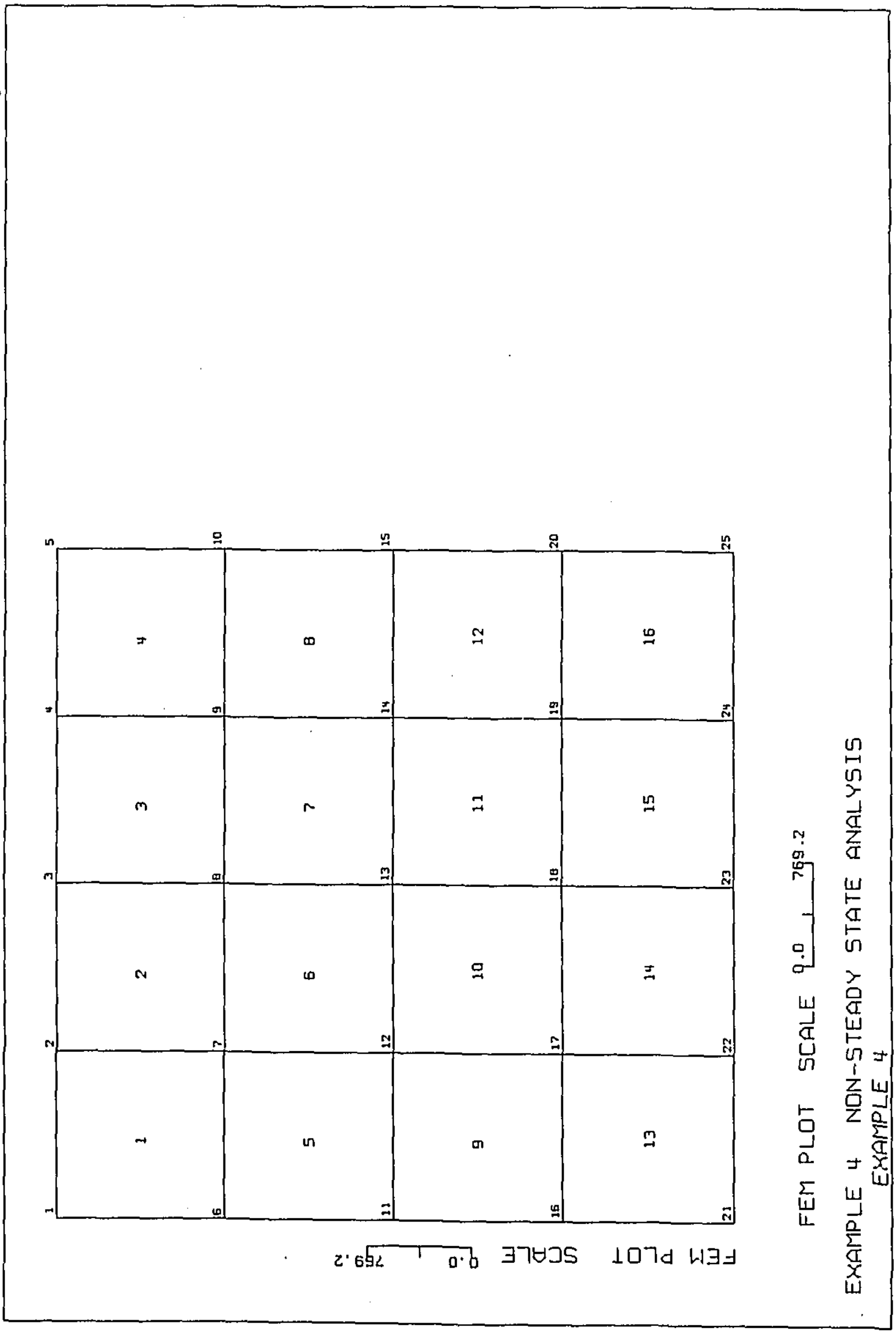
9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter]

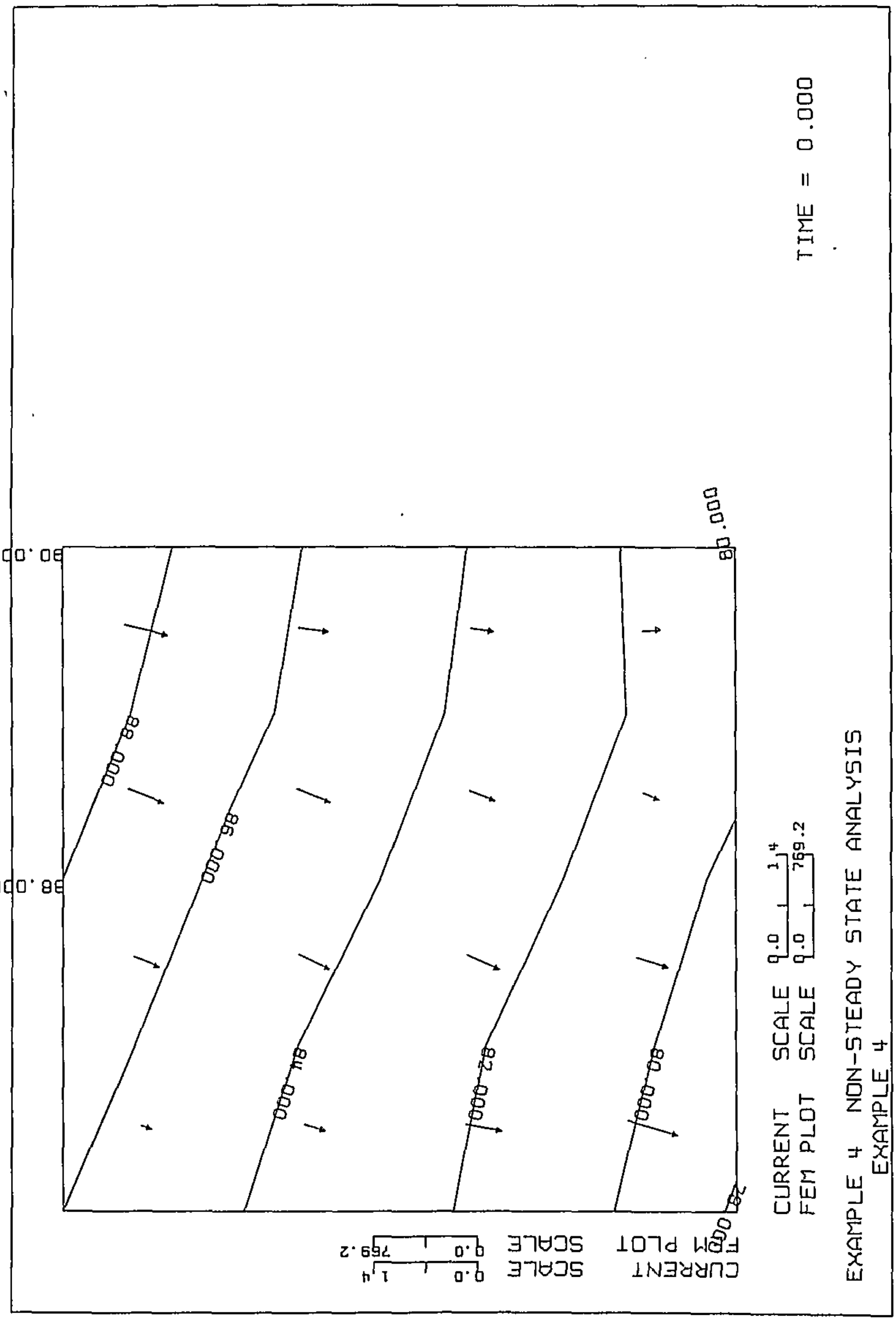
6. Output

(Plot output only)

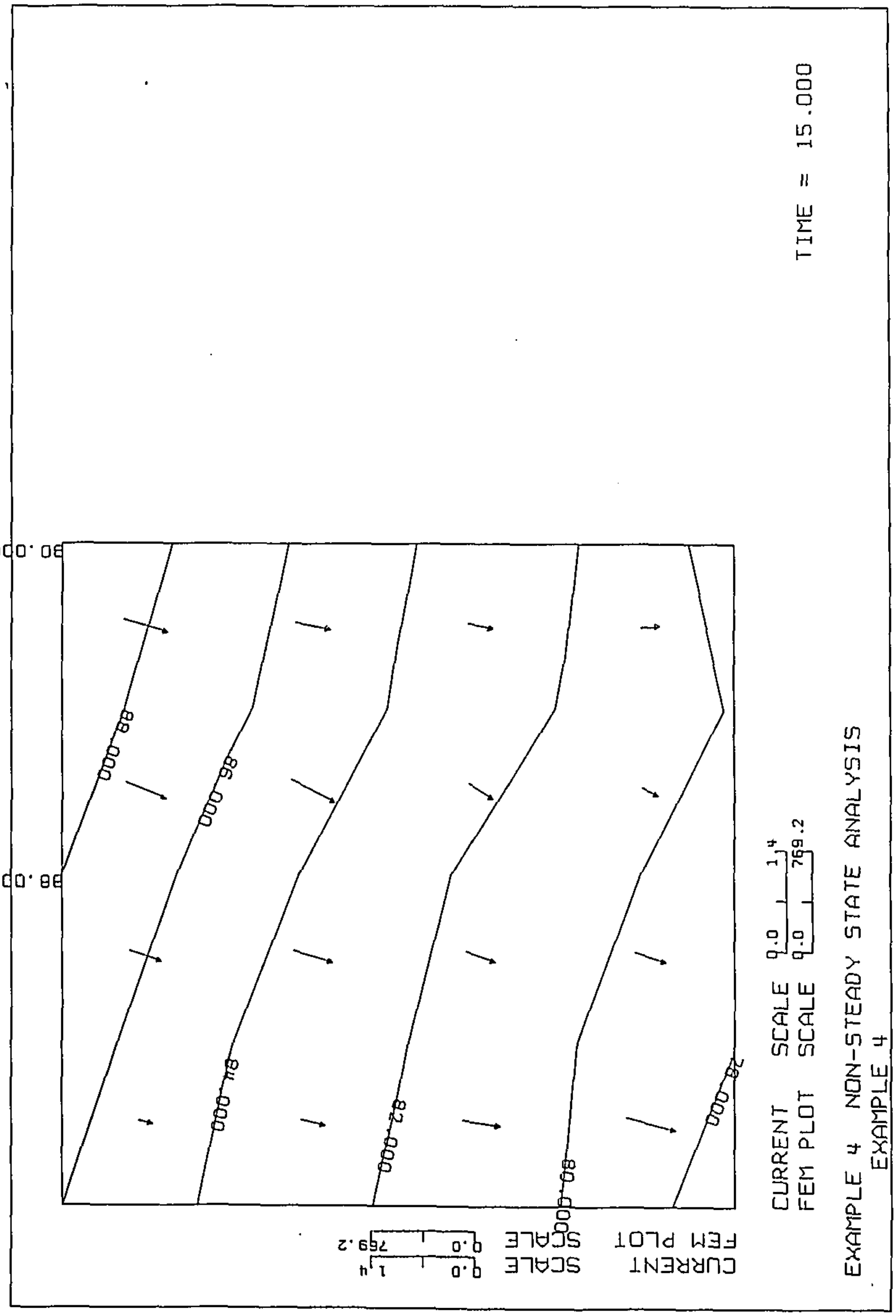
Mesh



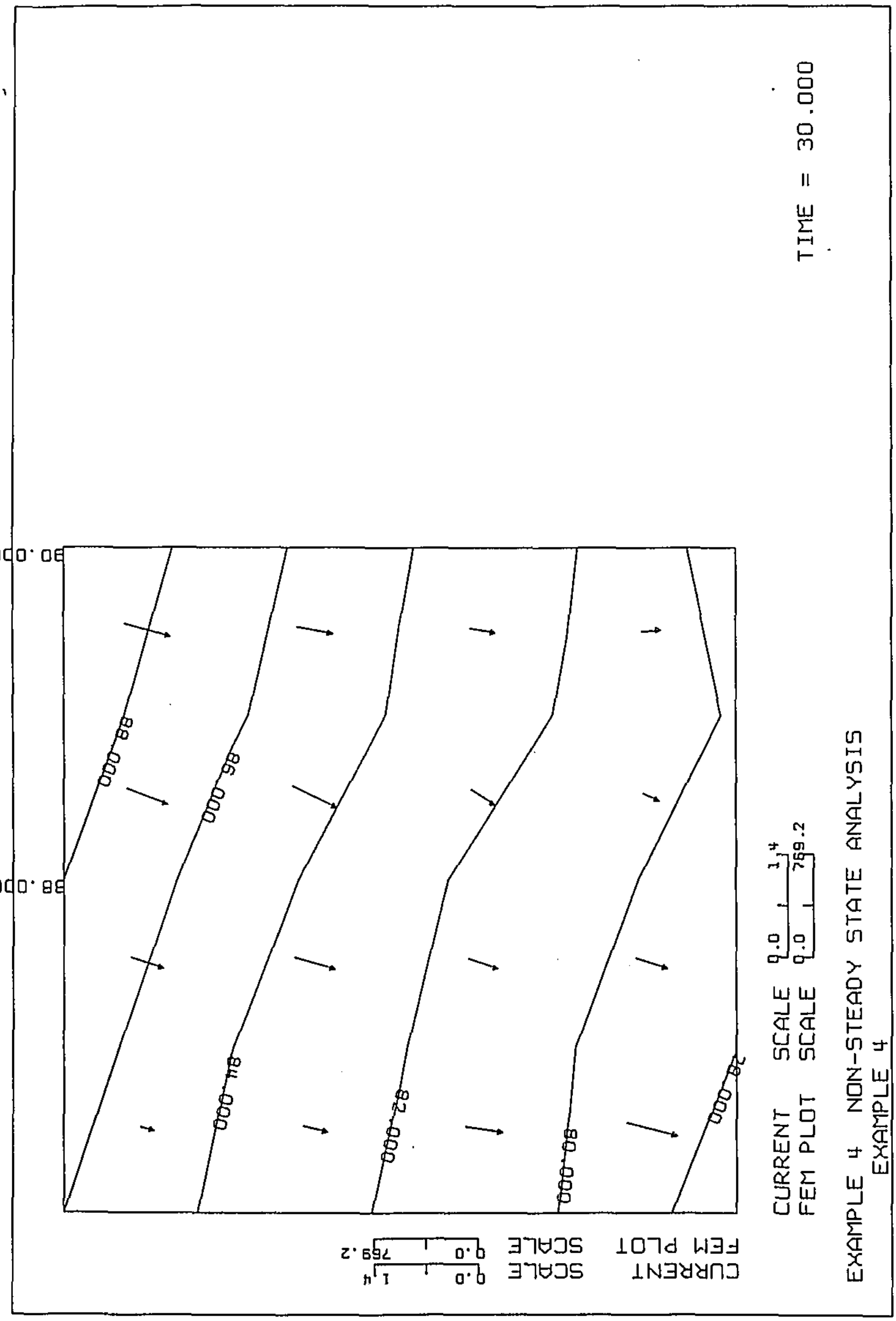
Piezometric Surface and Flow Vector



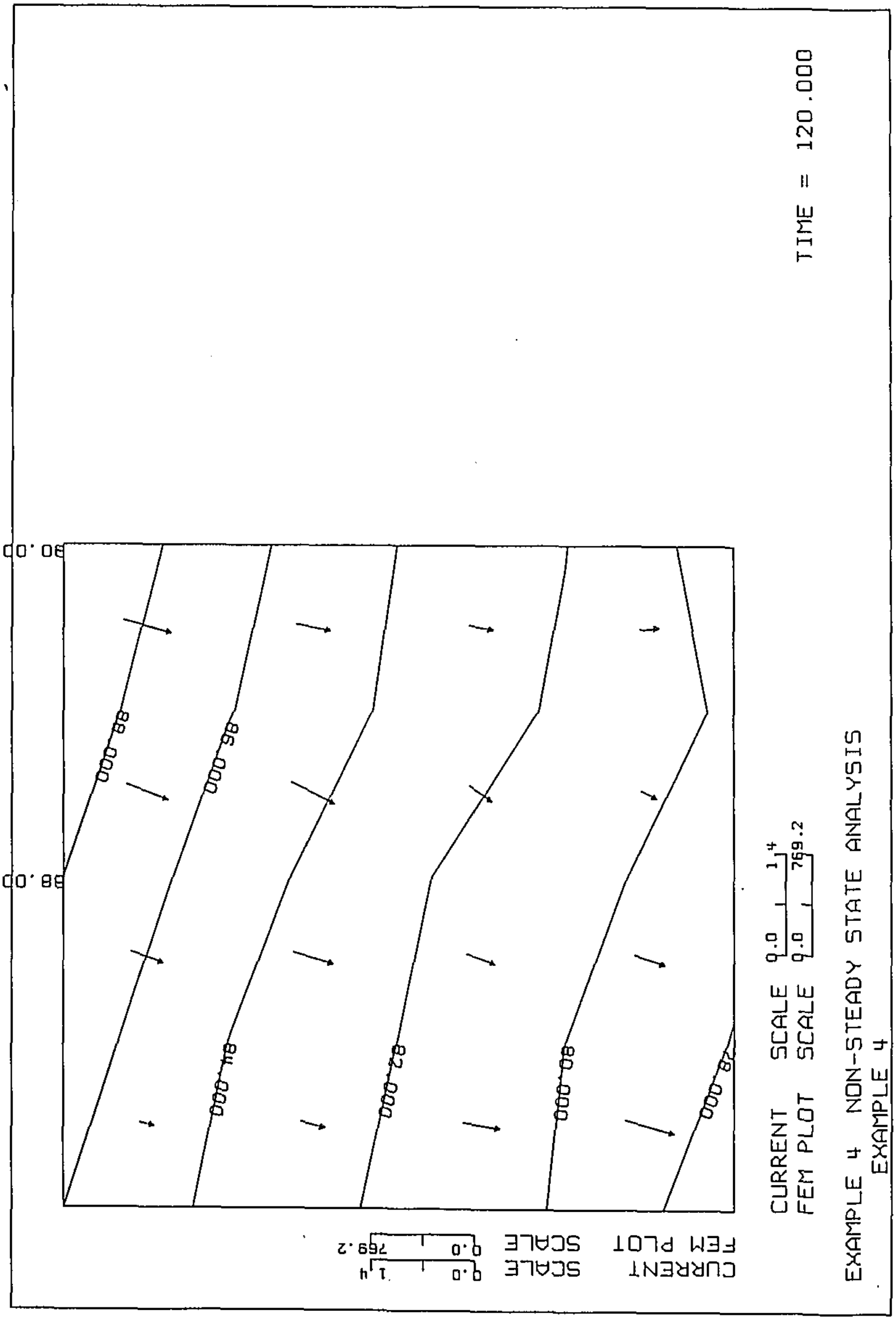
Piezometric Surface and Flow Vector



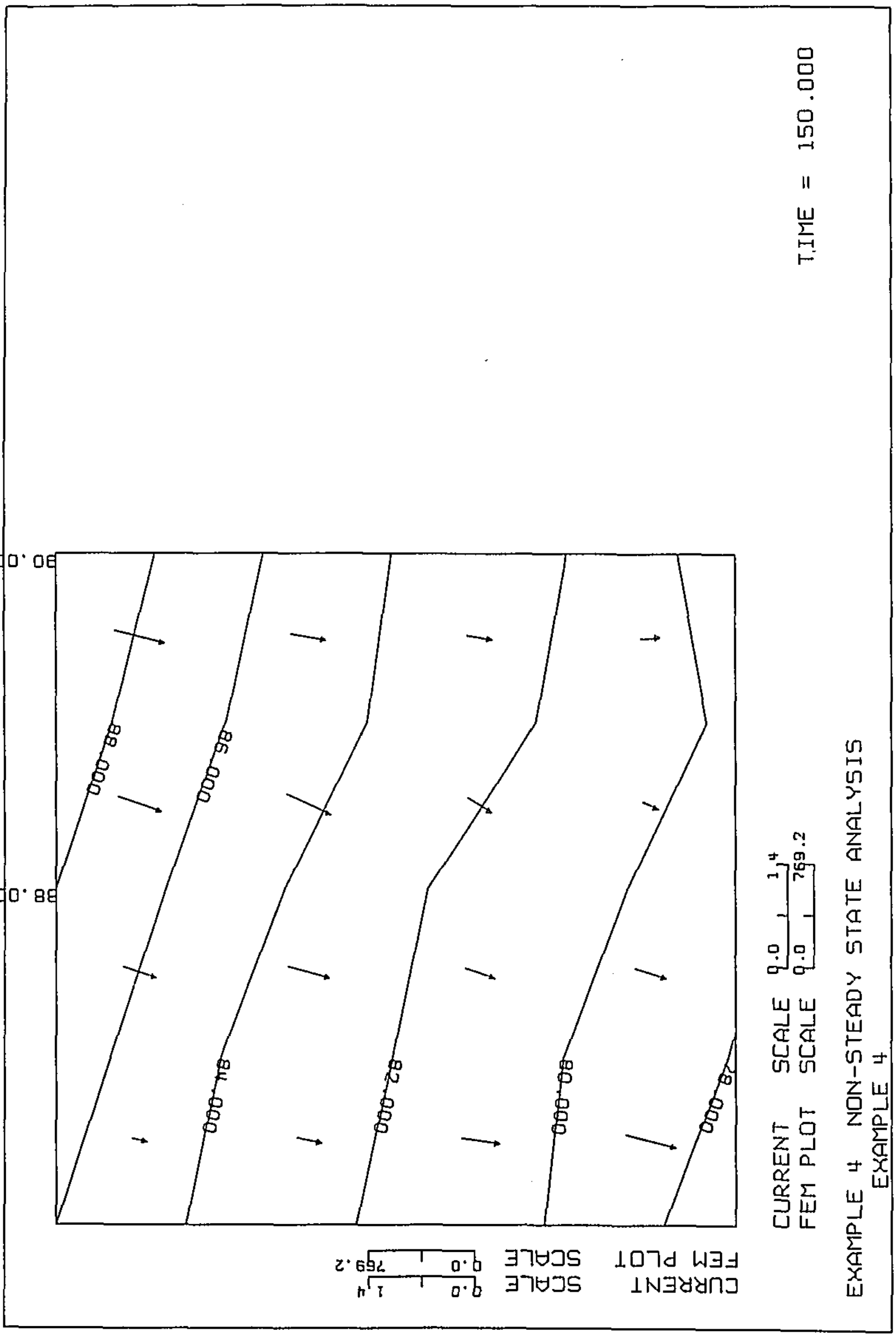
Piezometric Surface and Flow Vector



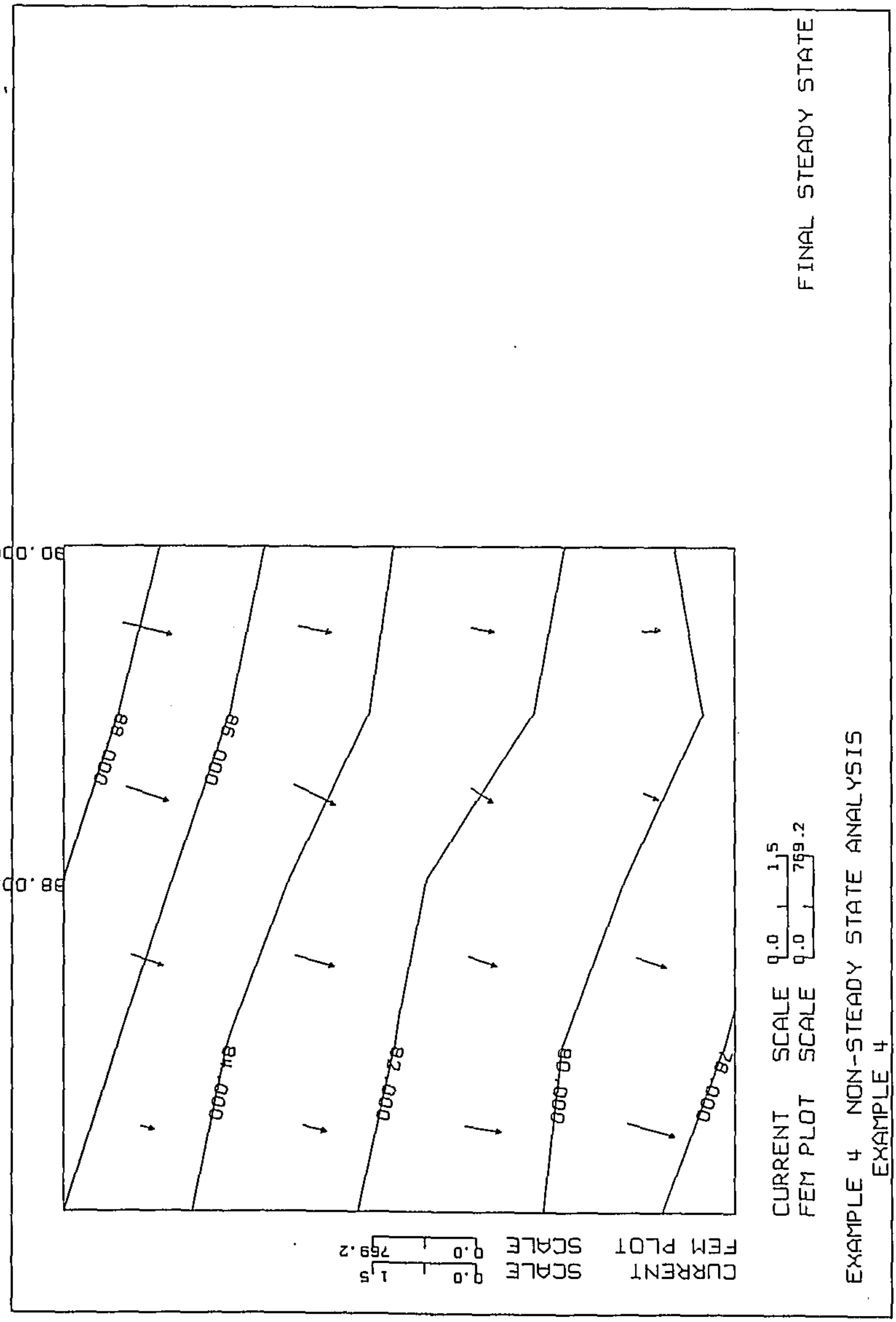
Piezometric Surface and Flow Vector



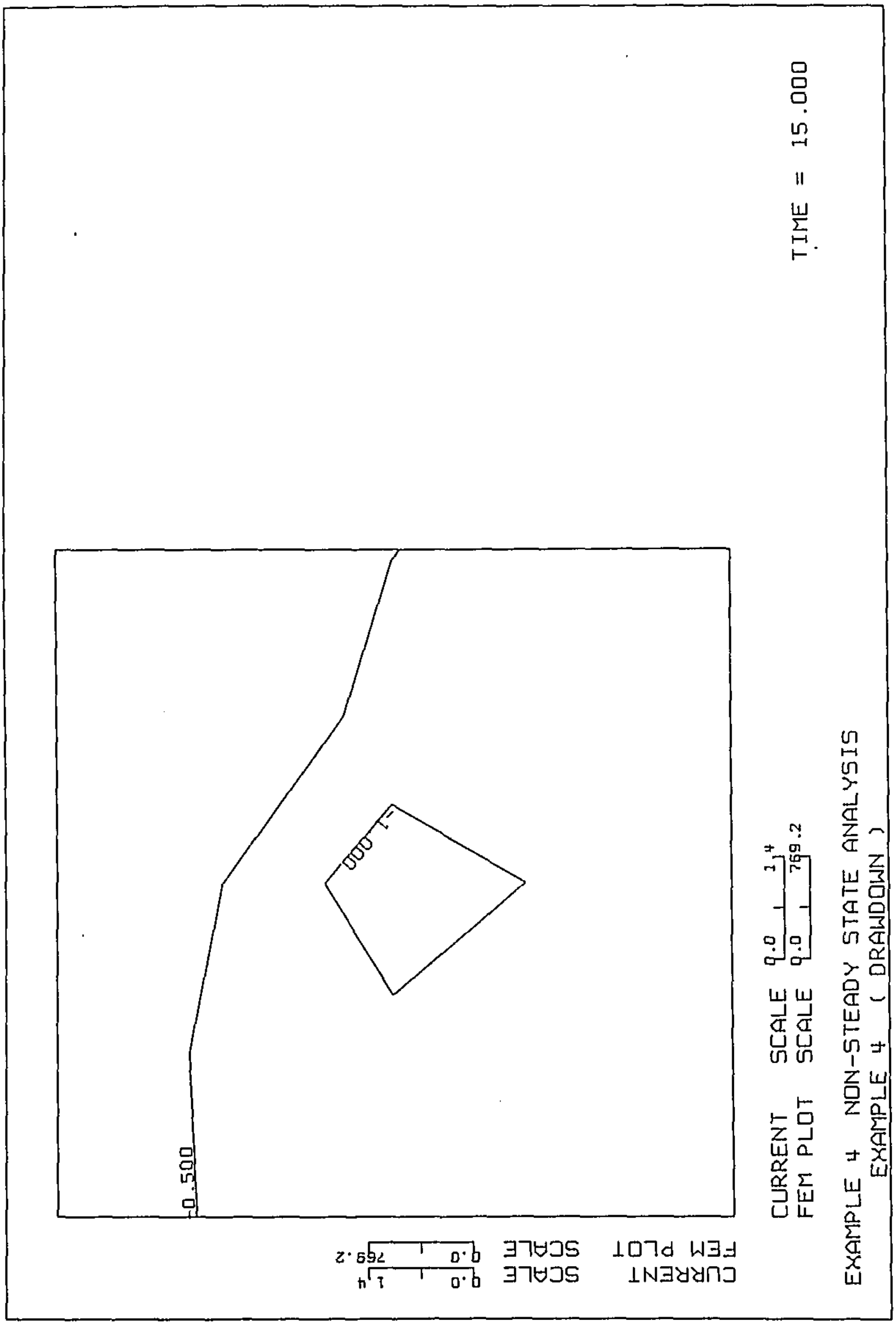
Piezometric Surface and Flow Vector



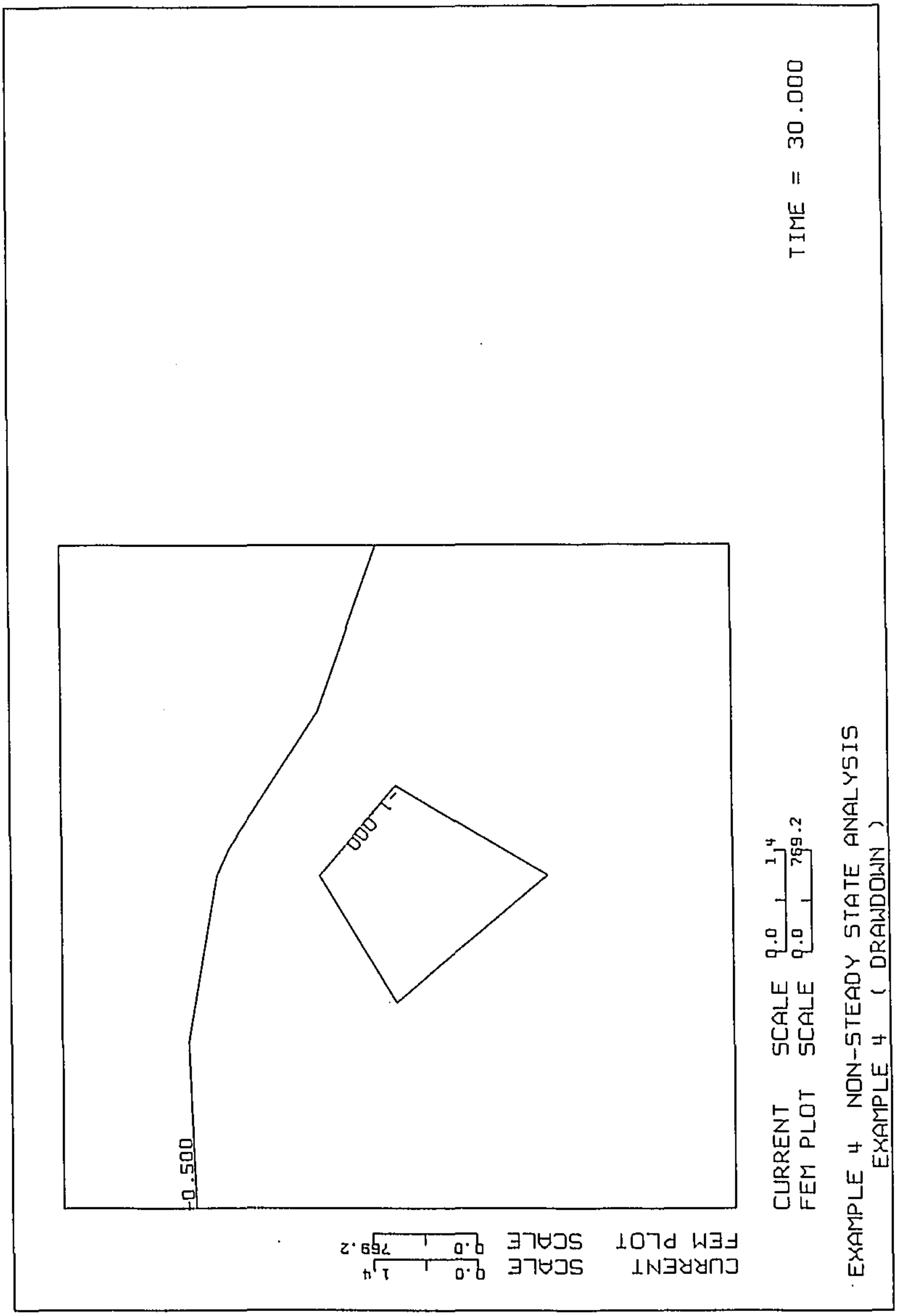
Piezometric Surface and Flow Vector



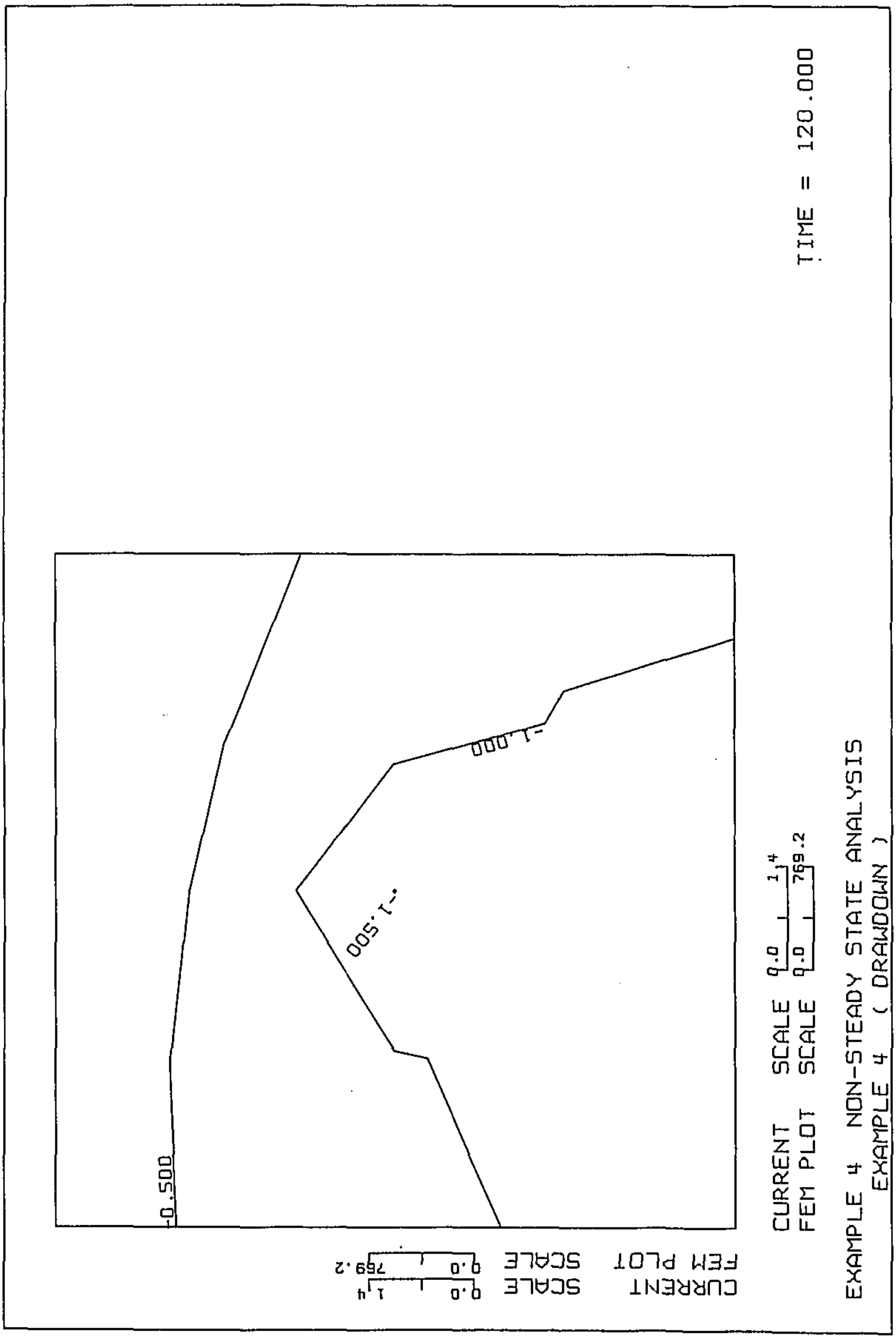
Drawdown Map



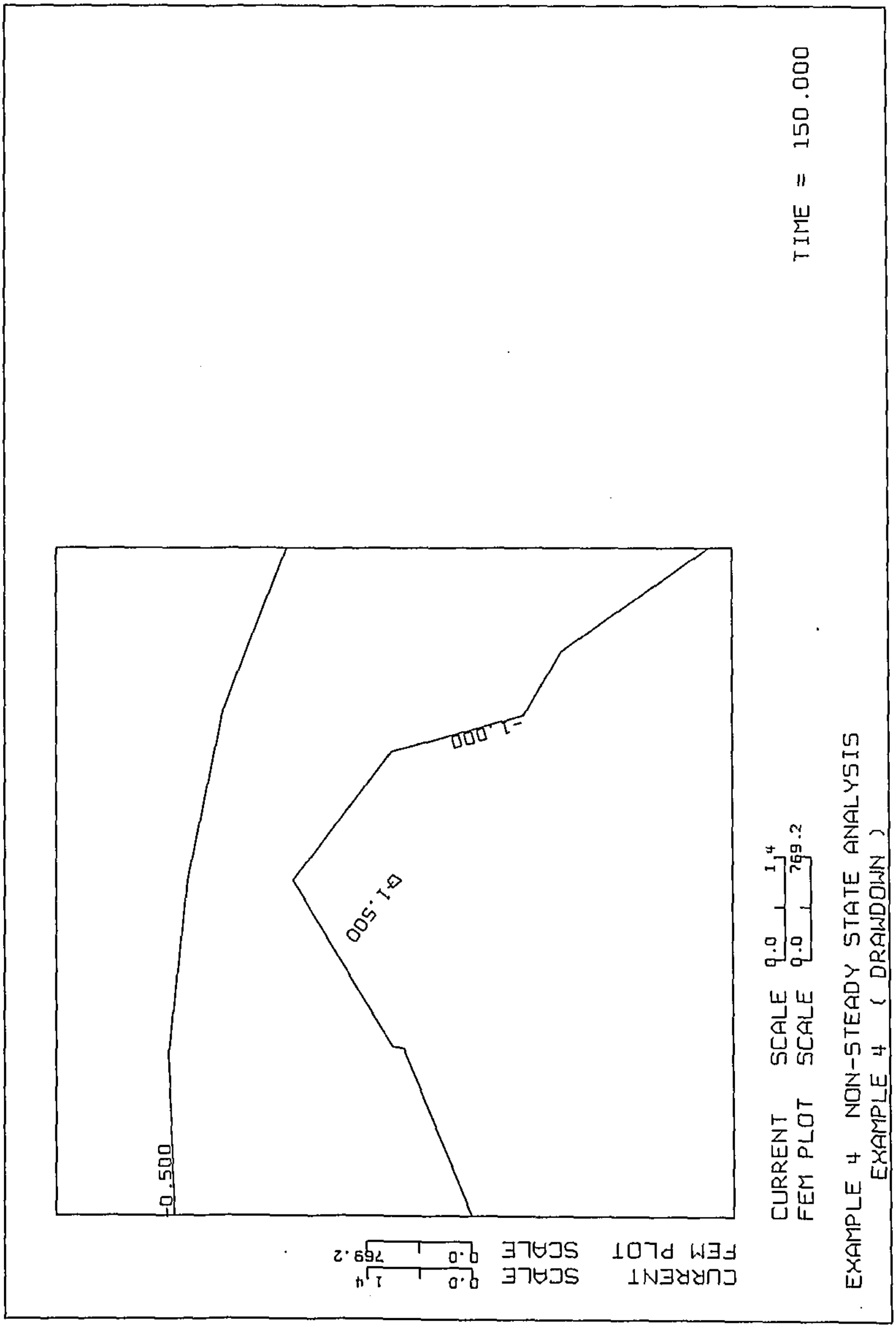
Drawdown Map



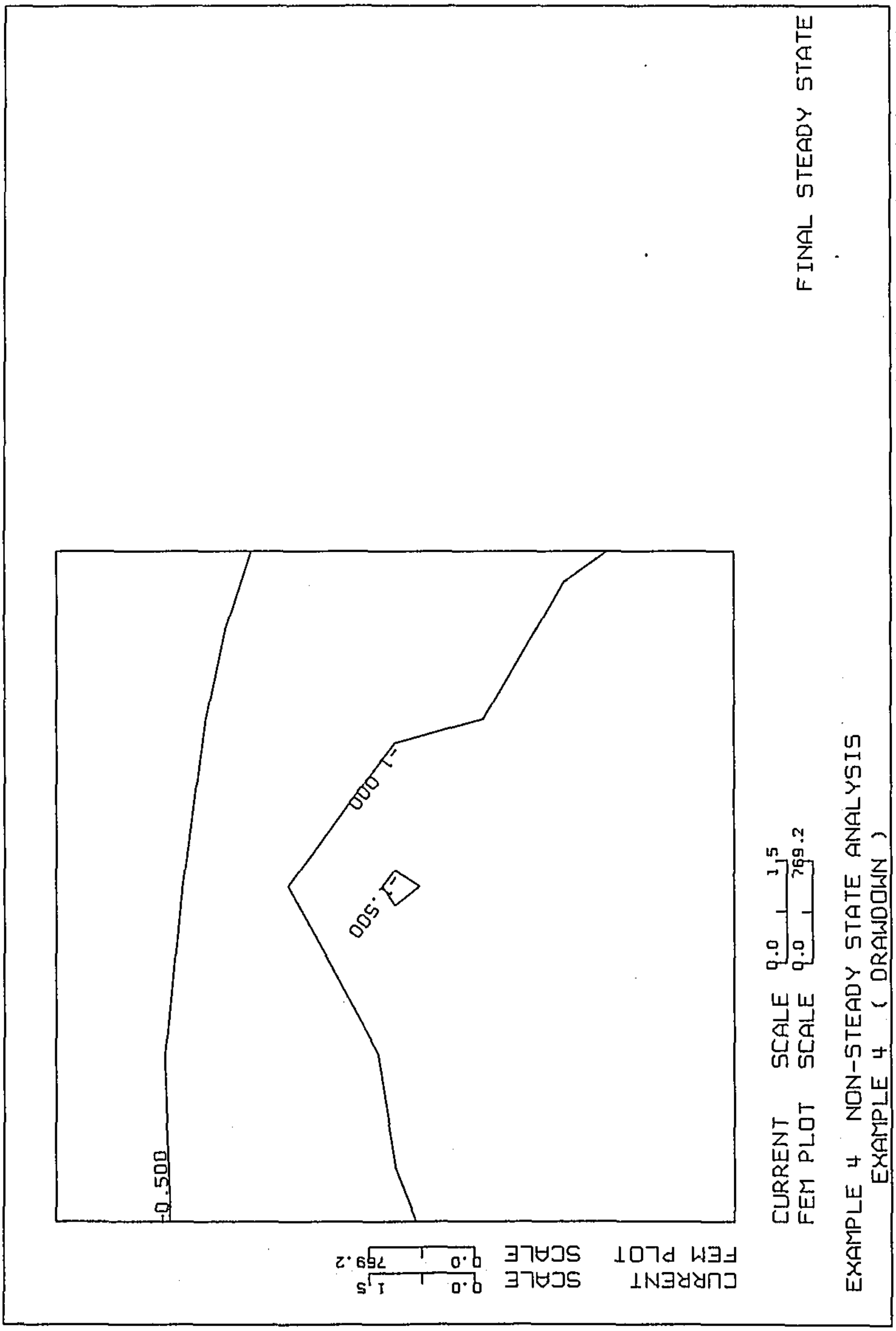
Drawdown Map



Drawdown Map



Drawdown Map



PART 3 GROUNDWATER SIMULATION OF THE JAFR BASIN (B2/A7 AQUIFER)

PART 3 GROUNDWATER SIMULATION OF THE JAFR BASIN (B2/A7 AQUIFER)

CONTENTS

CHAPTER I
MESH DATA PROCESSING

1. Data Input

The mesh division is made on the Jafr Basin and the Hasa Basin. The boundary of the mesh is extended to the edge of B2/A7 aquifer in the north, the edge of saturated B2/A7 aquifer in the south, the basin boundary in the east, and the edge of B2/A7 outcrop in the west. The 361 nodes and 386 elements are defined considering following items;

- Geological structures:	"Kalak - Wadi Al Fiha" fault "Salwan" fault "Arja - Uweina" flexure
- Location of existing well :	Hasa wellfield Western Highland
- Proposed wellfield :	South Hasa East Ma'an

The node coordinates are depend on Palestinian Grid. The element configuration is made by connecting the node numbers at vertexes of elements. The mesh data which include the node coordinates and the element connection is stored in the data file '**MESH.DAT**'. Input data are shown in PART 5.

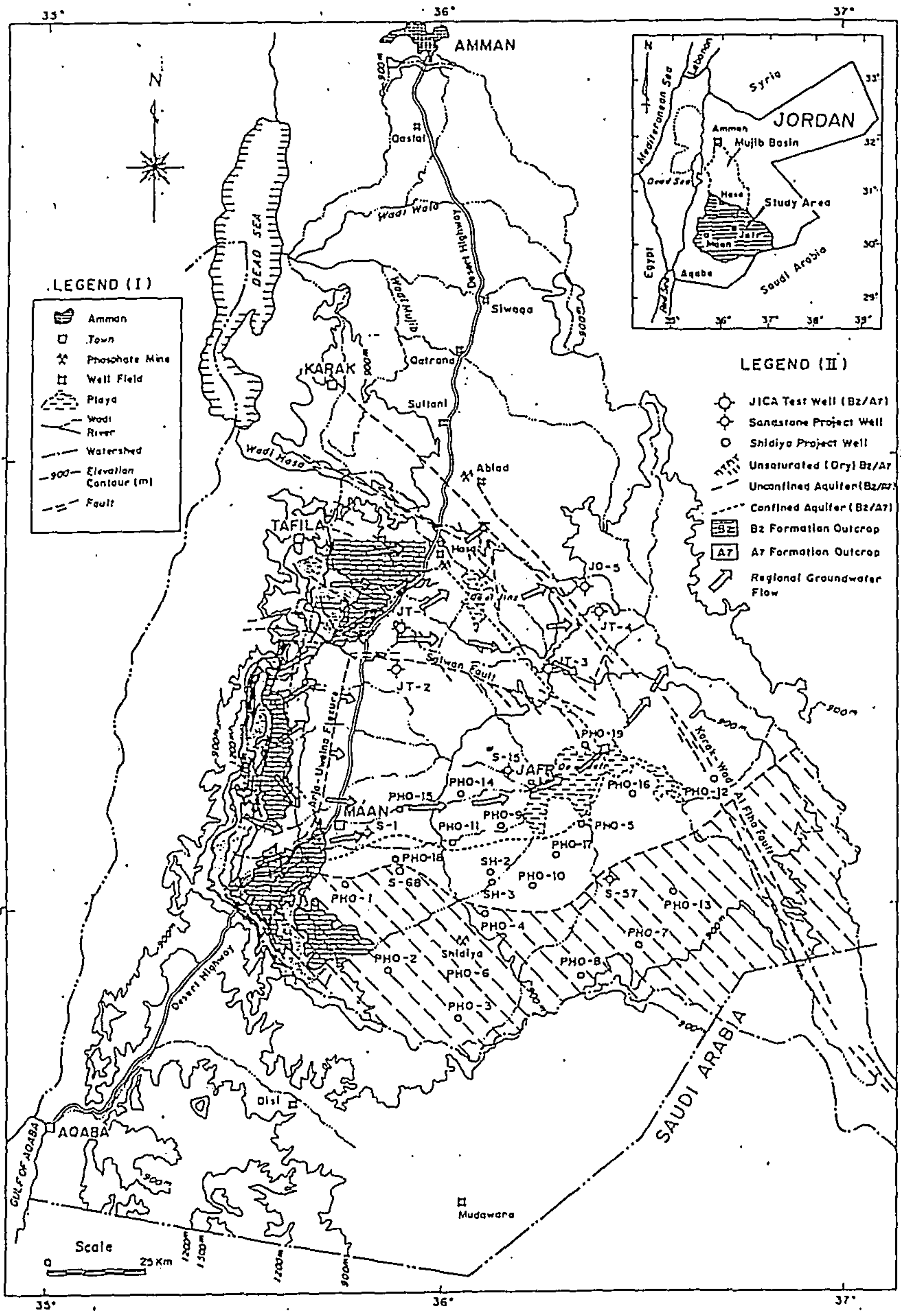


Fig. 1 Hydrogeological Map of Amman - Wadi Sir (B2/A7) Formation

2. Processing

The mesh data are processed by using the program 'UNISSF2/G'. After processing, the mesh data are stored in the data file 'MESH.RST' and the plotting data file of 'FOR040.DAT'. The mesh diagram is shown on the graphic display by using the program 'DISPLAY' with the data file 'FOR040.DAT'. The mesh diagram is also drawn by plotter with the program 'XYPLOT'.

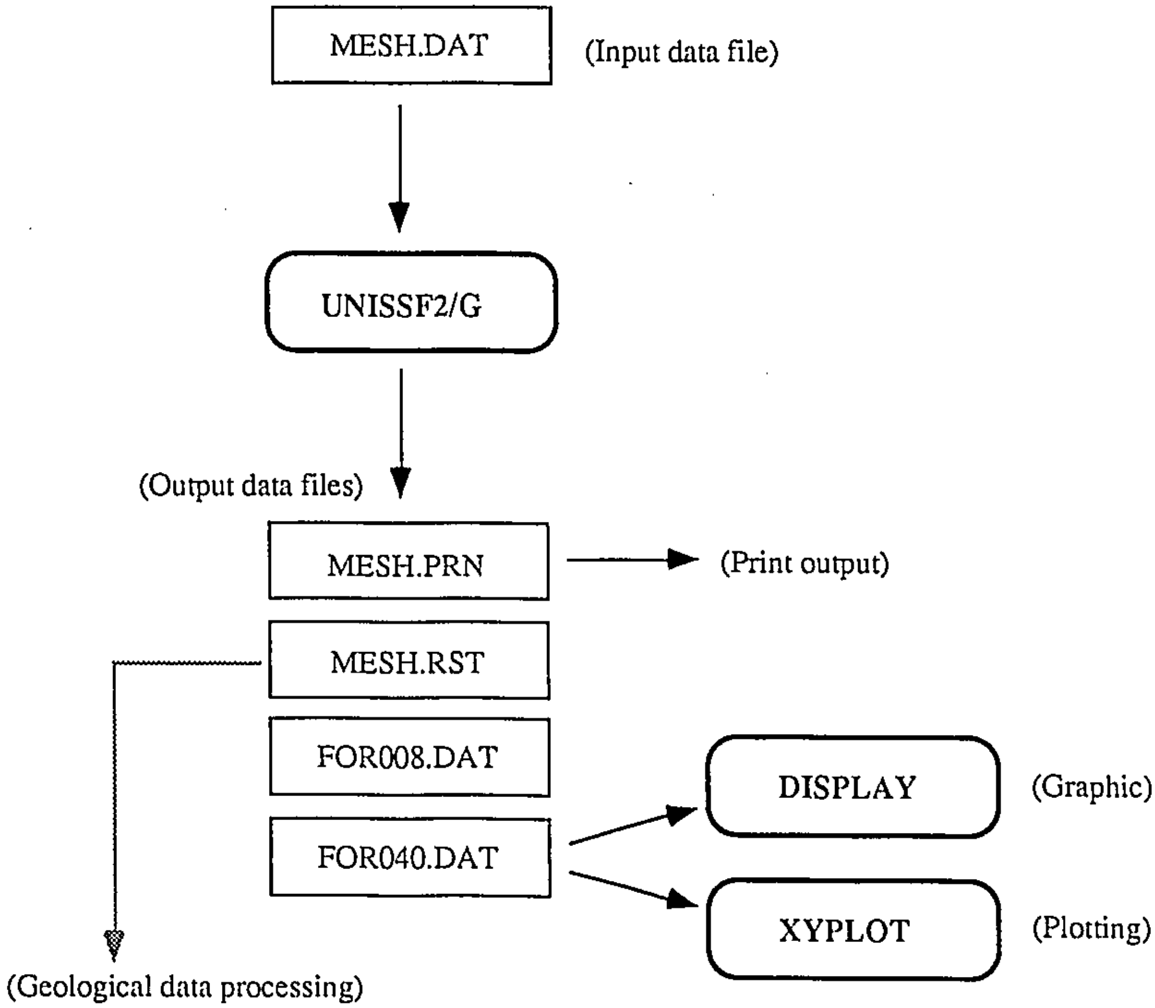


Fig. 2 Mesh Data Processing

3. Operation

(1) UNISSF2/G

1) $ **UNISSF** [enter]

2) UNISSF2 <M>
UNISSF2/G <G>
UNISSF2/P <P>
DISPLAY <D>
XYPLOT <X>

PLEASE ENTER ---> **G** [enter] ('G' for **UNISSF2/G**)

3) RESTART ? (Y/N) **N**

4) FILENAME (?.dat) **MESH**

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.
(processing)
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.
.
FORTRAN STOP

4) UNISSF2 <M>
UNISSF2/G <G>
UNISSF2/P <P>
DISPLAY <D>
XYPLOT <X>

PLEASE ENTER ---> **E** [enter] ('E' for end)

5) $ **ED MESH.PRN** [enter] (print output to be checked)

6) Press **PF4** function key (at the end of check)
7) Command : **QUIT** [enter]

(2) Graphic

1) Press **SET UP** key
2) * **CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) $ **UNISSF** [enter]

5) UNISSF2 <M>
   UNISSF2/G <G>
   UNISSF2/P <P>
   DISPLAY <D>
   XYPLOT <X>

   PLEASE ENTER ---> **D** [enter] ('D' for **DISPLAY**)

6) FILE NAME : **FOR040.DAT** [enter]

7) Press **CLEAR** key

   .
   .
   .
   (Graphic1) (Press [enter] for next)
   (Graphic2) (Press 'E' for end)
   .
   .
   .

8) UNISSF2 <M>
   UNISSF2/G <G>
   UNISSF2/P <P>
   DISPLAY <D>
   XYPLOT <X>

   PLEASE ENTER ---> **E** [enter] ('E' for end)

9) Press **SET UP** key
10) * **CODE ANSI** [enter]
11) Press **SET UP** key, and [enter]

(3) Plotting

1) Plotter set up
2) Paper set
3) Press 'On-line' soft key

4) $ UNISSF [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> X [enter] ('X' for XYPLOT)

6) FILE NAME : FOR040.DAT [enter]

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(Plotting)

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.

7) If there are more than 2 drawings, the plotting is stopped and the message 'HALT RECIEVED...' is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press 'On-line' soft key.

8) At the end of plotting, the message 'PLOT COMPLETE' is shown on the plotter window.

9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> E [enter]

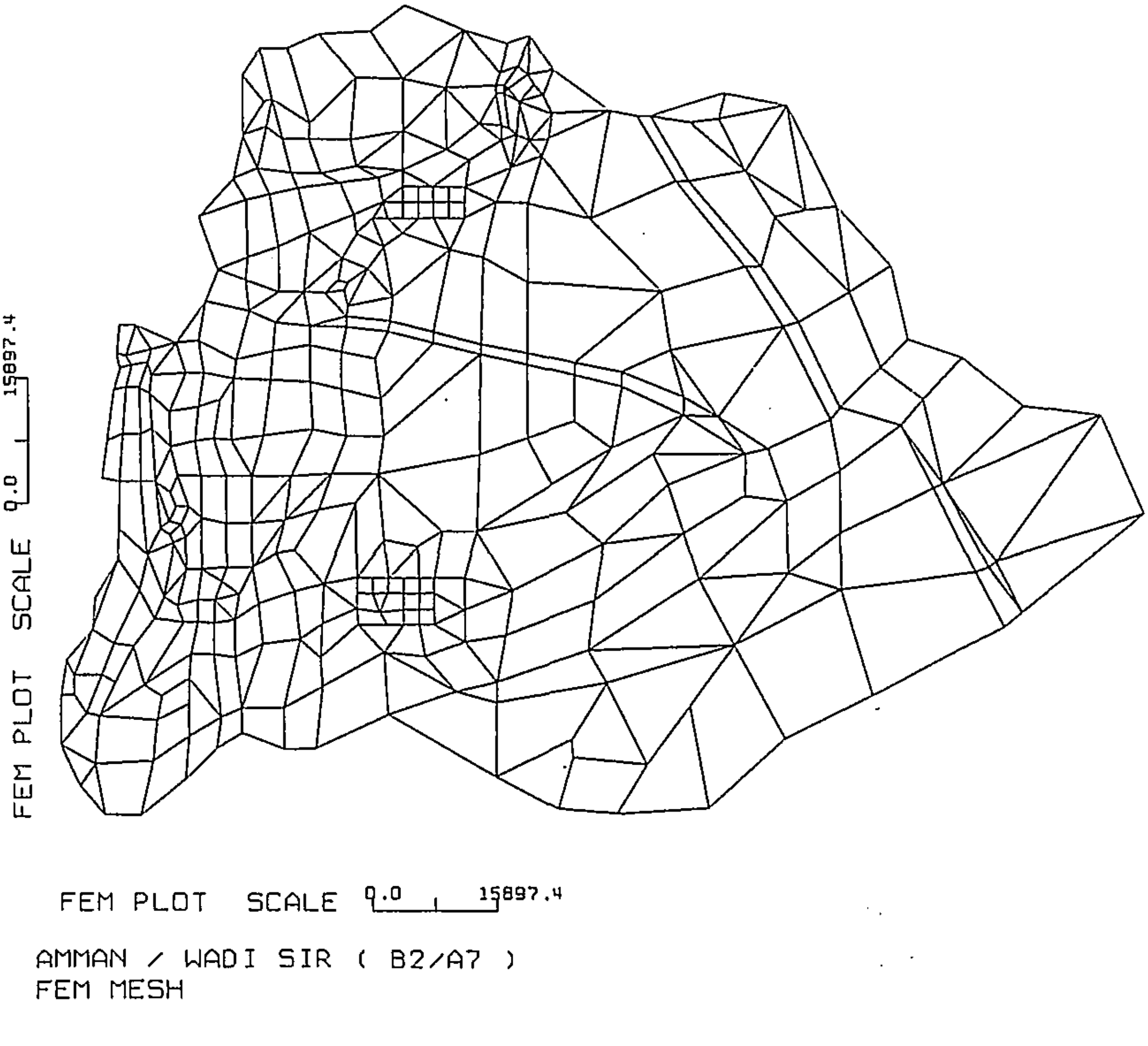


Fig. 3 Mesh Diagram

CHAPTER II
GEOLOGICAL DATA PROCESSING

1. Data Input

Geological data is necessary to demonstrate the geological structures in the study area. The geological data are composed of the following items:

- Elevation contour of the bottom of B2/A7 aquifer
- Elevation contour of the top of B2/A7 aquifer
- Elevation contour of ground surface

From the contour diagram above, the elevations are estimated for each node which is defined on the mesh diagram. The mesh diagram of the B2/A7 aquifer includes 361 nodes. This number is too much to give the geological data for each node manually. In this case, the auto generator which is a function of the program 'UNISSF2/G' is available.

The input data of using the auto genarator of 'UNISSF2/G' are composed of the geological data at several number of key points, which are selected nodes on the mesh diagram. The geological data of the nodes which are in the region enclosed by the four key points are interpolated with the data at key points.

The 54 key points are selected on the mesh diagram of B2/A7 aquifer, and the 39 regions are defined on the mesh diagram. The mesh diagram is almost covered with the regions. Selected key points and geological data at key points are shown on Table 1. The regions defined on the mesh diagram are shown on Fig. 4. The data file named 'GEOL.DAT' for the auto generator of 'UNISSF2/G' is shown in PART 5.

2. Processing

After mesh data processing, the mesh data are stored in the data file 'MESH.RST'. Geological data are processed by using the auto generator of 'UNISSF2G' with the data files 'MESH.RST' and 'GEOL.DAT'. Generated geological data are entered into the data file 'GEOL.FT21' and the plotting data file of 'FOR040.DAT'.

Table 1 Key Points for Geological Data Processing

Key Points Node Number	Elevation (EL m) Bottom of B2/A7 (BASE)	Top of B2/A7 (AQUI)	Ground Surface (SURF)	Remarks * : B2/A7 outcrop ** : Edge of B2/A7
1	1100	1250	-	*
4	800	950	-	*
6	780	880	1000	
9	670	770	900	
26	630	730	880	
27	1090	1290	-	*
37	800	950	-	*
40	650	750	880	
48	610	760	880	
51	660	910	940	
52	660	910	1000	
59	1000	1400	-	*
83	640	740	880	
84	640	740	900	
87	630	800	1000	
89	600	700	1050	
114	560	770	1000	
117	640	740	890	
128	680	800	910	
135	670	720	870	
139	640	740	910	
144	560	660	970	
149	1350	1620	-	*
154	900	1350	-	*
157	380	580	1200	
160	400	600	1080	
191	1420	1670	-	*
197	1100	1300	-	*
201	440	600	1100	
203	500	600	930	
206	610	660	870	
208	1380	1600	-	*
226	1000	1200	-	*
229	730	900	1180	
233	460	560	900	
260	490	560	870	
282	1000	1200	-	*
286	640	720	1120	
291	610	690	900	
301	1430	1600	-	*
313	1450	1600	-	*
324	1470	1600	-	*
325	1230	1500	-	*
328	1000	1150	-	*
331	750	850	1050	
334	580	660	870	
338	630	680	870	
340	670	720	870	
344	730	880	950	
349	730	880	900	
351	710	760	870	
358	680	730	920	
360	670	-	860	**
361	670	-	920	**

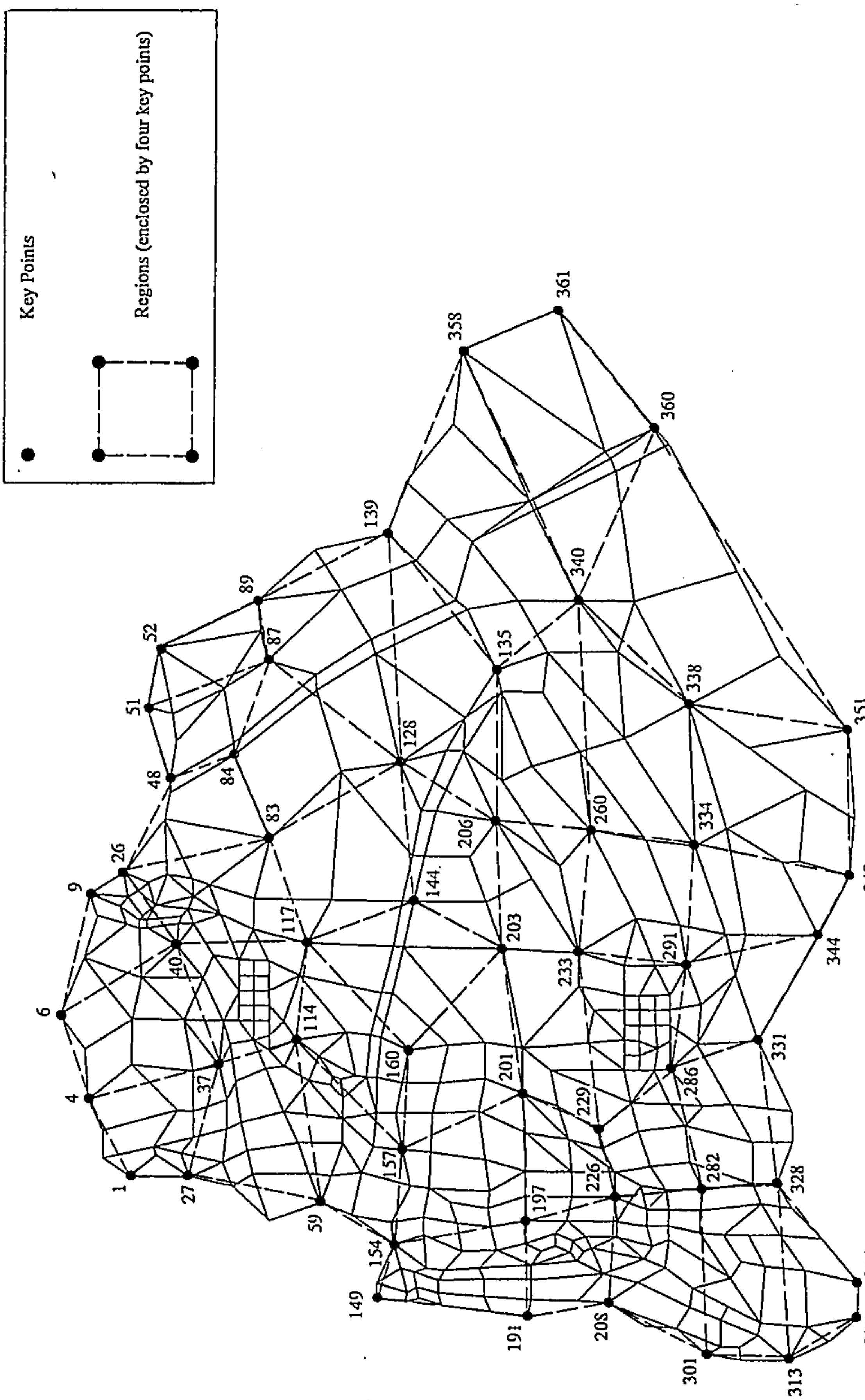


Fig. 4 Keypoints and Regions

The geological contour diagrams are shown on the graphic display by using the program 'DISPLAY' with the data file 'FOR040.DAT'. The contour diagrams are also drawn by plotter with 'XYPLOT'.

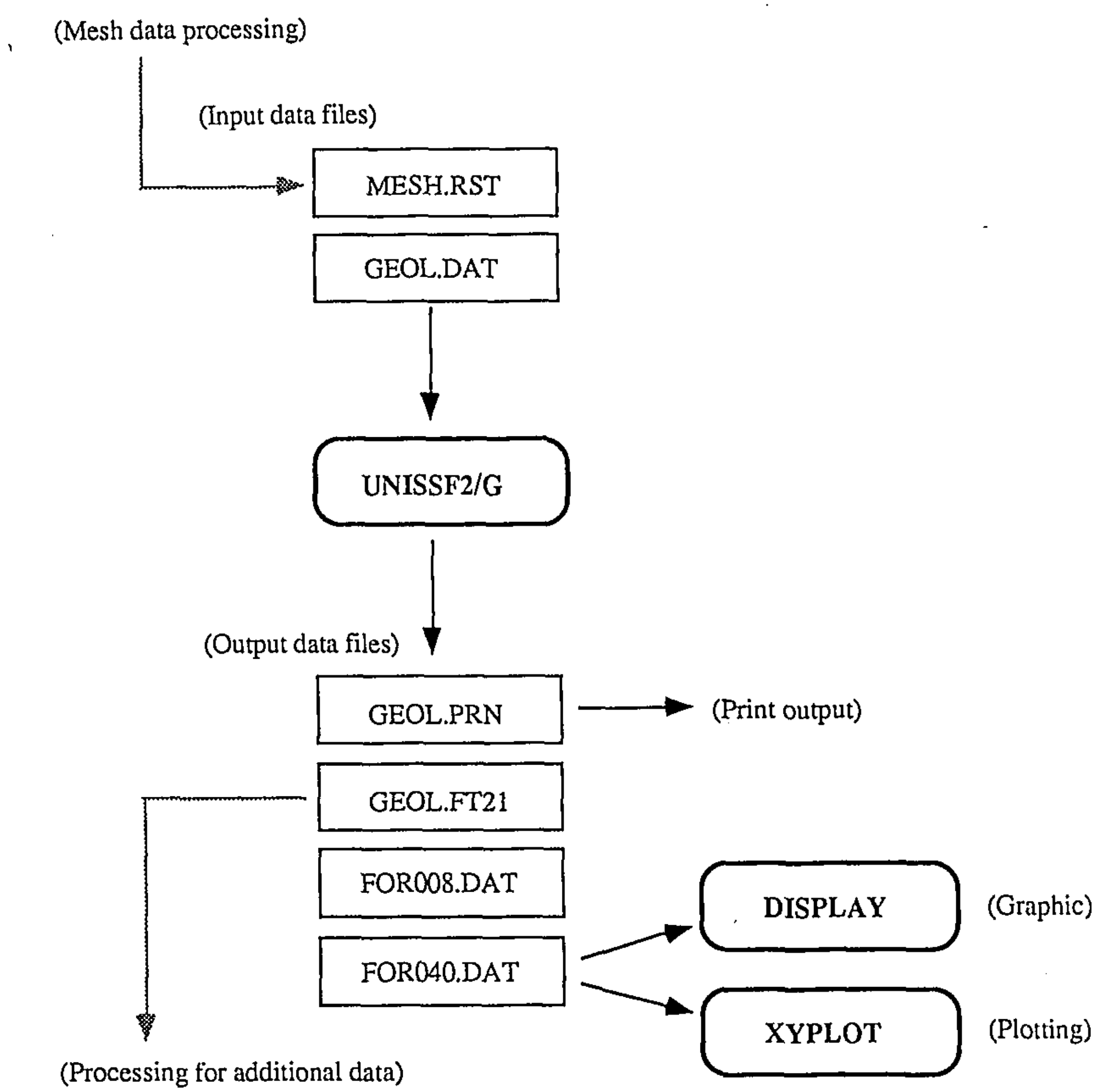


Fig. 5 Geological Data Processing

3. Operation

(1) UNISSF2/G

1) $ UNISSF [enter]

2)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
```

PLEASE ENTER ---> G [enter] ('G' for UNISSF2/G)

3) RESTART ? (Y/N) N

4) FILENAME (?.dat) GEOL

5) RESTART FILENAME (?.dat) MESH

.
.
.
(processing)
.
.
.
FORTRAN STOP

4)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
```

PLEASE ENTER ---> E [enter] ('E' for end)

5) $ ED GEOL.PRN [enter] (print output to be checked)

6) Press PF4 function key (at the end of check)

7) Command: QUIT [enter]

(2) Graphic

1) Press SET UP key
2) * CODE TEK [enter]
3) Press SET UP key, and [enter]

4) $ UNISSF [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> D [enter] ('D' for DISPLAY)

6) FILE NAME : FOR040.DAT [enter]

7) Press CLEAR key

.
.
.
(Graphic1) (Press [enter] for next)
(Graphic2) (Press 'E' for end)
.
.
.

8) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> E [enter] ('E' for end)

9) Press SET UP key
10) * CODE ANSI [enter]
11) Press SET UP key, and [enter]

(3) Plotting

1) Plotter set up
2) Paper set
3) Press 'On-line' soft key

4) $ UNISSF [enter]

5)
```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

PLEASE ENTER ----> X [enter] ('X' for XYPLOT)

6) FILE NAME : FOR040.DAT [enter]

.
.
.
(Plotting)
.
.
.

7) If there are more than 2 drawings, the plotting is stopped and the message 'HALT RECIEVED...' is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press 'On-line' soft key.

8) At the end of plotting, the message 'PLOT COMPLETE' is shown in the plotter window.

9)
```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

PLEASE ENTER ----> E [enter]

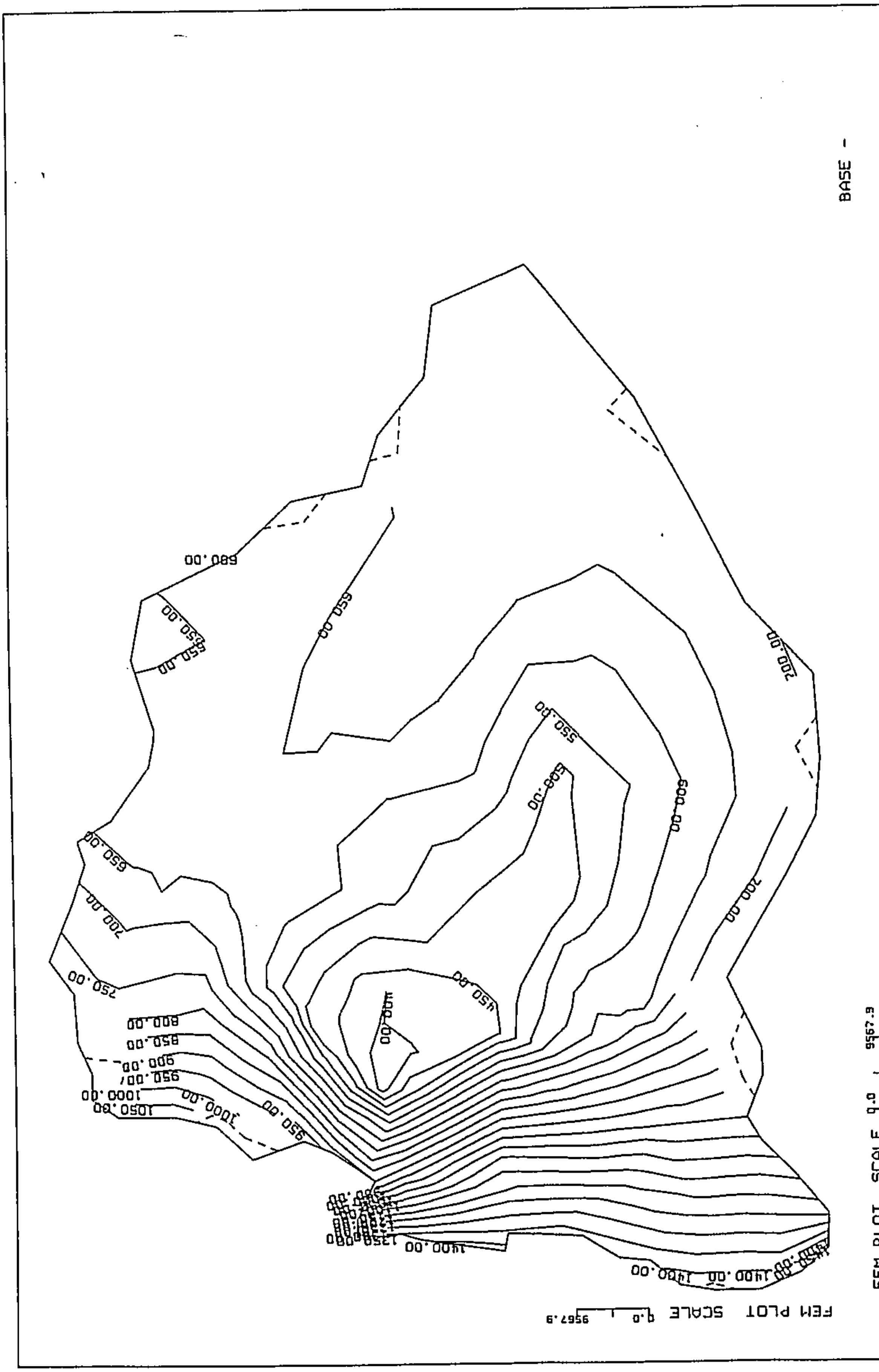


Fig. 6 Elevation Contour by Auto Generator (Bottom of B2/A7)

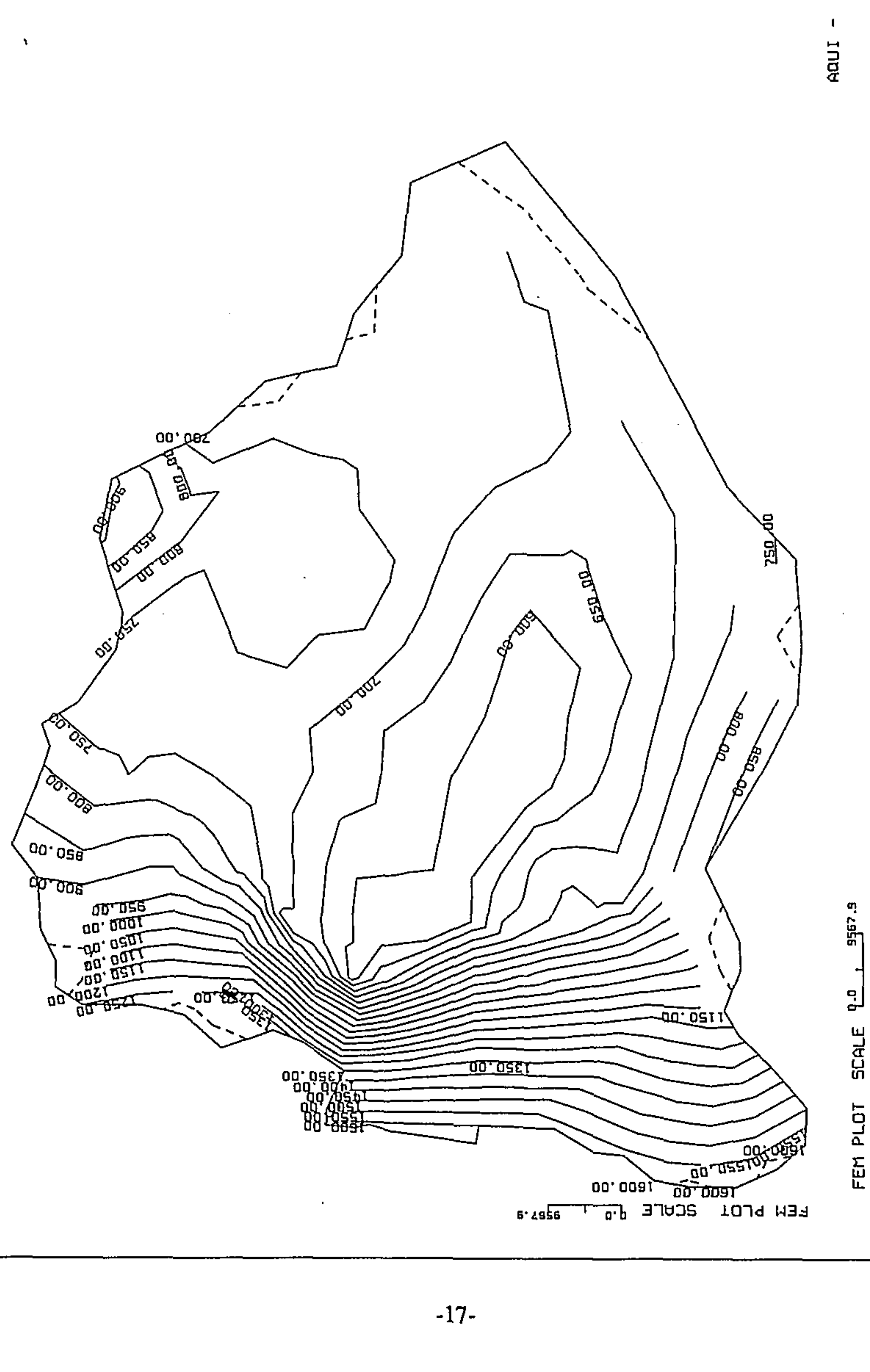


Fig. 7 Elevation Contour by Auto Generator (Top of B2/A7)

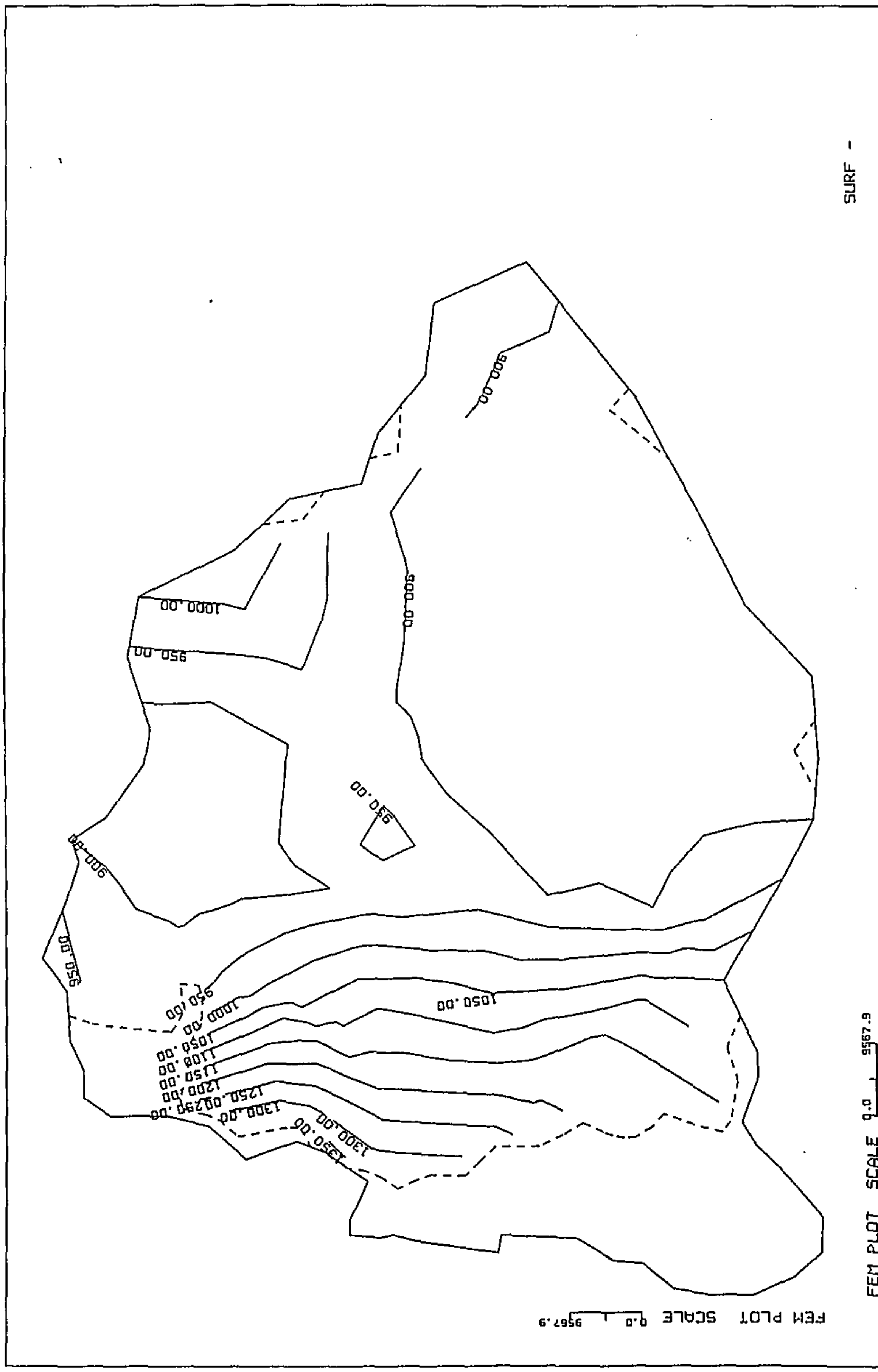


Fig. 8 Elevation Contour by Auto Generator (Ground Surface)

5. Additional Geological Data

The generated geological data are stored in the data file '**GEOL.FT21**'. But geological data at some nodes are not incorporated in the 'GEOL.FT21'. These nodes are located outside of the regions enclosed by the key points so that the data are not generated by the auto generator of 'UNISSF2/G'. Nodes located outside of the regions are shown on Fig. 10. Geological data for these nodes are added to the data file 'GEOL.FT21' by using the program '**GADD**'. The additional data are shown on Table 2.

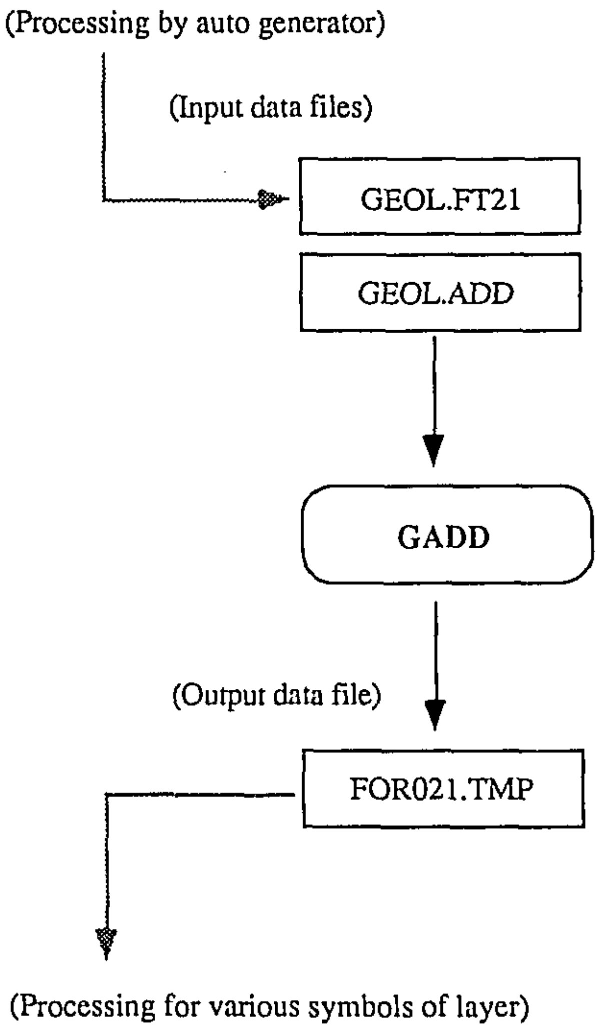


Fig. 9 Processing for Additional Geological Data

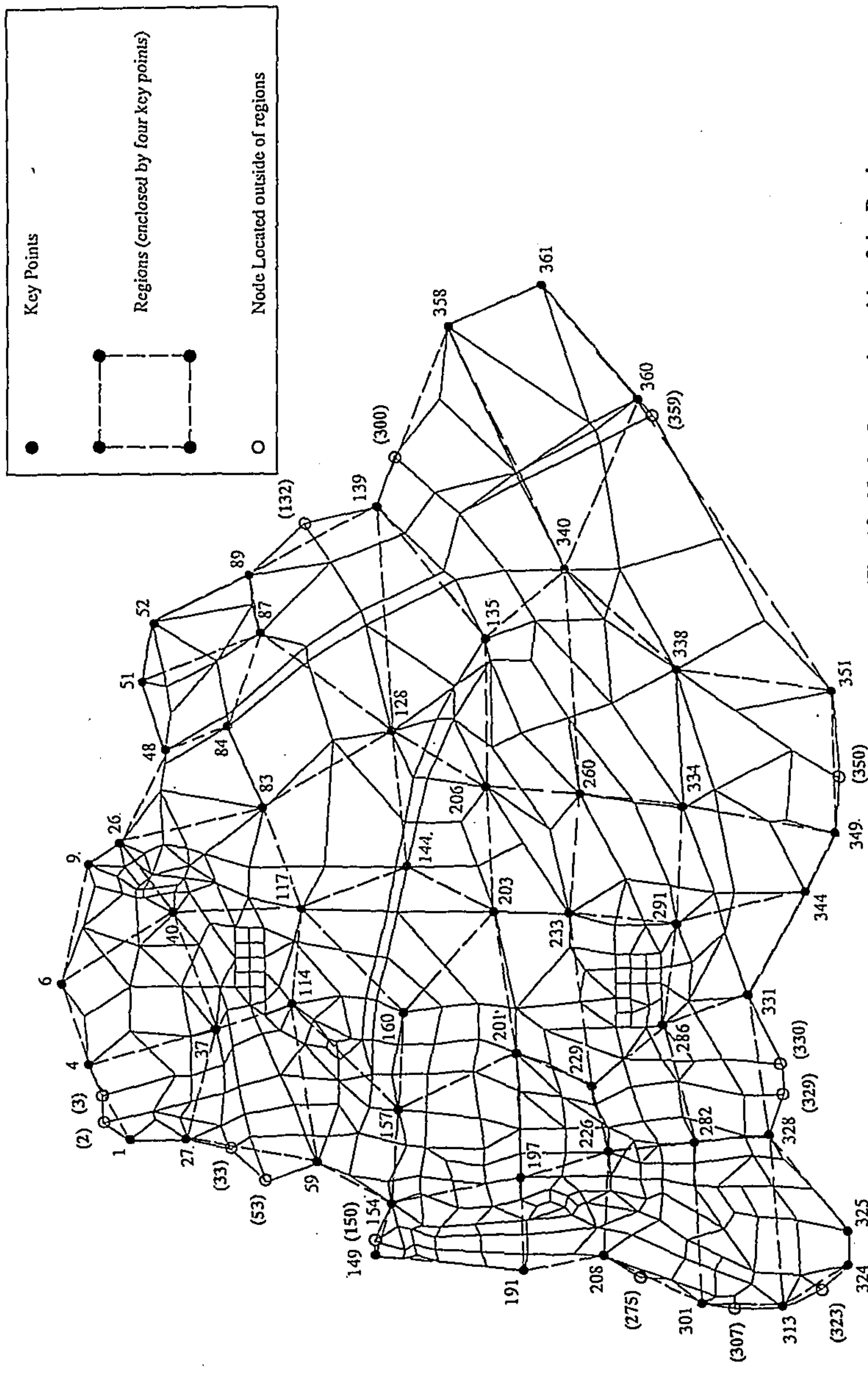


Fig. 10 Nodes Located outside of the Regions

Table 2 Aditional Geological Data

	Elevation (EL m)			Remarks
Node Number	Bottom of B2/A7 (BASE)	Top of B2/A7 (AQUI)	Ground Surface (SURF)	* : B2/A7 outcrop ** : Edge of B2/A7
2	900	1100	-	*
3	800	1050	-	*
33	1080	1300	-	*
53	1080	1300	-	*
132	650	700	1000	
150	1350	1520	-	*
275	1430	1650	-	*
300	620	740	920	
307	1450	1670	-	*
323	1450	1650	-	*
329	860	960	1200	
330	810	910	1100	
350	730	780	880	
359	680	-	880	**

The data file '**GEOL.ADD**' is prepared for the additional geological data (shown in PART 5). By the program 'GADD', the data on 'GEOL.ADD' are combined with the data on 'GEOL.FT21'. The combined data are entered into the data file '**FOR021.TMP**' which includes the geological data for the all nodes. Operation of the program 'GADD' is described below;

1) **$ GADD** [enter]

2) Default File Name :

   UNIT 1 : GEOL.FT21
   UNIT 2 : GEOL.ADD
   UNIT 3 : FOR021.TMP (default only)

   Use Default ? (Y/N) **Y** [enter]

3) UNIT 1 : GEOL.FT21
   UNIT 2 : GEOL.ADD
   UNIT 3 : FOR021.TMP

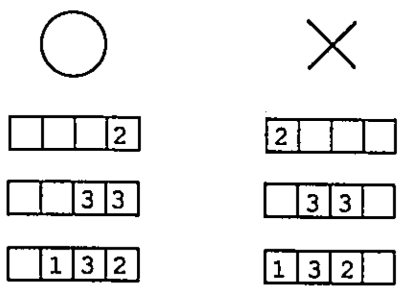
   Press enter to continue [enter]

   .
   .
   .
   (processing)
   .
   .
   .
   FORTRAN STOP

```
GEOL       2       2       1       1
  BASE    AQUI
 900.00 1100.00
.
.
.
.
GEOL     132     132       1       2
  BASE    AQUI    SURF
 650.00  700.00 1000.00
.
.
.
.
ADDEND
```

▒ Blank (or Comma)

Alignment :



(OK) (NO)

Fig. 11 Data Input Format for 'GEOL.ADD'

CHAPTER III
AQUIFER CONSTANTS

1. Aquifer Symbols and Constants

The data file 'FOR021.TMP' includes the geological data which are composed of the top elevation of the three layers symbolized **'BASE'**, **'AQUI'** and **'SURF'**. The layer symbolized 'AQUI' is the B2/A7 aquifer and the layer above the B2/A7 is considered as less permeable layer, which is symbolized 'SURF'.

Aquifer constants, coefficient of permeability (K) and coefficient of storage (S), are various in the study area so that the various K and S are given as data for each node

For expression of this, several number of symbols are necessary for the B2/A7 and the upper layer, instead of the symbols AQUI and SURF included in the geological data respectively.

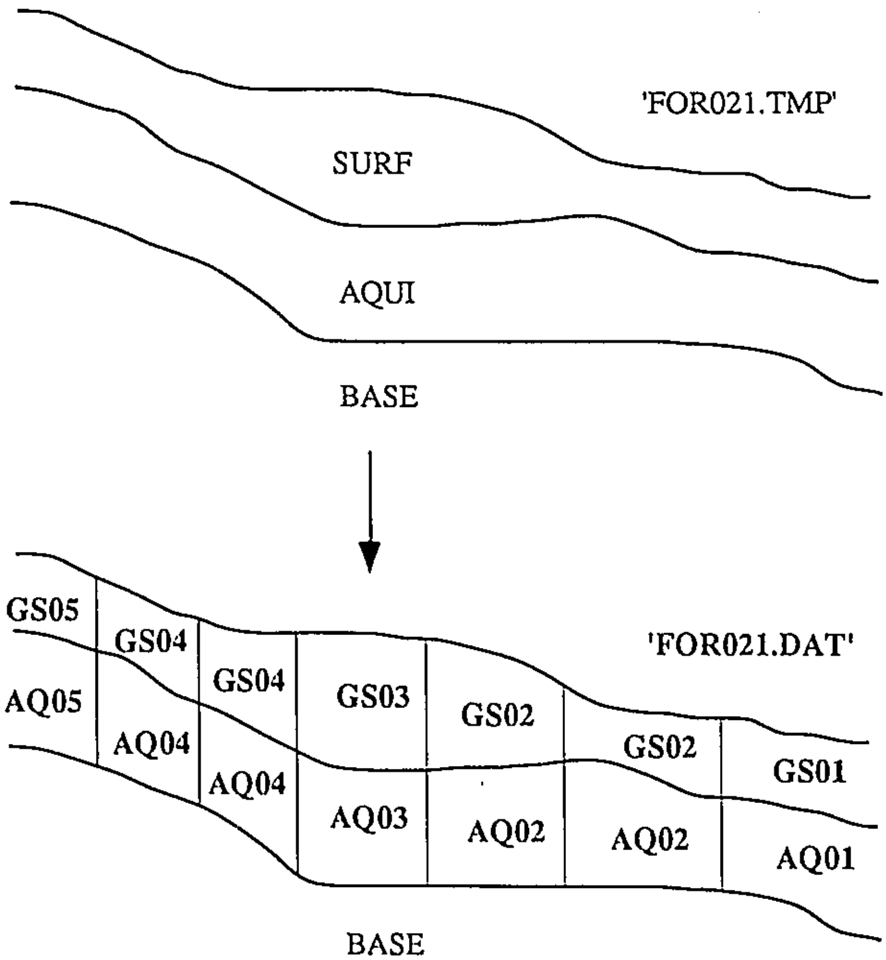


Fig. 12 Various Symbols

2. Processing

The data of various symbols for each node are prepared in the data file **'NMAT.DAT'**. The input format of 'NMAT.DAT' is illustrated in Fig. 14. By the program **'NMAT'**, the symbols 'AQUI' and 'SURF' in the data file 'FOR021.TMP' are revised according to the various symbols in the 'NMAT.DAT' and the revised geological data are stored in the data file **'FOR021.DAT'**

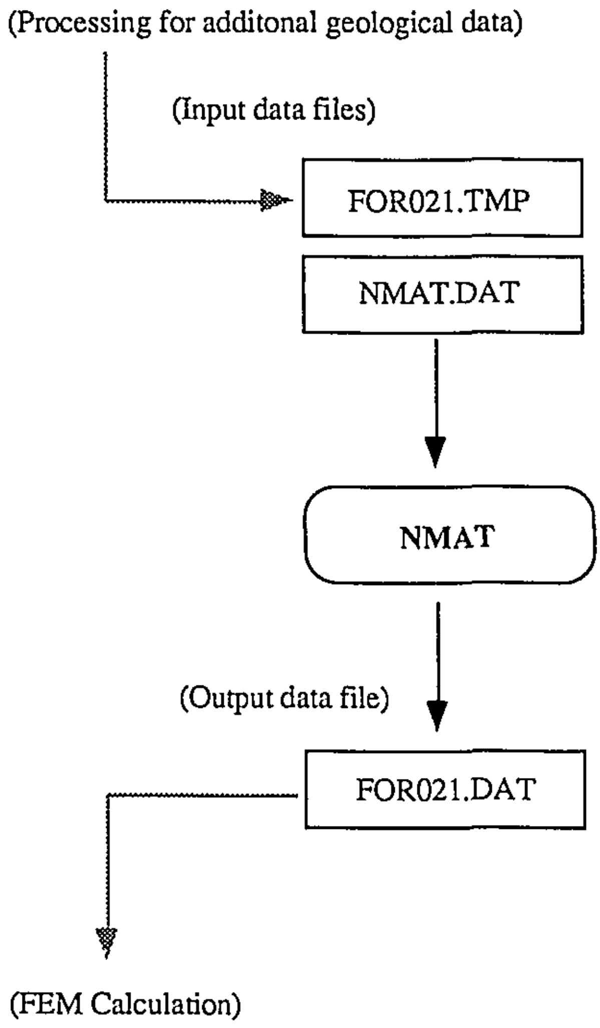


Fig. 13 Processing for Various Symbols of Layer

			1	▒	▒	▒	▒	A	Q	1	4
			2	▒	▒	▒	▒	A	Q	1	2
			3	▒	▒	▒	▒	A	Q	1	2

⋮

	3	5	9	▒	▒	▒	▒	A	Q	1	0
	3	6	0	▒	▒	▒	▒	A	Q	1	2
	3	6	1	▒	▒	▒	▒	A	Q	1	2
A	Q	E	N	D							

▒ Blank

Alignment :

○				✕			
			2	2			
		3	3		3	3	
	1	3	2	1	3	2	
(OK)				(NO)			

Fig. 14 Data Input Format for 'NMAT.DAT'

3. Operation

1) $ NMAT [enter]

2) Default File Name

   UNIT1 : NMAT.DAT
   UNIT2 : FOR021.TMP (default only)
   UNIT3 : FOR021.DAT (default only)

   Use Default ? (Y/N) Y

3) UNIT1 : NMAT.DAT
   UNIT2 : FOR021.TMP
   UNIT3 : FOR021.DAT

   Press enter to continue [enter]

   .
   .
   .
   (processing)
   .
   .
   .
   FORTRAN STOP

4. Data Preparation of K and S

The aquifer constants K and S are prepared for each symbol of layer included in the data file FOR021.DAT. The 40 symbols are included in the 'FOR021.DAT', which require the 40 pair of the constants such as K and S are also prepared. Table 3 shows the symbols and aquifer constants.

Table 3 Symbols and Aquifer Constants

Symbol	K	S
GS00	1.0E-08 /1	1.00E-07 /2
GS01	1.0E-08	1.00E-03
GS02	1.0E-08	9.09E-04
GS03	1.0E-08	8.03E-04
GS04	1.0E-08	6.75E-04
GS05	1.0E-08	5.02E-04
GS06	1.0E-08	3.73E-04
GS07	1.0E-08	3.30E-04
GS08	1.0E-08	2.77E-04
GS09	1.0E-08	2.06E-04
GS10	1.0E-08	1.39E-04
GS11	1.0E-08	1.23E-04
GS12	1.0E-08	1.03E-04
GS13	1.0E-08	7.67E-05
GS14	1.0E-08	5.18E-05
GS15	1.0E-08	3.85E-05
GS16	1.0E-08	1.93E-05
GS17	1.0E-08	7.20E-06
GS18	1.0E-08	2.68E-06
GS19	1.0E-08	1.00E-06
AQ00	1.0E-08	1.00E-07 /3
AQ01	100.0	0.25
AQ02	80.0	0.2391
AQ03	60.0	0.2258
AQ04	40.0	0.2082
AQ05	20.0	0.1813
AQ06	10.0	0.1578
AQ07	7.5	0.1490
AQ08	5.0	0.1374
AQ09	2.5	0.1197
AQ10	1.0	0.0997
AQ11	0.75	0.0941
AQ12	0.50	0.0868
AQ13	0.25	0.0756
AQ14	0.10	0.0629
AQ15	0.05	0.0548
AQ16	0.01	0.0397
AQ17	0.001	0.0251
AQ18	0.0001	0.0158
AQ19	0.0000	0.0100

Note : Maximum number of symbols is 40.

/1 Upper layer (symbol 'GSxx') is assumed to be impervious.

/2 Coefficent of storage for 'AQ00', 'AQ01', 'AQ02', . . . , 'AQ19' in the case of the confined aquifer

These values are given to the upper layer 'GRSF' which is symbolized 'GS00', 'GS01', 'GS02', . . , 'GS19'.

Coefficient of Storage (S)

	Confined	Unconfined
AQ01	1.00E-03	0.25

↓

Input Data of S for **GS01**

	Confined	Unconfined
AQ02	9.09E-04	0.2391

↓

Input Data of S for **GS02**

.
.
.

/3 Coefficient of storage in the case of unconfined aquifer

CHAPTER IV
FEM CALCULATION BY UNISSF2

1. Data Input

The mesh data and geological data are prepared in the data file 'FOR021.DAT' through the pre-processing. The data of boundary condition, initial condition and aquifer constants are stored in another data file which is used for FEM calculation by the program 'UNISSF2' with the data file 'FOR021.DAT'.

(1) Boundary Condition

The boundary conditions are either of the specified-head or specified flow type.Nodes along the western basin boundary, where average annual rainfall exceeds 150 mm in the outcrop area, are of specified-head type of boundary condition. The specified-flow of outflow type is given to the node along the eastern boundary of the model, where ground water flows out to further east to northeast. The northern boundary is along the edge of B2/A7 aquifer and the southern boundary is along the edge of the saturated B2/A7 aquifer. Both the northern and the southern boundary are considered as the boundary of no inflow/outflow type. The condition of nodes along the boundary is shown in Table 4 and Fig. 15 .

Table 4 **Boundary Conditions**

Western Boundary (Specified Head Type) Node	Specified Piezometric Head (EL m)	Eastern Boundary (Specified Flow Type) Node	Specified Flow (m3/day)
1	1120	7	-1800
27	1120	8	-2400
33	1120	9	-2400
53	1140	26	-2400
59	1160	46	-2400
104	1190	47	-1400
149	1450	48	-1400
150	1420	51	-2800
151	1440	52	-2800
154	1310	89	-4000
161	1440	132	-4800
172	1440	139	-5600
179	1460	300	-5600
191	1500	343	-4800
192	1420	358	-4800
208	1480		
242	1480		
275	1500		
276	1470		
301	1500		
307	1500		
313	1500		
323	1500		
324	1500		

Note : Minus (-) means outflow from the study area.

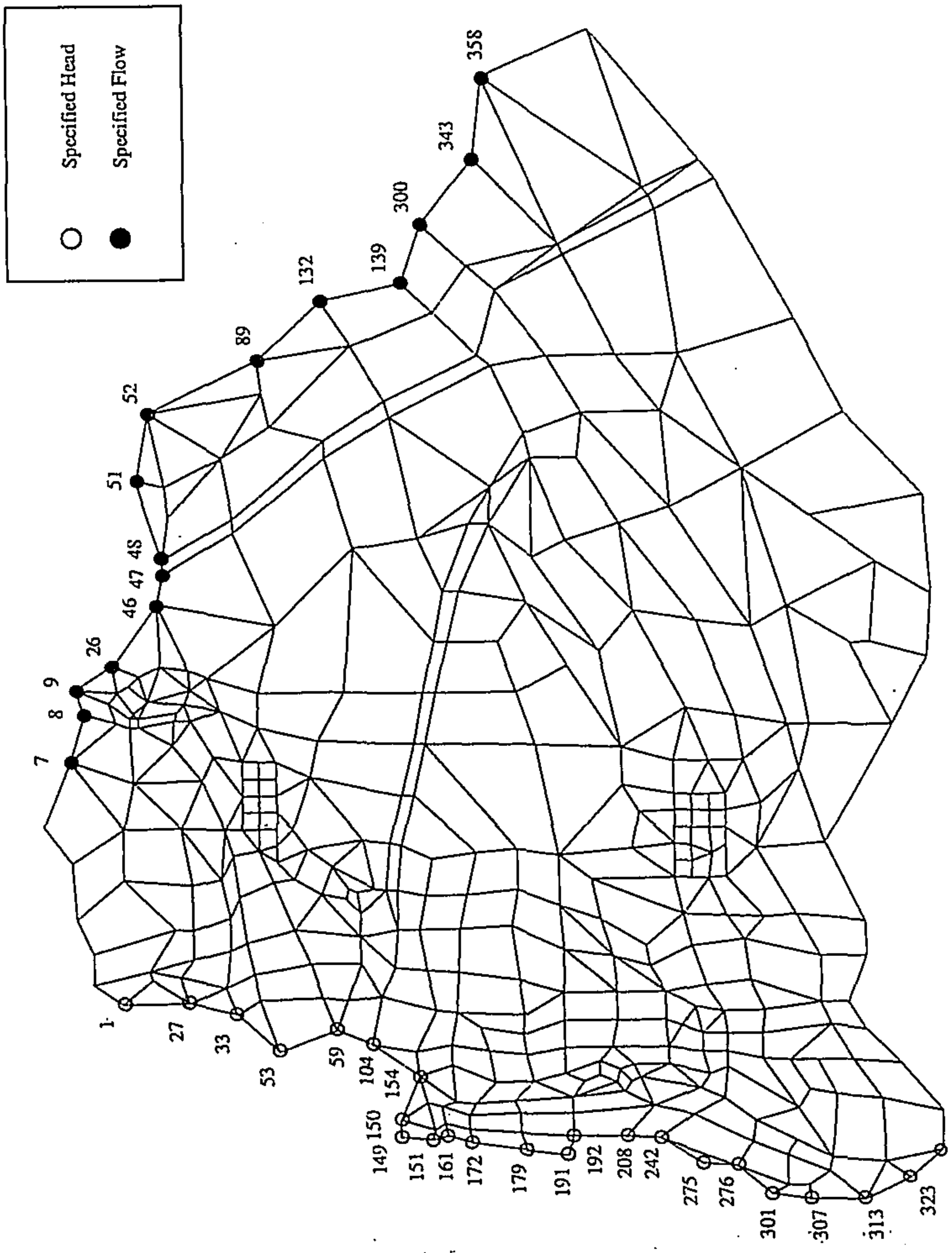


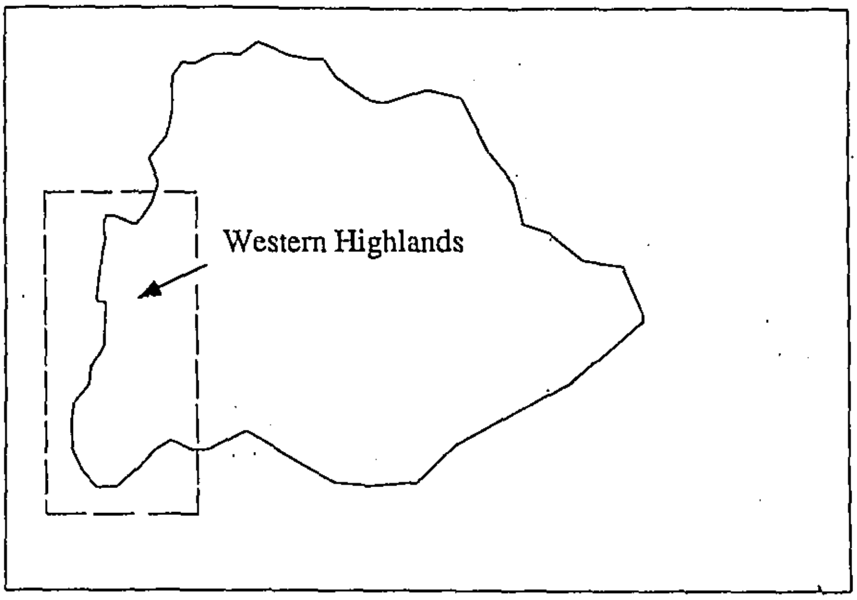
Fig. 15 Boundary Conditions

(2) Recharge through the Wadi Bed

From the surface runoff analysis, groundwater recharge through the wadi bed on the outcrops of B2/A7 in the Jafr Basin is estimated at approximately 6.7 MCM/y. The groundwater recharge through the wadi bed is distributed to nodes around the Western Highlands as shown on Table 5 and Fig 16.

Table 5 Recharge through Wadi Bed

Node	Recharge (mcm/year)	Recharge (m3/day)
162	0.70	1918
163	0.10	274
164	0.10	274
173	0.10	274
174	0.20	548
180	0.10	274
181	0.20	548
182	0.30	822
193	0.05	137
194	0.05	137
195	0.05	137
196	0.45	1233
209	0.65	1781
210	0.10	274
211	0.10	274
212	0.10	274
215	0.10	274
216	0.10	274
217	0.10	274
218	0.10	274
236	0.15	411
237	0.15	411
243	0.10	274
244	0.10	274
245	0.20	548
277	0.10	274
278	0.15	411
279	0.15	411
302	0.05	137
303	0.10	274
304	0.15	411
305	0.15	411
308	0.05	137
309	0.05	137
310	0.10	274
311	0.05	137
312	0.05	137
314	0.25	685



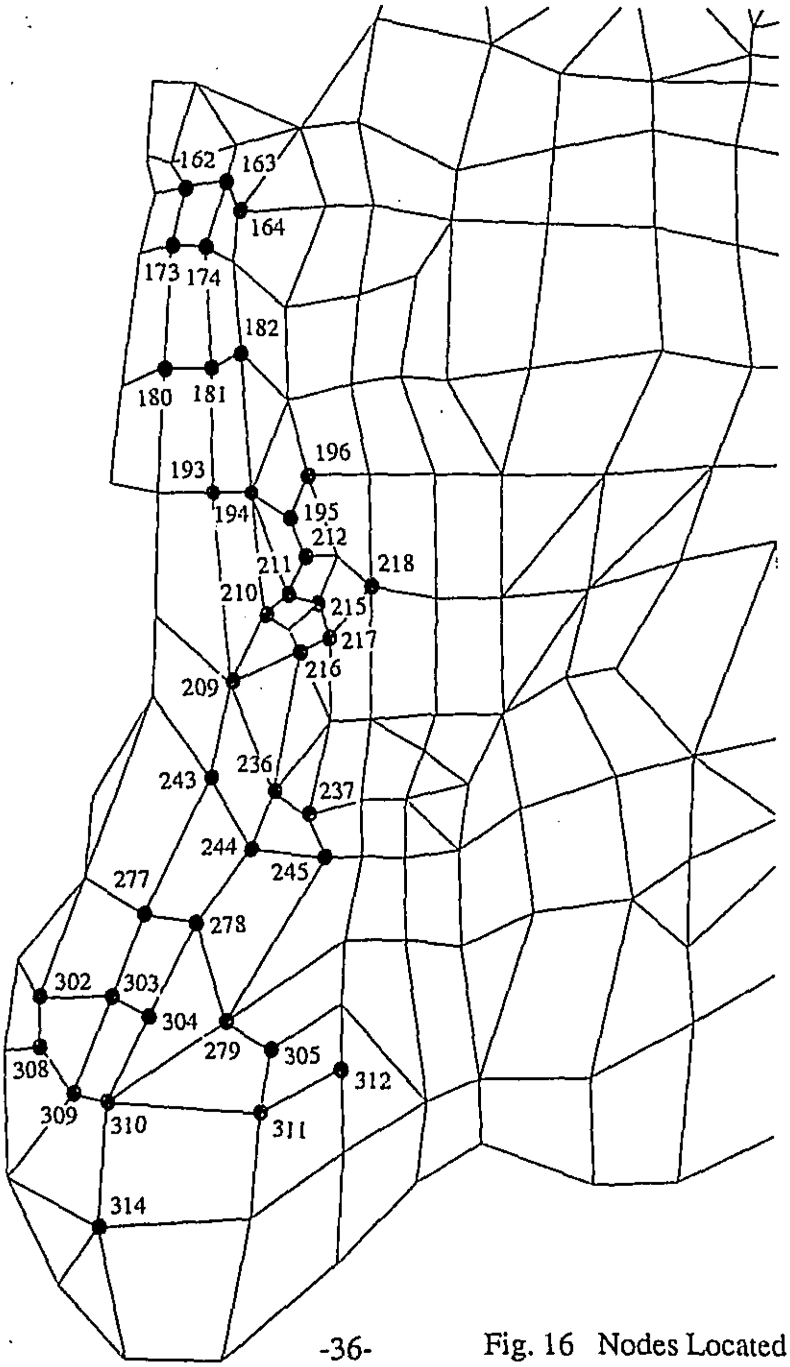


Fig. 16 Nodes Located in the B2/A7 Outcrop

(3) Abstractions

The steady state analysis is based on the simple assumption that there are no artificial abstractions from the B2/A7 aquifer. A semi-steady state condition is assumed to calibrate the simulation model, which is based on assumptions that artificial abstraction does not exceed the annual average groundwater recharge without any influences on the regional piezometric surface. It is assumed that the piezometric surface in the study area was in a steady state and/or semi-steady state before 1970.

(4) **Aquifer Constants**

Aquifer constants of K and S with the symbol of layer ,which are shown on Table 3, are stored in the data file for FEM calculation. Each pair of K and S is specified for each node according to the symbol of layer which is also included in the data file 'FOR021.DAT'.

The data including above items are stored in the data file **'MODEL2.NEW'** shown below.

```
SETTING,  CHEC,  3600,    0
TITLE
     WATER RESOURCES STUDY OF THE JAFR BASIN  ( B2 / A7 )
1ST ,  361,  386,    8,  361,    3
2ND ,    2,    0,    0,    0,    0
3RD ,    0,    0,    0,    0,    0,    0
4TH ,    0,    0
*
*    --- MESH ---                                    Mesh data are read
*                                                    from 'FOR021.DAT'
GENE                                                 by GENE command.
*
*
UNIT,  ME    ,  DAY ,  25,  1.0E-01
CONT,  STEADY,  SURF
*
*
*    --- BOUNDARY CONDITION ---
*
*       HF :  SPECIFIED HEAD                         Definition of
*       QF :  SPECIFED FLOW                          node condition
*
*     NODE           CONDITION
*
NCON,    1,    1,   1,  HF                           Western boundary
NCON,   27,   27,   1,  HF                           (specified head)
NCON,   33,   33,   1,  HF
NCON,   53,   53,   1,  HF
NCON,   59,   59,   1,  HF
NCON,  104,  104,   1,  HF
NCON,  149,  149,   1,  HF
NCON,  150,  150,   1,  HF
NCON,  151,  151,   1,  HF
NCON,  154,  154,   1,  HF
NCON,  161,  161,   1,  HF
NCON,  172,  172,   1,  HF
NCON,  179,  179,   1,  HF
NCON,  191,  191,   1,  HF
NCON,  192,  192,   1,  HF
NCON,  208,  208,   1,  HF
NCON,  242,  242,   1,  HF
NCON,  275,  275,   1,  HF
NCON,  276,  276,   1,  HF
NCON,  301,  301,   1,  HF
NCON,  307,  307,   1,  HF
NCON,  313,  313,   1,  HF
```

```
NCON,  323, 323,  1,  HF
NCON,  324, 324,  1,  HF
*
NCON,    7,   7,  1,  QF
NCON,    8,   8,  1,  QF
NCON,    9,   9,  1,  QF
NCON,   26,  26,  1,  QF
NCON,   46,  46,  1,  QF
NCON,   47,  47,  1,  QF
NCON,   48,  48,  1,  QF
NCON,   49,  49,  1,  QF
NCON,   51,  51,  1,  QF
NCON,   52,  52,  1,  QF
NCON,   89,  89,  1,  QF
NCON,  132, 132,  1,  QF
NCON,  139, 139,  1,  QF
NCON,  300, 300,  1,  QF
NCON,  343, 343,  1,  QF
NCON,  358, 358,  1,  QF
*
*
NCON,  162, 162,  1,  QF
NCON,  163, 163,  1,  QF
NCON,  164, 164,  1,  QF
NCON,  173, 173,  1,  QF
NCON,  174, 174,  1,  QF
NCON,  180, 180,  1,  QF
NCON,  181, 181,  1,  QF
NCON,  182, 182,  1,  QF
NCON,  193, 193,  1,  QF
NCON,  194, 194,  1,  QF
NCON,  195, 195,  1,  QF
NCON,  196, 196,  1,  QF
NCON,  209, 209,  1,  QF
NCON,  210, 210,  1,  QF
NCON,  211, 211,  1,  QF
NCON,  212, 212,  1,  QF
NCON,  215, 215,  1,  QF
NCON,  216, 216,  1,  QF
NCON,  217, 217,  1,  QF
NCON,  218, 218,  1,  QF
NCON,  236, 236,  1,  QF
NCON,  237, 237,  1,  QF
NCON,  243, 243,  1,  QF
NCON,  244, 244,  1,  QF
NCON,  245, 245,  1,  QF
NCON,  277, 277,  1,  QF
NCON,  278, 278,  1,  QF
NCON,  279, 279,  1,  QF
NCON,  302, 302,  1,  QF
NCON,  303, 303,  1,  QF
NCON,  304, 304,  1,  QF
NCON,  305, 305,  1,  QF
NCON,  308, 308,  1,  QF
NCON,  309, 309,  1,  QF
NCON,  310, 310,  1,  QF
NCON,  311, 311,  1,  QF
NCON,  312, 312,  1,  QF
NCON,  314, 314,  1,  QF
*
*
*    --- INITIAL CONDITION ---
```

Eastern boundary (specified flow) — applies to nodes 7 through 358.

Recharge through wadi bed (specified flow) — applies to nodes 162 through 314.

```
*
*        NODE                        HEAD(M)
*
INIP,      1,       1,        1,1120.00
INIP,     27,      27,        1,1120.00
INIP,     33,      33,        1,1120.00
INIP,     53,      53,        1,1140.00
INIP,     59,      59,        1,1160.00
INIP,    104,     104,        1,1190.00
INIP,    149,     149,        1,1450.00
INIP,    150,     150,        1,1420.00
INIP,    151,     151,        1,1440.00
INIP,    154,     154,        1,1310.00
INIP,    161,     161,        1,1440.00
INIP,    172,     172,        1,1440.00
INIP,    179,     179,        1,1460.00
INIP,    191,     191,        1,1500.00
INIP,    192,     192,        1,1420.00
INIP,    208,     208,        1,1480.00
INIP,    242,     242,        1,1480.00
INIP,    275,     275,        1,1500.00
INIP,    276,     276,        1,1470.00
INIP,    301,     301,        1,1500.00
INIP,    307,     307,        1,1500.00
INIP,    313,     313,        1,1500.00
INIP,    323,     323,        1,1500.00
INIP,    324,     324,        1,1500.00
*
```

Specified head along the western boundary

```
INIQ,    7,    7,   1,  -1800
INIQ,    8,    8,   1,  -2400
INIQ,    9,    9,   1,  -2400
INIQ,   26,   26,   1,  -2400
INIQ,   46,   46,   1,  -2400
INIQ,   47,   47,   1,  -1400
INIQ,   48,   48,   1,  -1400
INIQ,   51,   51,   1,  -2800
INIQ,   52,   52,   1,  -2800
INIQ,   89,   89,   1,  -4000
INIQ,  132,  132,   1,  -4800
INIQ,  139,  139,   1,  -5600
INIQ,  300,  300,   1,  -5600
INIQ,  343,  343,   1,  -4800
INIQ,  358,  358,   1,  -4800
*
*
```

Specified flow along the eastern boundary

```
INIQ,  162,  162,   1,   1918
INIQ,  163,  163,   1,    274
INIQ,  164,  164,   1,    274
INIQ,  173,  173,   1,    274
INIQ,  174,  174,   1,    548
INIQ,  180,  180,   1,    274
INIQ,  181,  181,   1,    548
INIQ,  182,  182,   1,    822
INIQ,  193,  193,   1,    137
INIQ,  194,  194,   1,    137
INIQ,  195,  195,   1,    137
INIQ,  196,  196,   1,   1233
INIQ,  209,  209,   1,   1781
INIQ,  210,  210,   1,    274
INIQ,  211,  211,   1,    274
INIQ,  212,  212,   1,    274
INIQ,  215,  215,   1,    274
```

Specified flow for recharge through wadi bed

```
INIQ,  216, 216,  1,    274
INIQ,  217, 217,  1,    274
INIQ,  218, 218,  1,    274
INIQ,  236, 236,  1,    411
INIQ,  237, 237,  1,    411
INIQ,  243, 243,  1,    274
INIQ,  244, 244,  1,    274
INIQ,  245, 245,  1,    548
INIQ,  277, 277,  1,    274
INIQ,  278, 278,  1,    411
INIQ,  279, 279,  1,    411
INIQ,  302, 302,  1,    137
INIQ,  303, 303,  1,    274
INIQ,  304, 304,  1,    411
INIQ,  305, 305,  1,    411
INIQ,  308, 308,  1,    137
INIQ,  309, 309,  1,    137
INIQ,  310, 310,  1,    274
INIQ,  311, 311,  1,    137
INIQ,  312, 312,  1,    137
INIQ,  314, 314,  1,    685
*
*
*    -----  AQUIFER CONSTANTS  -----
*
*       K : COEFFICIENT OF INFILTRATION CAPACITY
*       S : COEFFICIENT OF STORAGE
*
*                 SYMBOL OF     K          S
*                 AQUIFER
*
LAYE, 40
                  GS00,         1.0E-08,  1.00E-07
                  GS01,         1.0E-08,  1.00E-03
                  GS02,         1.0E-08,  9.09E-04
                  GS03,         1.0E-08,  8.03E-04
                  GS04,         1.0E-08,  6.75E-04
                  GS05,         1.0E-08,  5.02E-04
                  GS06,         1.0E-08,  3.73E-04
                  GS07,         1.0E-08,  3.30E-04
                  GS08,         1.0E-08,  2.77E-04
                  GS09,         1.0E-08,  2.06E-04
                  GS10,         1.0E-08,  1.39E-04
                  GS11,         1.0E-08,  1.23E-04
                  GS12,         1.0E-08,  1.03E-04
                  GS13,         1.0E-08,  7.67E-05
                  GS14,         1.0E-08,  5.18E-05
                  GS15,         1.0E-08,  3.85E-05
                  GS16,         1.0E-08,  1.93E-05
                  GS17,         1.0E-08,  7.20E-06
                  GS18,         1.0E-08,  2.68E-06
                  GS19,         1.0E-08,  1.00E-06
                  AQ00,         1.0E-08,  1.00E-07
                  AQ01,       100.0,      0.25
                  AQ02,        80.0,      0.2391
                  AQ03,        60.0,      0.2258
                  AQ04,        40.0,      0.2082
                  AQ05,        20.0,      0.1813
                  AQ06,        10.0,      0.1578
                  AQ07,         7.5,      0.1490
                  AQ08,         5.0,      0.1374
                  AQ09,         2.5,      0.1197
                  AQ10,         1.0,      0.0997
```

```
                 AQ11,         0.75,        0.0941
                 AQ12,         0.50,        0.0868
                 AQ13,         0.25         0.0756
                 AQ14,         0.10,        0.0629
                 AQ15,         0.05,        0.0548
                 AQ16,         0.01,        0.0397
                 AQ17,         0.001,       0.0251
                 AQ18,         0.0001,      0.0158
                 AQ19,         0.00001,     0.0100
*
*
*    --- GEOLOGICAL DATA ---
*
GENE
*
*
*
ENDD
```

Geological data are read from 'FOR021.DAT' by GENE command.

(5) Initial Condition

The initial condition of piezometric head is assumed at DH m above the elevation at bottom of the B2/A7 as shown below.

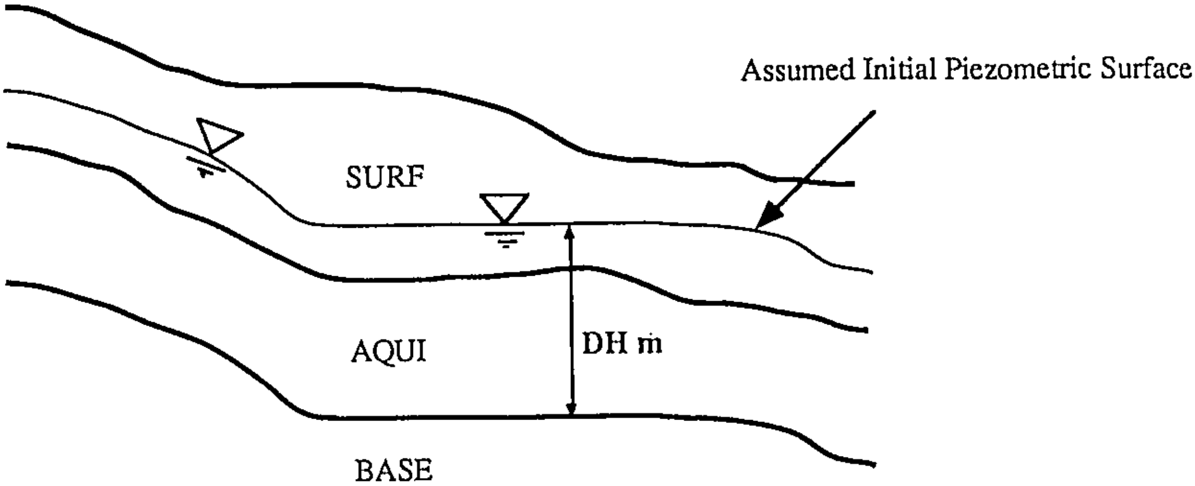


Fig. 17 Assumption of Initial Head

The data of initial condition for each node are prepared. The data file 'MODEL2.DAT', which ncludes all the data needed for FEM calculation, is created by the program '**INIP**'. The operation of 'INIP' is described below.

1) $ **INIP** [enter]

2) 1. New Date File
2. Old Data File

Please Select (1/2) ? **1**

3) Default File Name

UNIT1 : FOR021.DAT (default only)
UNIT2 : MODEL2.NEW
UNIT3 : MODEL2.DAT

Use Default ? (Y/N) **Y**

4) UNIT1: FOR021.DAT
UNIT2: MODEL2.NEW
UNIT3: MODEL2.DAT

Press enter to continue [enter]

5) Setting Initial Head
(Initial Head) = (top of BASE) + DH

DH (m) ? = **150** — Initial head is assumed at 150 m above the top elevation of layer symbolized 'BASE'

.
.
.

(processing)

.
.
.

FORTRAN STOP

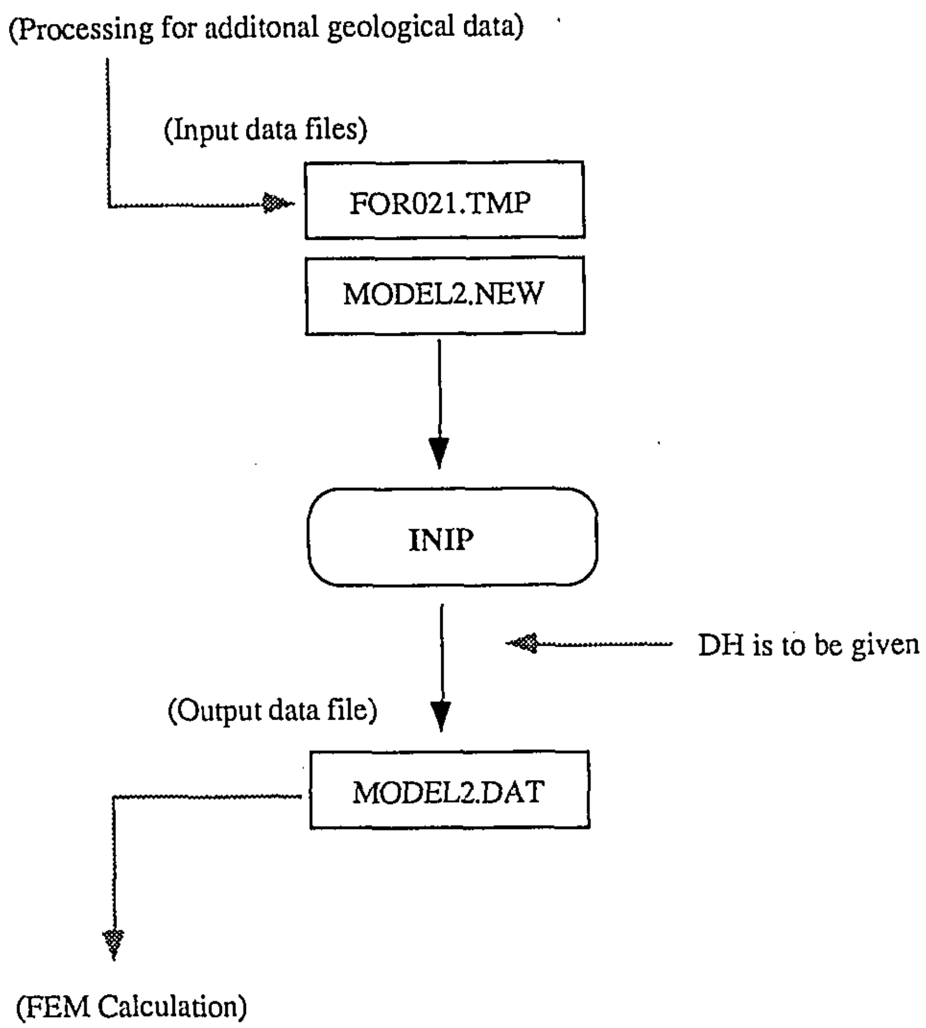


Fig. 18 Processing for Assumption of Initial Head

2. FEM Calculation by UNISSF2

(1) Data Check

1) $ UNISSF [enter]

2)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
END         < E >
```

PLEASE ENTER ----> M [enter] ('M' for UNISSF2)

3) RESTART ? (Y/N) N [enter]

4) FILE NAME(?.dat) MODEL2 [enter]

.
.
.
(checking the data)
.
.
.

FORTRAN STOP

```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
END         < E >
```

PLEASE ENTER ----> E [enter] ('E' for end)

5) $ ED MODEL2.PRN [enter] (print output to be checked)

6) Press PF4 function key (at the end of check)

7) Command : QUIT [enter]

(2) FEM Calculation

1) **$ ED MODEL2.DAT** [enter]

   1st line of the data to be changed

```
SETTING, CHEC,  100
   ↓
SETTING, RUN ,  100
          ↑
```

   (RUN + one blank)

2) Press **PF4** key (at the end of edit)
3) Command : **EXIT** [enter] (save the data)

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >

   PLEASE ENTER ---> M [enter] ('M' for UNISSF2)

6) RESTART ? (Y/N) **N**

7) FILENAME (?.dat) **MODEL2**

   .
   .
   .
   (processing) It takes about 30 minutes by VAX 8200
   .
   .
   .
   FORTRAN STOP

8) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >

   PLEASE ENTER ---> **E** [enter]

9) **$ ED MODEL2.PRN** [enter]

10) Press **PF4** function key
11) Command: **QUIT** [enter]

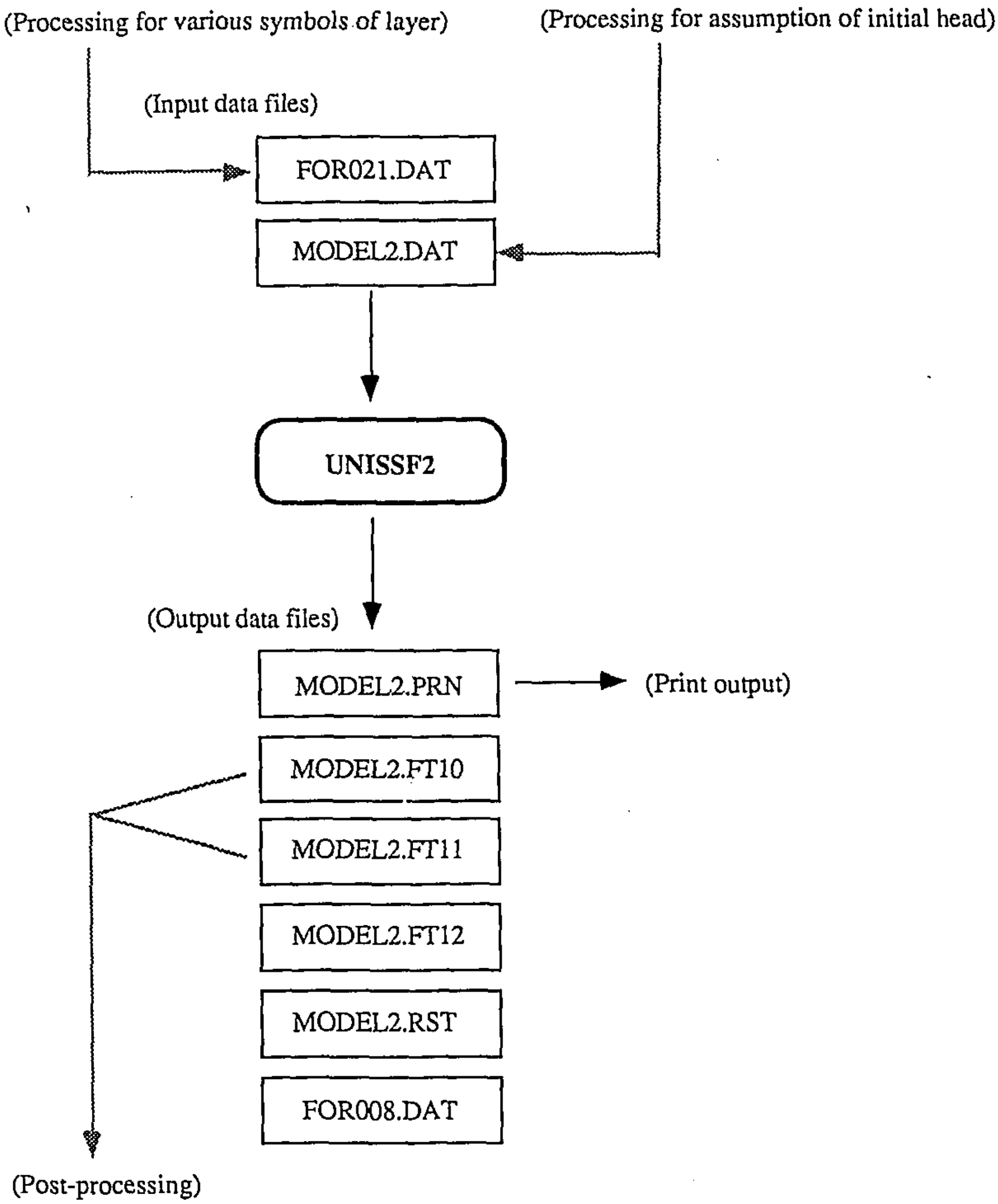


Fig. 19 FEM Calculation

3. Post-processing by UNISSF2/P

(1) Creation of the data file for plot control

1) $ ED CONT.DAT

2) Input Data

```
START,2,TP
SUBTITLE

NNUM, OFF
ENUM, OFF
DIVI, OFF
DOWN, OFF
MESH, OFF
FPRI, ON
SCAL, A4
CONT, MANU
 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950,
1000,1050,1100,1150,1200,1250,1300,1350,1400,1450,1500,1550,
1600,1650
VECT, 25
PLOT, ALL
END
```

3) Press PF4 function key
4) Command : EXIT [enter]

(2) Post-processing

1) $ UNISSF [enter]

2) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **P** [enter] ('M' for **UNISSF2/P**)

3) FILENAME (?.dat) **CONT**

4) FILENAME (FT10) **MODEL2.FT10** [enter]

5) FILENAME (FT11) **MODEL2.FT11** [enter]

.
.
.
(processing)
.
.
.
FORTRAN STOP

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **E** [enter]

6) **$ ED CONT.PRN** [enter] (print output to be checked)

7) Press **PF4** function key (at the end of check)
8) Command: **QUIT** [enter]

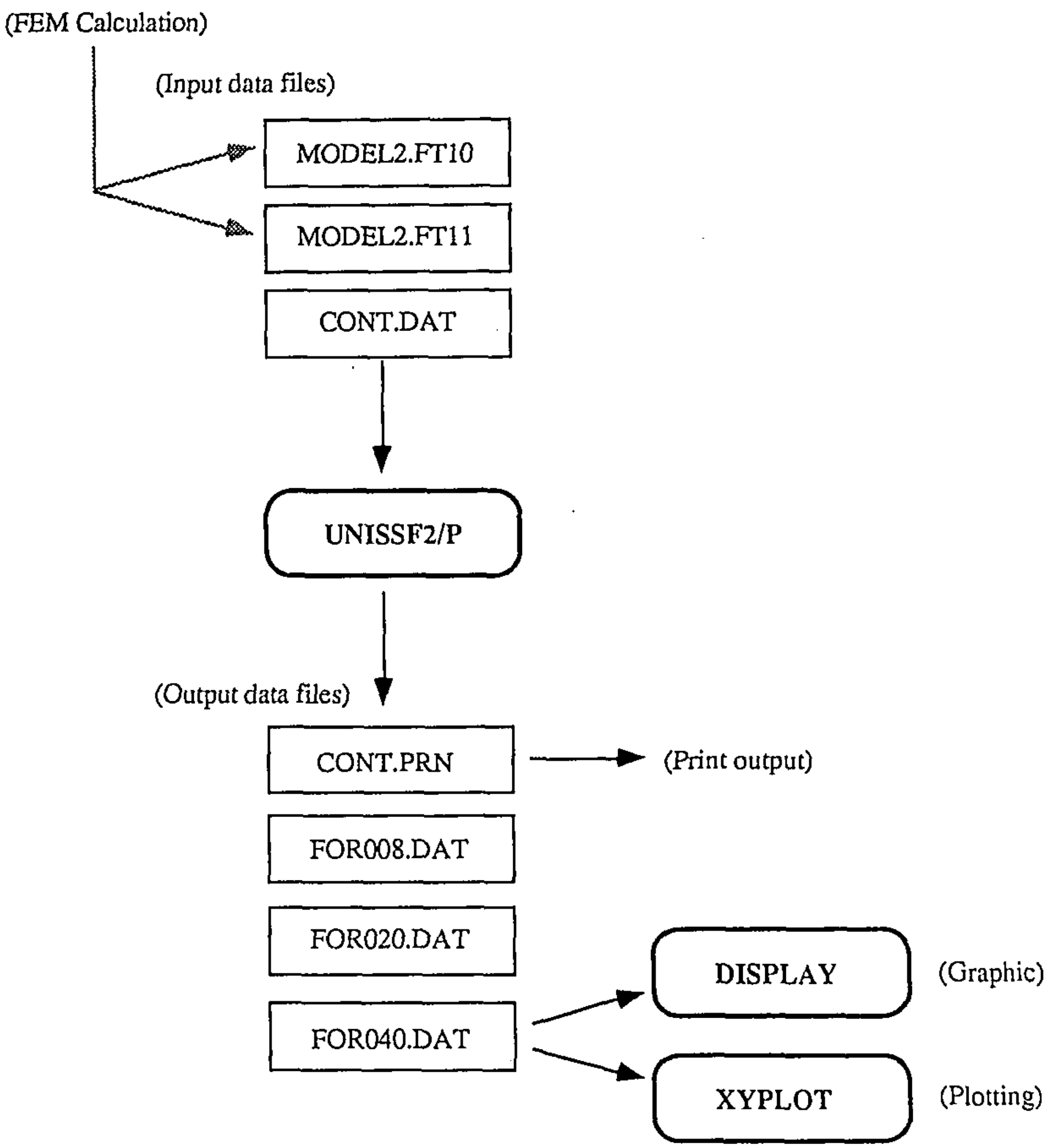


Fig. 20 Post-processing

(2) Plotting

1) Plotter set up
2) Paper set
3) Press '**On-line**' soft key

4) **$ UNISSF** [enter]

5)
```
UNISSF2     <M>
UNISSF2/G   <G>
UNISSF2/P   <P>
DISPLAY     <D>
XYPLOT      <X>
END         <E>
```

PLEASE ENTER ----> X [enter] ('X' for **XYPLOT**)

6) FILE NAME : **FOR040.DAT** [enter]

.
.
.
(plotting)
.
.
.

7) If there are more than 2 drawings, the plotting is stopped and the message '**HALT RECIEVED...**' is shown in the plotter window when each drawing is finished. Replace the paper, After sizing paper, press '**On-line**' soft key.

8) At the end of plotting, the message '**PLOT COMPLETE**' is shown in the plotter window.

9)
```
UNISSF2     <M>
UNISSF2/G   <G>
UNISSF2/P   <P>
DISPLAY     <D>
XYPLOT      <X>
END         <E>
```

PLEASE ENTER ----> E [enter]

(2) Plotting

1) Plotter set up
2) Paper set
3) Press '**On-line**' soft key

4) **$ UNISSF** [enter]

5)
```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

PLEASE ENTER ----> X [enter]   ('X' for XYPLOT)

6) FILE NAME : **FOR040.DAT** [enter]

.
.
.
(plotting)
.
.
.

7) If there are more than 2 drawings, the plotting is stopped and the message '**HALT RECIEVED...**' is shown in the plotter window when each drawing is finished. Replace the paper, After sizing paper, press '**On-line**' soft key.

8) At the end of plotting, the message 'PLOT COMPLETE' is shown in the plotter window.

9)
```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

PLEASE ENTER ----> E [enter]

CHAPTER V
STEADY STATE MODEL CALIBRATION

1. Assumption for the Steady State in the Study Area

The steady state analysis is based on the simple assumption that there are no artificial abstractions from the B2/A7 aquifer. A semi-steady state condition is assumed to calibrate the simulation model, which is based on assumptions that artificial abstraction does not exceed the annual average groundwater recharge without any influences on the regional piezometric surface. It is assumed that the piezometric surface in the study area was in a steady state and/or semi-steady state before 1970.

The model constructed by the data in 'FOR021.DAT' and MODEL2.DAT' is needed to be calibrated by comparing the calculated results with the estimated groundwater condition which was by the previous investigation and the studies.

2. Items to be Calibrated

(1) Piezometric Level at the Groundwater Monitoring Wells

The calculated head is needed to be calibrated by comparing with the piezometric head in the groundwater monitoring well. The 10 monitoring wells are selected and specified at the nodes in the FEM mesh as shown on Fig. 21. At these nodes, the calculated head is needed to be reasonably adjusted to the piezometric head of monitoring well.

(2) Piezometric Surface

The piezometric surface estimated by the field investigation and the studies prior to the groundwater model analysis is shown on Fig. 22. The contour diagram of piezometric surface obtained by calculation is need to approximately coincide with the estimated one.

(3) Groundwater Flow Path

The direction of groundwater flow in the B2/A7 aquifer is estimated as follows.

Western Highland → South Hasa → Hasa
Western Highland → Ma'an → Jafr

Monitoring wells (as of 1989)

Node	Well no.	Piezometric Level (El m)
16	H-15	783.00
50	JO-5	724.00
87	JT-4	785.17
94	S-121	988.49
114	JT-1	880.03
128	JO-3	790.28
160	JT-2	794.47
185	S-111	1179.29
197	S-65	1192.82
214	S-118	1270.67

Fig. 21 Groundwater Monitoring Wells

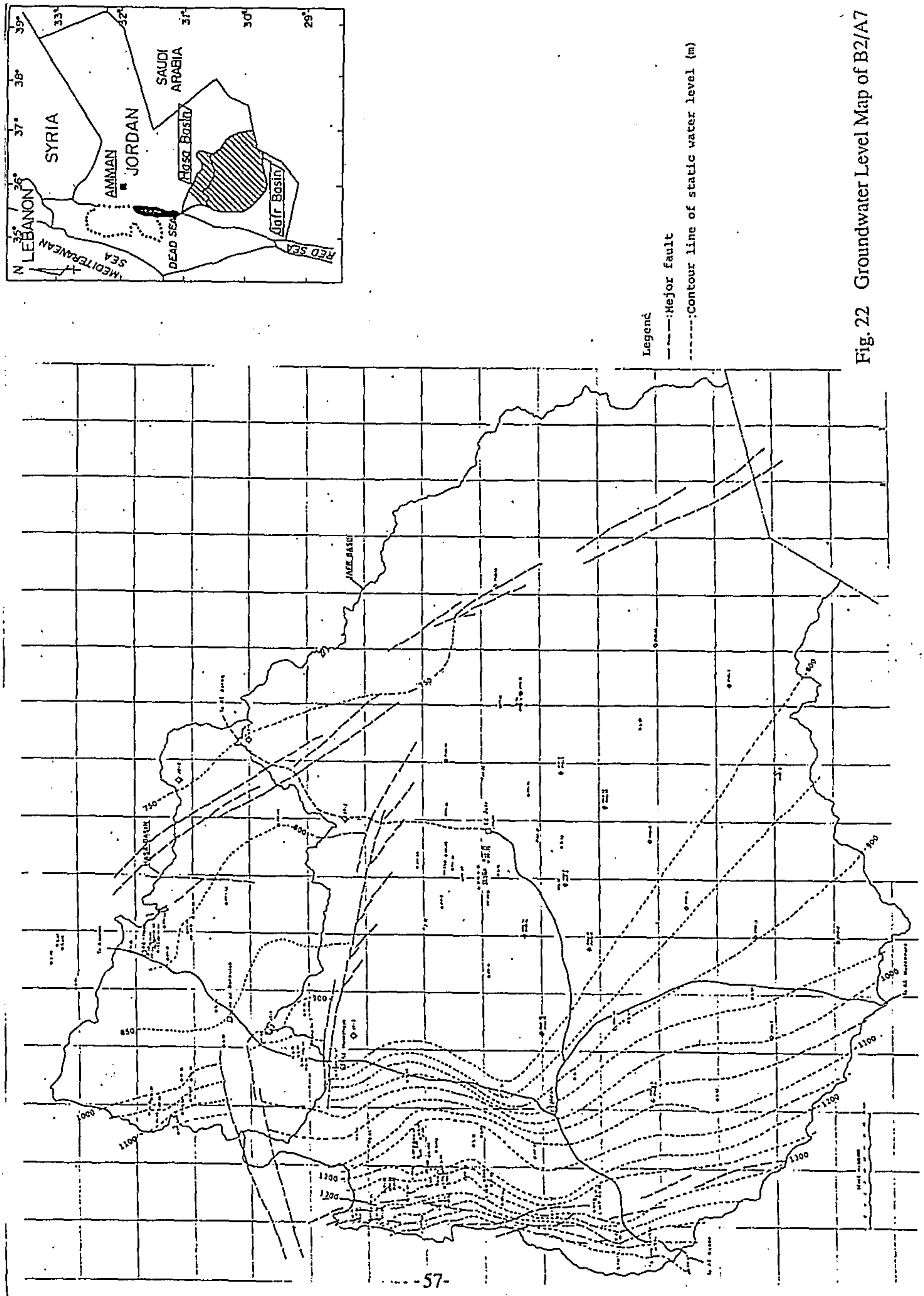


Fig. 22 Groundwater Level Map of B2/A7

4) Water Balance

Water Balance through the boundaries in the B2/A7 aquifer was estimated to be +/- 15 through 20 MCM/y. The calculated result of total recharge (+) / discharge (-) is need to be match with the range above.

2. Convergence of Solution

Unknown piezometric head is calculated by numerical analysis. Solution of the dominant equation for groundwater flow condition is obtained by iterative calculation. The calculation of unknown head is started from the initial condition. The value of head is fluctuating during iterative calculation. After several times of the iteration, the fluctuation is gradually decreasing. Finally, the value of head is almost stable and the range of fluctuation is nearly equal to zero. It is the convergence of solution and the calculation is successfully finished at this case. But in some case, the fluctuation is not decreased by the iteration and the stable solutions is not obtained. The convergence of solution is depend on the model which is made up with the input data.

The data for calculation control such as the maximum times of iteration and the error, which is a criterion for the convergence, are prepared for numerical analysis. These data are incorporated in the data file 'MODEL2.DAT' in the case of UNISSF.

(1) Maximum Times of Iteration and Error

Given by 'UNIT' command in 'MODEL2.DAT'

UNIT, ME, DAY, 25, **1.0E-01**

- Max. times of iteration : 25 times
- Error for the criterion of convergence : 0.1 m

(2) Output in the case of successful results

```
                                   CP-TIME IS   0.0000E+00  SEC. FOR INPUTS OR PREPARATION OF CAL.

TIME -       0.000    TIME STEP -   0    MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   0  WAS  6.07447E+02  AT NODE    157
TIME -       0.000    TIME STEP -   0    MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   1  WAS  3.06587E+01  AT NODE    113
***** FIX HEAD TO BOTTOM   ITER-  2 NODE-  10 P-  1.0243E+03  TO PNEW-  1.0270E+03
TIME -       0.000    TIME STEP -   0    MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   2  WAS  1.54330E+01  AT NODE      2
TIME -       0.000    TIME STEP -   0    MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   3  WAS  6.27172E+00  AT NODE    329
TIME -       0.000    TIME STEP -   0    MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   4  WAS  2.71737E+00  AT NODE    326
TIME -       0.000    TIME STEP -   0    MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   5  WAS  1.25960E+00  AT NODE    328
TIME -       0.000    TIME STEP -   0    MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   6  WAS  4.92750E-01  AT NODE    326
TIME -       0.000    TIME STEP -   0    MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   7  WAS  2.40776E-01  AT NODE    317
TIME -       0.000    TIME STEP -   0    MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION   8  WAS  9.19104E-02  AT NODE    330
```

The last line " ... **MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION 8 WAS 9.19194E-02 AT NODE 330**" shows the maximum fluctuation of calculated head is less than the error which is given by 0.1 m so that the calculation is successfully finished at the 8th of iteration.

(3) Output in the case of unsuccessful results

```
TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  18  WAS  7.90159E+01  AT NODE     3
***** FIX HEAD TO BOTTOM    ITER= 19 NODE= 299 P=  6.5864E+02  TO PNEW=  6.6255E+02
TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  19  WAS  2.52081E+02  AT NODE    13
***** FIX HEAD TO BOTTOM    ITER= 20 NODE= 300 P=  5.3358E+02  TO PNEW=  6.2000E+02
TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  20  WAS  1.08147E+02  AT NODE   241
TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  21  WAS  1.19977E+02  AT NODE     5
TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  22  WAS  1.55174E+02  AT NODE     4
***** FIX HEAD TO BOTTOM    ITER= 23 NODE=   5 P=  7.7595E+02  TO PNEW=  7.7676E+02
***** FIX HEAD TO BOTTOM    ITER= 23 NODE=   8 P=  6.7652E+02  TO PNEW=  6.8112E+02
***** FIX HEAD TO BOTTOM    ITER= 23 NODE=   9 P=  6.6582E+02  TO PNEW=  6.7000E+02
***** FIX HEAD TO BOTTOM    ITER= 23 NODE= 331 P=  7.2098E+02  TO PNEW=  7.5000E+02
***** FIX HEAD TO BOTTOM    ITER= 23 NODE= 344 P=  7.1115E+02  TO PNEW=  7.3000E+02
***** FIX HEAD TO BOTTOM    ITER= 23 NODE= 349 P=  7.0973E+02  TO PNEW=  7.3000E+02
***** FIX HEAD TO BOTTOM    ITER= 23 NODE= 350 P=  7.0878E+02  TO PNEW=  7.3000E+02
***** FIX HEAD TO BOTTOM    ITER= 23 NODE= 351 P=  7.0300E+02  TO PNEW=  7.1000E+02
TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  23  WAS  7.45509E+01  AT NODE   329
TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  24  WAS  1.05338E+02  AT NODE   196
TIME =       0.000     TIME STEP =   0     MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  25  WAS  1.22021E+02  AT NODE   196
```

The last line " ... **MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION 25 WAS 1.22021E+02 AT NODE 196**" shows the maximum fluctuation of calculated head is over the error which is given by 0.1 m so that the calculation is unsuccessfully finished in accordance with the maximum times of iteration.

For such case, the model constructed by the data is needed to be modified. Check items are described below;

- Maximum times of iteration is not enough
- Error of criterion for convergence is too small.
- Boundary condition is not appropriate.
- Initial condition is not appropriate.
- Model is too complicated.

3. Data Modification for Calibration

The model calibration is carried out by Trial and Error. After FEM calculation by 'UNISSF2' and post-processing by 'UNISSF2/P', the calculated results are delivered by print output and graphics and plotting. These outputs are compared with the estimated actual groundwater condition. If the calculated results do not coincide reasonably, the data in 'FOR021.DAT' and 'MODEL2.DAT' are needed to be modified and the next trial of calculation is to be performed.

The data modification and the trial of calculation are to be repeated until the reasonable results are obtained. Procedures from modification of data for the next trial are described below.

(1) Mesh Data

Case : - Mesh data is incorrect.
- Add or delete the nodes

1) **$ ED MESH.DAT** [enter]

2) (Data modification)

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) Mesh Data Processing ⟶ Refer to Page 4
6) Geological Data Processing ⟶ Refer to Page 12
7) Additional Geological Data ⟶ Refer to Page 21
8) Aquifer Symbols ⟶ Refer to Page 26

9) Assumption of Initial Head

1- **$ RENAME MODEL2.DAT MODEL2.OLD** [enter]
2- **$ INIP** [enter]

3- 1. New Date File
2. Old Data File

Please Select (1/2) ? **2**

4- Default File Name

UNIT1 : FOR021.DAT (default only)
UNIT2 : MODEL2.OLD
UNIT3 : MODEL2.DAT

Use Default ? (Y/N) **Y**

5- UNIT1: FOR021.DAT
UNIT2: MODEL2.NEW
UNIT3: MODEL2.DAT

Press enter to continue [enter]

6- Setting Initial Head
(Initial Head) = (top of BASE) + DH

DH (m) ? = **(INPUT)**

.
.
.

(processing)

.
.
.

FORTRAN STOP

10) FEM Calculation → Refer to Page 45
11) Post-processing → Refer to Page 48
12) Graphic or Plotting → Refer to Page 49 or 50

(2) Geological Data

Case : - Geological data is incorrect.
- Geological contour diagram is not preferable.

1) **$ ED GEOL.DAT** [enter]

2) (Data modification)

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) Geological Data Processing → Refer to Page 12
6) Additional Geological Data → Refer to Page 21
7) Aquifer Symbols → Refer to Page 26

8) Assumption of Initial Head

1- **$ RENAME MODEL2.DAT MODEL2.OLD** [enter]
2- **$ INIP** [enter]

3- 1. New Date File
2. Old Data File

Please Select (1/2) ? **2**

4- Default File Name

UNIT1 : FOR021.DAT (default only)
UNIT2 : MODEL2.OLD
UNIT3 : MODEL2.DAT

Use Default ? (Y/N) **Y**

5- UNIT1: FOR021.DAT
UNIT2: MODEL2.NEW
UNIT3: MODEL2.DAT

Press enter to continue [enter]

6- Setting Initial Head
(Initial Head) = (top of BASE) + DH

DH (m) ? = **(INPUT)**

.
.
.
(processing)
.
.
.

FORTRAN STOP

9) FEM Calculation → Refer to Page 45
10) Post-processing → Refer to Page 48
11) Graphic or Plotting → Refer to Page 49 or 50

(3) Additional Geological Data

Case : - Nodes needed to give the additional data are changed due to the modification of the geological data for key points and regions.

1) **$ ED GEOL.ADD** [enter]

2) (Data modification)

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) Additional Geological Data → Refer to Page 21
6) Aquifer Symbols → Refer to Page 26

7) Assumption of Initial Head

1- **$ RENAME MODEL2.DAT MODEL2.OLD** [enter]
2- **$ INIP** [enter]

3- 1. New Date File
2. Old Data File

Please Select (1/2) ? **2**

4- Default File Name

UNIT1 : FOR021.DAT (default only)
UNIT2 : MODEL2.OLD
UNIT3 : MODEL2.DAT

Use Default ? (Y/N) **Y**

5- UNIT1: FOR021.DAT
UNIT2: MODEL2.NEW
UNIT3: MODEL2.DAT

Press enter to continue [enter]

6- Setting Initial Head
(Initial Head) = (top of BASE) + DH

DH (m) ? = **(INPUT)**

.
.
.

(processing)

.
.
.

FORTRAN STOP

8)	FEM Calculation	→	Refer to Page 45
9)	Post-processing	→	Refer to Page 48
10)	Graphic or Plotting	→	Refer to Page 49 or 50

(4) Symbol of Layer (Aquifer Constants)

Case: - Calculated contour diagram of groundwater piezometric head is not preferable.

Aquifer constants K and S are changed in accordance with the modification of symbol of layer.

Example:

1- Modification of Symbols in 'NMAT.DAT'

Node	Symbol		Modified Symbol
1	AQ01	→	AQ04
2	AQ02	→	AQ05
3	AQ03	→	AQ06

2- Modification of Symbols in 'FOR021.DAT'

After modifying the 'NMAT.DAT', the program 'NMAT' is processed and the data stored in 'FOR021.DAT' are modified in accordance with the modified data in the 'NMAT.DAT'

(Previous)

GEOL,	1,	1,	1,	2
	BASE,	AQ01,		GS01
	(H_{11})	(H_{12})		(H_{13})
GEOL,	2,	2,	1,	2
	BASE,	AQ02,		GS02
	(H_{21})	(H_{22})		(H_{23})
GEOL,	3,	3,	1,	2
	BASE,	AQ03,		GS03
	(H_{31})	(H_{32})		(H_{33})

(Modified)

GEOL,	1,	1,	1,	2
	BASE,	**AQ04,**		**GS04**
	(H_{11})	(H_{12})		(H_{13})
GEOL,	2,	2,	1,	2
	BASE,	**AQ05,**		**GS05**
	(H_{21})	(H_{22})		(H_{23})
GEOL,	3,	3,	1,	2
	BASE,	**AQ06,**		**GS06**
	(H_{31})	(H_{32})		(H_{33})

3- Modification of K and S

K and S are automatically selected from the table of symbols, K and S in 'MODEL2.DAT'.

(Table of Symbols, K and S in 'MODEL2.DAT')

Symbol	K	S
GS01	K_1	S_1
GS02	K_2	S_2
GS03	K_3	S_3
GS04	K_4	S_4
GS05	K_5	S_5
GS06	K_6	S_6
.		
.		
.		
AQ01	K'_1	S'_1
AQ02	K'_2	S'_2
AQ03	K'_3	S'_3
AQ04	K'_4	S'_4
AQ05	K'_5	S'_5
AQ06	K'_6	S'_6
.		
.		
.		

(Modified 'FOR021.DAT')

GEOL, 1,	1, 1,	2	
	BASE,	AQ04,	GS04
	(H_{11})	(H_{12})	(H_{13})
GEOL, 2,	2, 1,	2	
	BASE,	AQ05,	GS05
	(H_{21})	(H_{22})	(H_{23})
GEOL, 3,	3, 1,	2	
	BASE,	AQ06,	GS06
	(H_{31})	(H_{32})	(H_{33})

(K and S selected during FEM calculation)

Node 1	Upper layer	$K = K_4$,	$S = S_4$
	Aquifer	$K = K'_4$,	$S = S'_4$
Node 2	Upper layer	$K = K_5$,	$S = S_5$
	Aquifer	$K = K'_5$,	$S = S'_5$
Node 3	Upper layer	$K = K_6$,	$S = S_6$
	Aquifer	$K = K'_6$,	$S = S'_6$

1) **$ ED NMAT.DAT** [enter]

2) (Data modification)

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) Aquifer Symbols (Modification of symbols in 'FOR021.DAT') ──► Refer to Page 26

6) FEM Calculation ──► Refer to Page 45
7) Post-processing ──► Refer to Page 48
8) Graphic or Plotting ──► Refer to Page 49 or 50

(5) Boundary Conditions

Case:
- Calculated contour diagram of groundwater piezometric head is not preferable.
- Calculated water balance in the study area is not reasonable.
- Solution is not converged.

1) **$ ED MODEL2.DAT** [enter]

2) (Data modification)

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) FEM Calculation → Refer to Page 45
6) Post-processing → Refer to Page 48
7) Graphic or Plotting → Refer to Page 49 or 50

(6) Initial Condition

Case: - Calculated contour diagram of groundwater piezometric head is not preferable.
- Solution is not converged.

1) Assumption of Initial Head

1- **$ RENAME MODEL2.DAT MODEL2.OLD** [enter]
2- **$ INIP** [enter]

3- 1. New Date File
2. Old Data File

Please Select (1/2) ? 2

4- Default File Name

UNIT1 : FOR021.DAT (default only)
UNIT2 : MODEL2.OLD
UNIT3 : MODEL2.DAT

Use Default ? (Y/N) **Y**

5- UNIT1: FOR021.DAT
UNIT2: MODEL2.NEW
UNIT3: MODEL2.DAT

Press enter to continue [enter]

6- Setting Initial Head
(Initial Head) = (top of BASE) + DH

DH (m) ? = **(INPUT)** (another DH to examine)

.
.
.
(processing)
.
.
.
FORTRAN STOP

2)	FEM Calculation	→	Refer to Page 45
3)	Post-processing	→	Refer to Page 48
4)	Graphic or Plotting	→	Refer to Page 49 or 50

Table 6 Calibrated Piezometric Level (Steady State Calibration)

Well no.	Node	Piezometric Level (as of 1988, El m)	Calculated (EL m)
H-15	16	783.00	805
JO-5	50	724.00	739
JT-4	87	785.17	748
S-121	94	988.49	991
JT-1	114	880.03	888
JO-3	128	790.28	778
JT-2	160	794.47	808
S-111	185	1179.29	1167
S-65	197	1192.82	1194
S-118	214	1270.67	1276

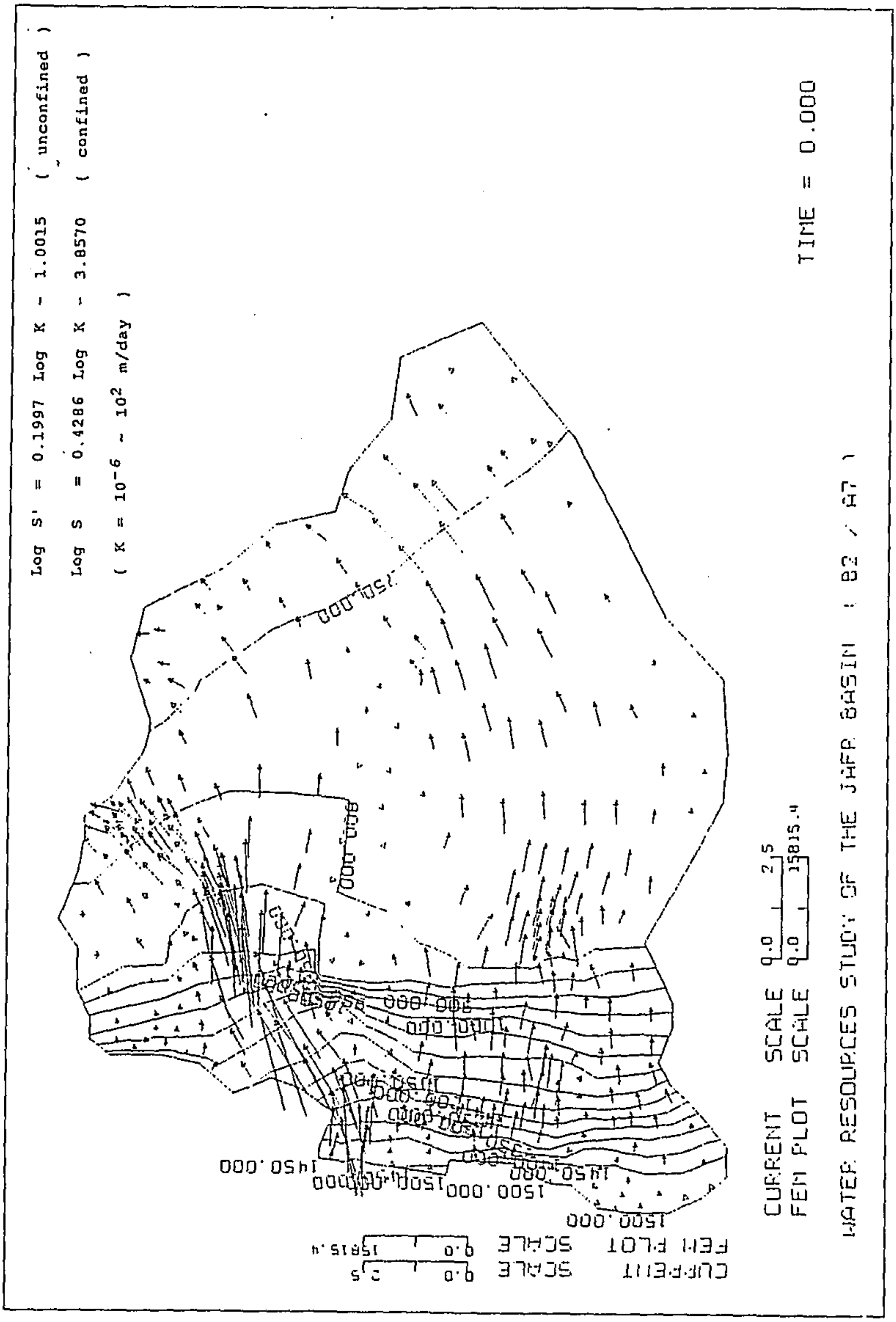


Fig. 23 Calibrated Piezometric Surface and Regional Flow Vector

CHAPTER VI
NON-STEADY STATE CALIBRATION

1. Calibration of Drawdown

The non-steady state model calibration is performed to estimate the coefficient of storage (S) in the monitoring area. The drawdown of piezometric surface is depend on the coefficient of storage. For example, the more drawdown is given by the less coefficient of storage. The coefficient of storage of the model is adjusted by comparing calculated drawdown with actual drawdown in the monitoring well.

Successive decreases in the piezometric head have been monitored in the monitoring well at S-121 since 1973. The non-steady state model assumes that the regional piezometric surface was in a steady state and/or semi-steady state before 1970. Fifteen years of monitoring records (1973-1988) are used to calibrate the computed piezometric head.

2. Additional Data for Non-steady State Calibration

(1) Abstractions

The existing abstractions from 1973 to 1988 are estimated to calculate the drawdown of piezometric surface in the study area. The abstractions are mainly located in the Hasa Mine and the Western Highlands as shown in Figs. 24 and 25. The installation year of wells and the increasing of pumping rate are also considered. The data of abstractions are shown on Tables 7 to 10.

(2) Time Step

FEM Calculation for non-steady analysis is proceeded by time-step, which is a short time length divided from the total calculation time of 16 year (1973 -1988). The time step is possible to give stage-wise. The time step DT1, DT2 and DT3 are given to the STAGE1,STAGE2 and STAGE3 respectively. In general, time step is needed to be short in the early stage and longer in the later stage to save the calculation time.

(6) Output time

Print and plot outputs are obtained by specifying the output time.

Table 7 Existing Abstractions

Hasa Basin as of 1988

Node	Pumping (mcm/year)	Pumping (m3/day)	Remarks
14	-0.74	-2027	(H-23)
16	-0.04	-110	(H-15)
19	-0.93	-2548	(H-20)
20	-0.45	-1233	(H-17)
21	-1.09	-2986	(H-19)
22	-1.41	-3863	(H-21)
41	-1.28	-3507	(H-12)
43	-0.23	-630	(H-11)
44	-0.09	-247	(H-13)
72	-1.12	-3068	(H-6)
92	-0.25	-685	Cement factory
93	-0.25	-685	Cement factory
95	-0.10	-274	Irrigation
109	-0.10	-274	Irrigation
110	-0.10	-274	Irrigation
111	-0.10	-274	Irrigation

Table 8 Existing Abstractions and Recharge through Wadi Bed

Jafr Basin as of 1988

Node	Pumping (mcm/year)	Pumping (m3/day)	Recharge through Wadi Bed (mcm/year)	Recharge through Wadi Bed (m3/day)	Total (m3/day)	Remarks
152	-0.30	-822			-822	Irrigation
162	-1.75	-4795	0.70	1918	-2877	Shoubak
163			0.10	274	274	
164			0.10	274	274	
173	-0.30	-822	0.10	274	-548	Irrigation
174	-0.30	-822	0.20	548	-274	Irrigation
175	-0.20	-548			-548	Irrigation
176	-0.20	-548			-548	Irrigation
180	-0.27	-740	0.10	274	-466	Irrigation
181	-0.30	-822	0.20	548	-274	Irrigation
182	-0.30	-822	0.30	822	0	Irrigation
183	-0.20	-548			-548	Irrigation
193	-0.30	-822	0.05	137	-685	Irrigation
194	-0.30	-822	0.05	137	-685	Irrigation
195	-0.30	-822	0.05	137	-685	Irrigation
196	-0.70	-1918	0.45	1233	-685	Arja
209	-0.85	-2329	0.65	1781	-548	Qa Ma'an
210			0.10	274	274	
211			0.10	274	274	
212			0.10	274	274	
215			0.10	274	274	
216			0.10	274	274	
217			0.10	274	274	
218			0.10	274	274	
236			0.15	411	411	
237			0.15	411	411	
239	-1.35	-3699			-3699	Tahouneh
243			0.10	274	274	
244			0.10	274	274	
245			0.20	548	548	
277			0.10	274	274	
278			0.15	411	411	
279			0.15	411	411	
282	-0.20	-548			-548	Irrigation
283	-0.20	-548			-548	Irrigation
302			0.05	137	137	
303			0.10	274	274	
304	-0.30	-822	0.15	411	-411	Irrigation
305			0.15	411	411	
306	-0.20	-548			-548	Irrigation
308			0.05	137	137	
309			0.05	137	137	
310			0.10	274	274	
311			0.05	137	137	
312			0.05	137	137	
314	-0.53	-1452	0.25	685	-767	Irrigation
345	-0.365	-1000			-1000	Shadya Mine
346	-0.365	-1000			-1000	Shadya Mine

Table 9 Input Data for Existing Abstractions (1)

Hasa Mine * ( ) : Node number

Year	H-23 (14)	H-15 (16)	H-20 (19)	H-17 (20)	H-19 (21)	H-21 (22)	H-12 (41)	H-11 (43)	H-13 (44)	H-6 (72)
1988	-2027	-110	-2548	-1233	-2986	-3863	-3507	-630	-247	-3068
1987	-1927	-104	-2422	-1172	-2839	-3672	-3334	-599	-234	-2917
1986	-1832	-99	-2302	-1114	-2699	-3491	-3169	-569	-223	-2773
1985	-1742	-94	-2189	-1059	-2565	-3318	-3012	-541	-212	-2636
1984	-1656	-89	-2081	-1007	-2439	-3155	-2864	-515	-201	-2506
1983	-1574	-85	-1978	-957	-2318	-2999	-2722	-489	-191	-2382
1982	-1496	-81	-1880	-910	-2204	-2851	-2588	-465	-182	-2264
1981	-1422	-77	-1787	-865	-2095	-2710	-2460	-442	-173	-2152
1980	-1352	-73	-1699	-822	-1991	-2576	-2338	-420	-164	-2046
1979	-1285	-69	-1615	-782	-1893	-2449	-2223	-399	-156	-1945
1978	-1222	-66	-1535	-743	-1799	-2328	-2113	-380	-149	-1849
1977	-1161	-63	-1459	-706	-1711	-2213	-2009	-361	-141	-1758
1976	-1104	-60	-1387	-671	-1626	-2103	-1910	-343	-134	-1671
1975	-1049	-57	-1319	-638	-1546		-1815	-326	-128	-1588
1974	-998	-54	-1254	-607	-1469		-1726	-310	-121	-1510
1973	-948	-51	-1192	-577	-1397		-1640	-295	-115	-1435

Others ( ) : Node number

Year	Cement Factory		Irrigation **			
	(92)	(93)	(95)	(109)	(110)	(111)
1988	-685	-685	-274	-274	-274	-274
1987	-685	-685	-264	-264	-264	-264
1986	-685	-685	-255	-255	-255	-255
1985	-685	-685	-246	-246	-246	-246
1984			-237	-237	-237	-237
1983			-228	-228	-228	-228
1982			-220	-220	-220	-220
1981			-212	-212	-212	-212
1980			-205	-205	-205	-205
1979			-198	-198	-198	-198
1978			-191	-191	-191	-191
1977			-184	-184	-184	-184
1976			-177	-177	-177	-177
1975			-171	-171	-171	-171
1974			-165	-165	-165	-165
1973			-159	-159	-159	-159

Note : Assumption of increasing rate of pumping;

* Average increasing rate of pumping for the last 5 years

** Average increasing rate of population in Ma'an for the last 5 years

Table 10 Input Data for Existing Abstractions (2)

Water Supply * ( ) : Node number

Year	** Shoubak (162)	** Arja (196)	*** Qa Ma'an (209)	*** Tahouneh (239)
1988	-2877	-685	-548	-3699
1987	-2719	-622	-467	-3570
1986	-2567	-561	-387	-3443
1985	-2411	-499	-311	-3323
1984	-2260	-438	-233	-3198
1983	-2119	-382	-161	-3084
1982	-1983	-327	-92	-2974
1981	-1851	-275	-25	-2868
1980	-1723	-224	39	-2766
1979	-1600	-174	102	-2667
1978	-1481	-127	161	-2572
1977	-1366	-81	219	-2480
1976	-1255	-36	275	-2392
1975	-1148	7	329	-2306
1974	-1044	48	381	-2224
1973	-944	88	430	-2145

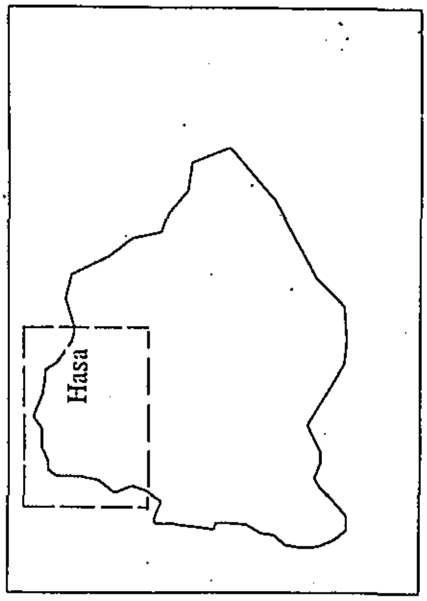
Note : * Recharge through wadi bed is considered.
Assumption of increasing rate of pumping;
** Average increasing rate of population in Tafila for the last 5 years
*** Average increasing rate of population in Ma'an for the last 5 years

Irrigation in the Shoubak Area * ( ) : Node number

Year	(152)	(173)	(174)	(175)	(176)	(180)	(181)	(182)	(183)	(193)	(194)	(195)
1988	-822	-548	-274	-548	-548	-466	-274	0	-548	-685	-685	-685
1987	-822	-548	-274	-548	-548	-466	-274	0	-548	-685	-685	-685
1986	-822	-548	-274	-548	-548	-466	-274	0	-548	-685	-685	-685
1985	-822	-548	-274	-548	-548	-466	-274	0	-548	-685	-685	-685
1984	-822	-548	-274	-548	-548	-466	-274	0	-548	-685	-685	-685
1983												
1982												
1981												
1980												
1979												
1978												
1977												
1976												
1975												
1974												
1973												

Others * ( ) : Node number

Year	Irrigation around Ma'an					Shidya Mine	
						SH1	SH2
	(282)	(283)	(306)	(304)	(314)	(345)	(346)
1988	-548	-548	-548	-411	-767	-274	-274
1987	-548	-548	-548	-411	-767	-274	-274
1986	-548	-548	-548	-411	-767	-274	-274
1985	-548	-548	-548	-411	-767	-274	-274
1984	-548	-548	-548	-411	-767	-274	-274
1983			-548	-411	-767		
1982			-548	-411	-767		
1981			-548	-411	-767		
1980			-548	-411	-767		
1979			-548	-411	-767		
1978			-548	-411	-767		
1977			-548	-411	-767		
1976			-548	-411	-767		
1975			-548	-411	-767		
1974			-548	-411	-767		
1973			-548	-411	-767		



Node	Pumping (MCM/y)
14	-0.74
16	-0.04
19	-0.93
20	-0.45
21	-1.09
22	-1.41
41	-1.28
43	-0.23
44	-0.09
72	-1.12
92	-0.25
93	-0.25
95	-0.10
109	-0.10
110	-0.10
111	-0.10

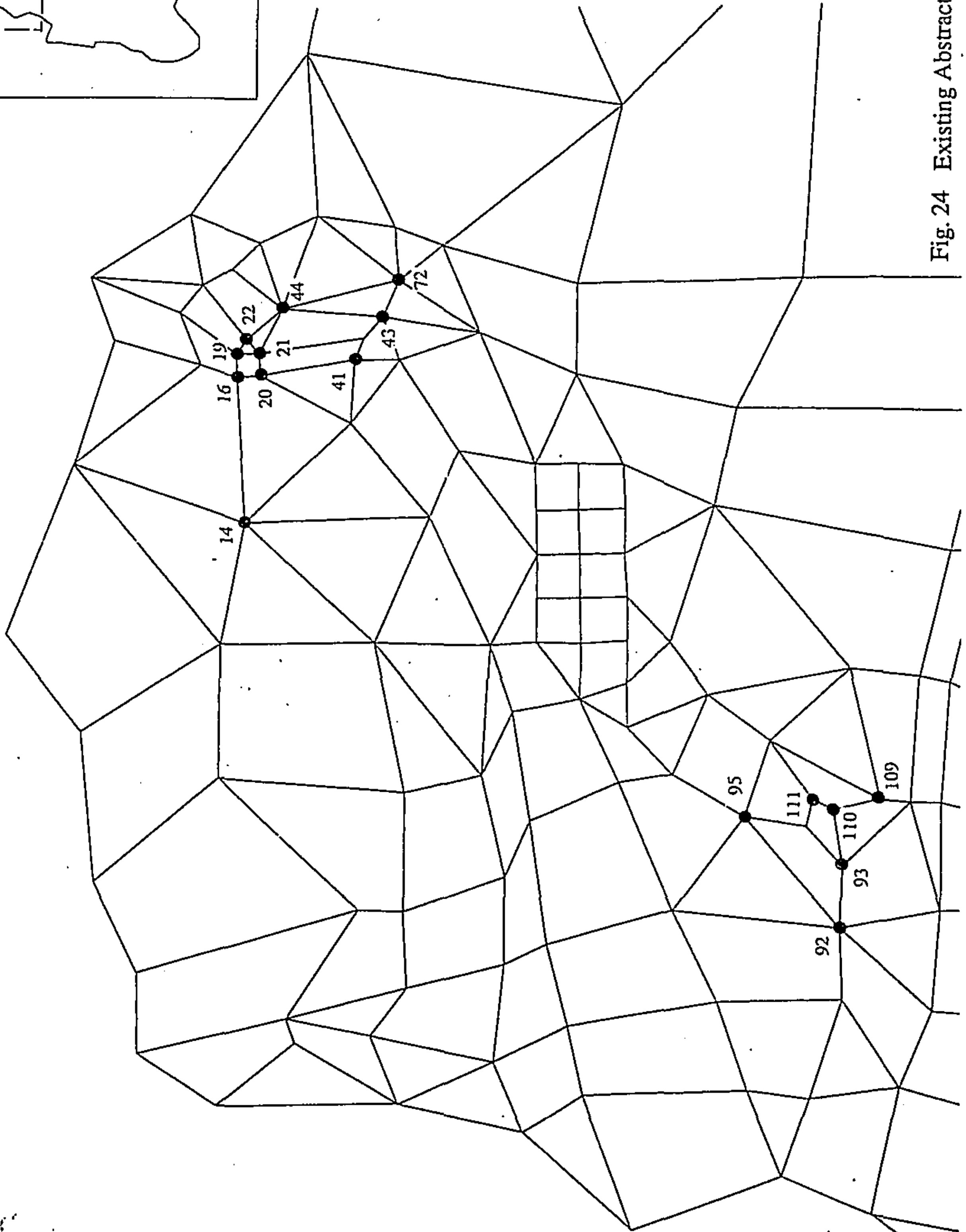
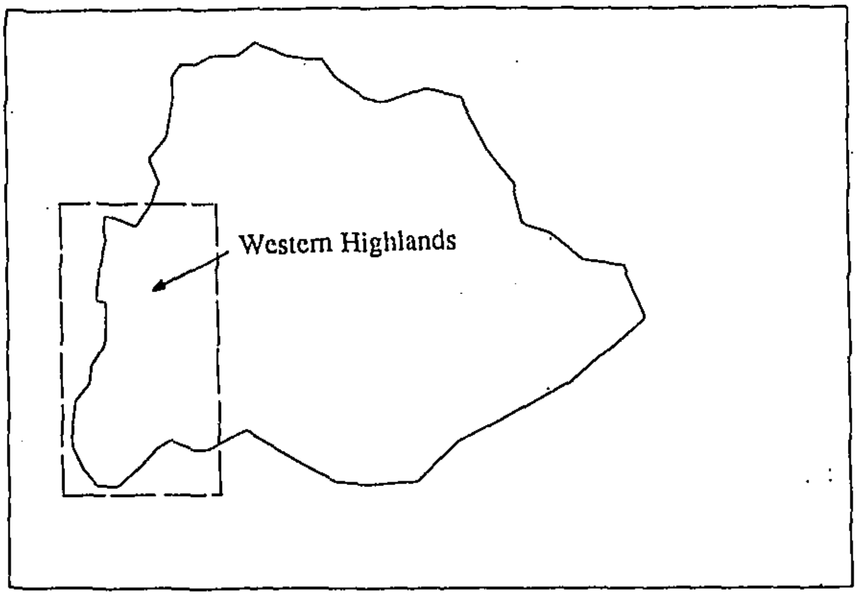
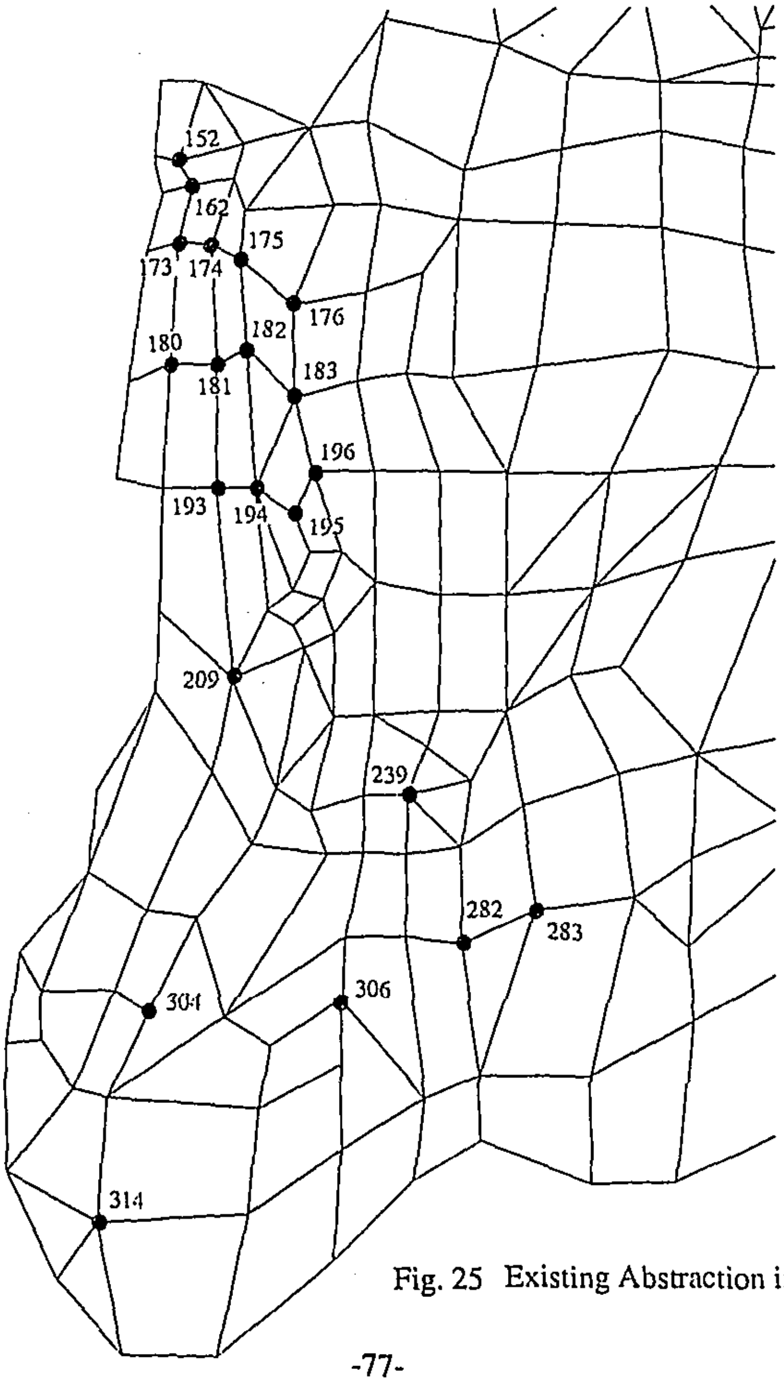


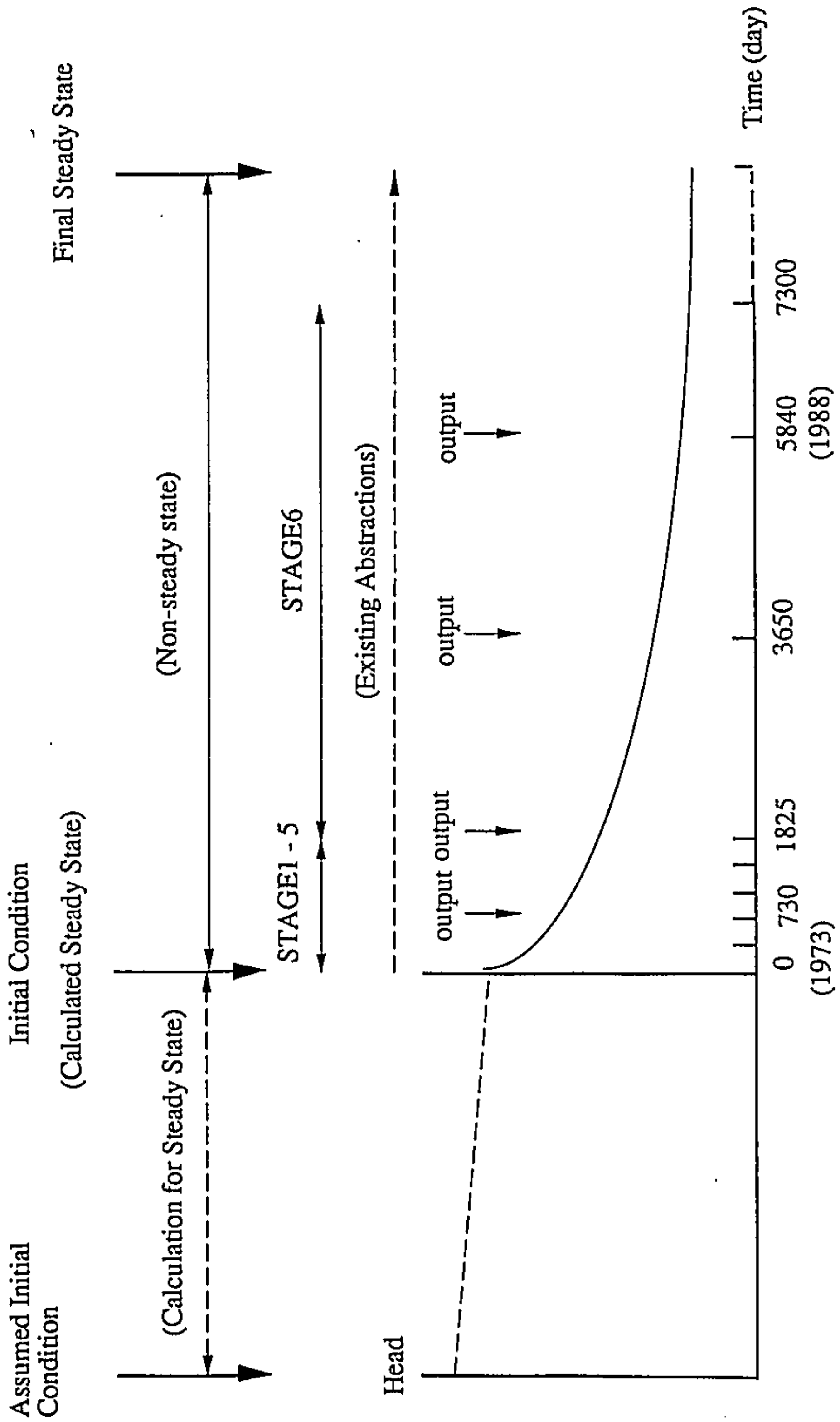
Fig. 24 Existing Abstraction in the Hasa Basin





	Pumping (MCM/y)
152	-0.30
162	-1.75
173	-0.30
174	-0.30
175	-0.20
176	-0.20
180	-0.27
181	-0.30
182	-0.30
183	-0.20
193	-0.30
194	-0.30
195	-0.30
196	-0.70
209	-0.85
239	-1.35
282	-0.20
283	-0.20
304	-0.30
306	-0.20
314	-0.53
345	-0.365
346	-0.365

Fig. 25 Existing Abstraction in the Western Highlands



STAGE	TIME STEP	End of STAGE
1	DT1 = 9.125	T = 365
2	DT2 = 18.25	T = 730
3	DT3 = 36.5	T = 1095
4	DT4 = 73	T = 1460
5	DT5 = 91.25	T = 1825
6	DT6 = 192.5	T = 7300

Fig. 26 Time Stage and Step

3. Procedure of Calculation

Calculation is proceeded from the steady state first, and the initial condition of non-steady state calibration (time = 0) is obtained as the calculated results of the steady state. After this, calculation for non-steady state is started from time with the newly given condition data which include the existing abstractions.

4. Data Input

Additional data for non-steady calibration are given to the data file 'MODEL4.DAT' as shown below;

1) $ COPY MODEL2 .DAT MODEL4.DAT [enter]
2) $ ED MODEL4.DAT [enter]

Modified Data :

```
SETTING,  RUN ,  3600,   0
TITLE
     WATER RESOURCES STUDY OF THE JAFR BASIN   ( B2 / A7 )
1ST ,  361,  386,    8,  361,    3
2ND ,    2,    0,    0,    0,    0
3RD ,    0,    0,    0,    0,   17,    3
4TH ,    0,    0
*
*    --- MESH ---
*
GENE
*
*
*    --- TIME STEP ---
*
TIME,  6
STEP,  1,   9.125,   365
STEP,  2,  18.25 ,   730
STEP,  3,  36.5  ,  1095
STEP,  4,  73.0  ,  1460
STEP,  5,  91.25 ,  1825
STEP,  6, 182.5  ,  7300
*
*
UNIT,  ME    ,  DAY , 25,  1.0E-01
CONT,  STUN  ,  SURF  , FLUX
*
*
*    --- BOUNDARY CONDITION ---
*
*        HF :  SPECIFIED HEAD
*        QF :  SPECIFIED FLOW
*
*      NODE          CONDITION
*
```

Mesh data are read from 'FOR021.DAT' by GENE command.

Time stage and step (Non-steady)

Definition of node condition

Western boundary (specified head)

```
NCON,    1,    1,   1,   HF
NCON,   27,   27,   1,   HF
NCON,   33,   33,   1,   HF
NCON,   53,   53,   1,   HF
NCON,   59,   59,   1,   HF
NCON,  104,  104,   1,   HF
NCON,  149,  149,   1,   HF
NCON,  150,  150,   1,   HF
NCON,  151,  151,   1,   HF
NCON,  154,  154,   1,   HF
NCON,  161,  161,   1,   HF
NCON,  172,  172,   1,   HF
NCON,  179,  179,   1,   HF
NCON,  191,  191,   1,   HF
NCON,  192,  192,   1,   HF
NCON,  208,  208,   1,   HF
NCON,  242,  242,   1,   HF
NCON,  275,  275,   1,   HF
NCON,  276,  276,   1,   HF
NCON,  301,  301,   1,   HF
NCON,  307,  307,   1,   HF
NCON,  313,  313,   1,   HF
NCON,  323,  323,   1,   HF
NCON,  324,  324,   1,   HF
*
```

Eastern boundary (specified flow)

```
NCON,    7,    7,   1,   QF
NCON,    8,    8,   1,   QF
NCON,    9,    9,   1,   QF
NCON,   26,   26,   1,   QF
NCON,   46,   46,   1,   QF
NCON,   47,   47,   1,   QF
NCON,   48,   48,   1,   QF
NCON,   49,   49,   1,   QF
NCON,   51,   51,   1,   QF
NCON,   52,   52,   1,   QF
NCON,   89,   89,   1,   QF
NCON,  132,  132,   1,   QF
NCON,  139,  139,   1,   QF
NCON,  300,  300,   1,   QF
NCON,  343,  343,   1,   QF
NCON,  358,  358,   1,   QF
*
*
```

Recharge through wadi bed (specified flow)

```
NCON,  162,  162,   1,   QF
NCON,  163,  163,   1,   QF
NCON,  164,  164,   1,   QF
NCON,  173,  173,   1,   QF
NCON,  174,  174,   1,   QF
NCON,  180,  180,   1,   QF
NCON,  181,  181,   1,   QF
NCON,  182,  182,   1,   QF
NCON,  193,  193,   1,   QF
NCON,  194,  194,   1,   QF
NCON,  195,  195,   1,   QF
NCON,  196,  196,   1,   QF
NCON,  209,  209,   1,   QF
NCON,  210,  210,   1,   QF
NCON,  211,  211,   1,   QF
NCON,  212,  212,   1,   QF
NCON,  215,  215,   1,   QF
NCON,  216,  216,   1,   QF
NCON,  217,  217,   1,   QF
```

```
NCON,  218, 218,  1,  QF
NCON,  236, 236,  1,  QF
NCON,  237, 237,  1,  QF
NCON,  243, 243,  1,  QF
NCON,  244, 244,  1,  QF
NCON,  245, 245,  1,  QF
NCON,  277, 277,  1,  QF
NCON,  278, 278,  1,  QF
NCON,  279, 279,  1,  QF
NCON,  302, 302,  1,  QF
NCON,  303, 303,  1,  QF
NCON,  304, 304,  1,  QF
NCON,  305, 305,  1,  QF
NCON,  308, 308,  1,  QF
NCON,  309, 309,  1,  QF
NCON,  310, 310,  1,  QF
NCON,  311, 311,  1,  QF
NCON,  312, 312,  1,  QF
NCON,  314, 314,  1,  QF
*
*
*    --- INITIAL CONDITION ----

*
*        NODE                    HEAD(M)
*
INIP,       1,        1,      1,1250.00
INIP,       2,        2,      1,1050.00
INIP,       3,        3,      1, 950.00
INIP,       4,        4,      1, 950.00
INIP,       5,        5,      1, 926.76
INIP,       6,        6,      1, 930.00
INIP,       7,        7,      1, 872.21
INIP,       8,        8,      1, 831.12
INIP,       9,        9,      1, 820.00
INIP,      10,       10,      1,1176.98
   .
   .
   .
   .
   .
   .

INIP,     352,      352,      1, 838.63
INIP,     353,      353,      1, 833.45
INIP,     354,      354,      1, 805.77
INIP,     355,      355,      1, 822.46
INIP,     356,      356,      1, 820.94
INIP,     357,      357,      1, 820.04
INIP,     358,      358,      1, 830.00
INIP,     359,      359,      1, 830.00
INIP,     360,      360,      1, 820.00
INIP,     361,      361,      1, 820.00
*
INIP,       1,        1,      1,1120.00
INIP,      27,       27,      1,1120.00
INIP,      33,       33,      1,1120.00
INIP,      53,       53,      1,1140.00
INIP,      59,       59,      1,1160.00
INIP,     104,      104,      1,1190.00
INIP,     149,      149,      1,1450.00
INIP,     150,      150,      1,1420.00
INIP,     151,      151,      1,1440.00
```

Specified head along the western boundary

```
INIP,      154,      154,        1,1310.00
INIP,      161,      161,        1,1440.00
INIP,      172,      172,        1,1440.00
INIP,      179,      179,        1,1460.00
INIP,      191,      191,        1,1500.00
INIP,      192,      192,        1,1420.00
INIP,      208,      208,        1,1480.00
INIP,      242,      242,        1,1480.00
INIP,      275,      275,        1,1500.00
INIP,      276,      276,        1,1470.00
INIP,      301,      301,        1,1500.00
INIP,      307,      307,        1,1500.00
INIP,      313,      313,        1,1500.00
INIP,      323,      323,        1,1500.00
INIP,      324,      324,        1,1500.00
*
INIQ,     7,    7,   1,   -1800
INIQ,     8,    8,   1,   -2400
INIQ,     9,    9,   1,   -2400
INIQ,    26,   26,   1,   -2400
INIQ,    46,   46,   1,   -2400
INIQ,    47,   47,   1,   -1400
INIQ,    48,   48,   1,   -1400
INIQ,    51,   51,   1,   -2800
INIQ,    52,   52,   1,   -2800
INIQ,    89,   89,   1,   -4000
INIQ,   132,  132,   1,   -4800
INIQ,   139,  139,   1,   -5600
INIQ,   300,  300,   1,   -5600
INIQ,   343,  343,   1,   -4800
INIQ,   358,  358,   1,   -4800
*
*
INIQ,   162,  162,   1,    1918
INIQ,   163,  163,   1,     274
INIQ,   164,  164,   1,     274
INIQ,   173,  173,   1,     274
INIQ,   174,  174,   1,     548
INIQ,   180,  180,   1,     274
INIQ,   181,  181,   1,     548
INIQ,   182,  182,   1,     822
INIQ,   193,  193,   1,     137
INIQ,   194,  194,   1,     137
INIQ,   195,  195,   1,     137
INIQ,   196,  196,   1,    1233
INIQ,   209,  209,   1,    1781
INIQ,   210,  210,   1,     274
INIQ,   211,  211,   1,     274
INIQ,   212,  212,   1,     274
INIQ,   215,  215,   1,     274
INIQ,   216,  216,   1,     274
INIQ,   217,  217,   1,     274
INIQ,   218,  218,   1,     274
INIQ,   236,  236,   1,     411
INIQ,   237,  237,   1,     411
INIQ,   243,  243,   1,     274
INIQ,   244,  244,   1,     274
INIQ,   245,  245,   1,     548
INIQ,   277,  277,   1,     274
INIQ,   278,  278,   1,     411
INIQ,   279,  279,   1,     411
INIQ,   302,  302,   1,     137
```

Specified flow along the eastern boundary (INIQ nodes 7–358 above)

Specified flow for recharge through wadi bed (INIQ nodes 162–302 above)

```
INIQ,  303, 303,  1,    274
INIQ,  304, 304,  1,    411
INIQ,  305, 305,  1,    411
INIQ,  308, 308,  1,    137
INIQ,  309, 309,  1,    137
INIQ,  310, 310,  1,    274
INIQ,  311, 311,  1,    137
INIQ,  312, 312,  1,    137
INIQ,  314, 314,  1,    685
*
*
*    --- ABSTRACTIONS ---
*
* NODE 14 ( H - 23 )
*
QTIME,  1, 1,    0.0,  -948
QTIME,  1, 2, 5840.0, -2027
QTIME,  1, 3, 7300.0, -2027
*
* NODE 16 ( H - 15 )
*
QTIME,  2, 1,    0.0,   -51
QTIME,  2, 2, 5840.0,  -110
QTIME,  2, 3, 7300.0,  -110
*
* NODE 19 ( H - 20 )
*
QTIME,  3, 1,    0.0, -1192
QTIME,  3, 2, 5840.0, -2548
QTIME,  3, 3, 7300.0, -2548
*
* NODE 20 ( H - 17 )
*
QTIME,  4, 1,    0.0,  -577
QTIME,  4, 2, 5840.0, -1233
QTIME,  4, 3, 7300.0, -1233
*
* NODE 22 ( H - 21 )
*
QTIME,  5, 1, 1095.0, -2103
QTIME,  5, 2, 5840.0, -3863
QTIME,  5, 3, 7300.0, -3863
*
* NODE 41 ( H - 12 )
*
QTIME,  6, 1,    0.0, -1640
QTIME,  6, 2, 5840.0, -3507
QTIME,  6, 3, 7300.0, -3507
*
* NODE 43 ( H - 11 )
*
QTIME,  7, 1,    0.0,  -295
QTIME,  7, 2, 5840.0,  -630
QTIME,  7, 3, 7300.0,  -630
*
* NODE 44 ( H - 15 )
*
QTIME,  8, 1,    0.0,  -115
QTIME,  8, 2, 5840.0,  -247
QTIME,  8, 3, 7300.0,  -247
*
* NODE 72 ( H - 6 )
```

Relationships of time and pumping
(T-Q tables)

Number of
T-Q tables : 17

Maximum number of
data in T-Q table : 3

(Refer to 4th command)

```
QTIME,  9, 1,    0.0, -1435
QTIME,  9, 2, 5840.0, -3068
QTIME,  9, 3, 7300.0, -3068
*
* NODE 95
*
QTIME, 10, 1,    0.0,  -159
QTIME, 10, 2, 5840.0,  -274
QTIME, 10, 3, 7300.0,  -274
*
* NODE 109
*
QTIME, 11, 1,    0.0,  -159
QTIME, 11, 2, 5840.0,  -274
QTIME, 11, 3, 7300.0,  -274
*
* NODE 110
*
QTIME, 12, 1,    0.0,  -159
QTIME, 12, 2, 5840.0,  -274
QTIME, 12, 3, 7300.0,  -274
*
* NODE 111
*
QTIME, 13, 1,    0.0,  -159
QTIME, 13, 2, 5840.0,  -274
QTIME, 13, 3, 7300.0,  -274
*
* NODE 162
*
QTIME, 14, 1,    0.0,  -944
QTIME, 14, 2, 5840.0, -2877
QTIME, 14, 3, 7300.0, -2877
*
* NODE 196
*
QTIME, 15, 1,    0.0,    88
QTIME, 15, 2, 5840.0,  -685
QTIME, 15, 3, 7300.0,  -685
*
* NODE 209
*
QTIME, 16, 1,    0.0,   430
QTIME, 16, 2, 5840.0,  -548
QTIME, 16, 3, 7300.0,  -548
*
* NODE 239
*
QTIME, 17, 1,    0.0, -2145
QTIME, 17, 2, 5840.0, -3699
QTIME, 17, 3, 7300.0, -3699
*
*
*       --- AQUIFER CONSTANTS ---
*
*       K : COEFFICIENT OF INFILTRATION CAPACITY
*       S : COEFFICIENT OF STORAGE
*
*                 SYMBOL OF    K          S
*                 AQUIFER
*
LAYE, 40
                  GS00,        1.0E-08,  1.00E-07      (K)
```

```
              GS01,         1.0E-08,  1.00E-03
              GS02,         1.0E-08,  9.09E-04
              GS03,         1.0E-08,  8.03E-04
              GS04,         1.0E-08,  6.75E-04
              GS05,         1.0E-08,  5.02E-04
              GS06,         1.0E-08,  3.73E-04
              GS07,         1.0E-08,  3.30E-04
              GS08,         1.0E-08,  2.77E-04
              GS09,         1.0E-08,  2.06E-04
              GS10,         1.0E-08,  1.39E-04
              GS11,         1.0E-08,  1.23E-04
              GS12,         1.0E-08,  1.03E-04
              GS13,         1.0E-08,  7.67E-05
              GS14,         1.0E-08,  5.18E-05
              GS15,         1.0E-08,  3.85E-05
              GS16,         1.0E-08,  1.93E-05
              GS17,         1.0E-08,  7.20E-06
              GS18,         1.0E-08,  2.68E-06
              GS19,         1.0E-08,  1.00E-06
              AQ00,         1.0E-08,  1.00E-07
              AQ01,       100.0,      0.25
              AQ02,        80.0,      0.2391
              AQ03,        60.0,      0.2258
              AQ04,        40.0,      0.2082
              AQ05,        20.0,      0.1813
              AQ06,        10.0,      0.1578
              AQ07,         7.5,      0.1490
              AQ08,         5.0,      0.1374
              AQ09,         2.5,      0.1197
              AQ10,         1.0,      0.0997
              AQ11,         0.75,     0.0941
              AQ12,         0.50,     0.0868
              AQ13,         0.25      0.0756
              AQ14,         0.10,     0.0629
              AQ15,         0.05,     0.0548
              AQ16,         0.01,     0.0397
              AQ17,         0.001,    0.0251
              AQ18,         0.0001,   0.0158
              AQ19,         0.00001,  0.0100
*
*
*    --- GEOLOGICAL DATA ---
*
GENE
*
*
PRTIME,   730, 1825, 3650, 5840, 7300
PLTIME,   730, 1825, 3650, 5840, 7300
*
*
NBTIME,   0.0, 1095, 3650
*
*
ENDD
NEWB,    19,  0.0
14 , QT,  1,  SS, 0.0, SS
16 , QT,  2,  SS, 0.0, SS
19 , QT,  3,  SS, 0.0, SS
20 , QT,  4,  SS, 0.0, SS
41 , QT,  6,  SS, 0.0, SS
43 , QT,  7,  SS, 0.0, SS
```

already calibrated in the steady state

(S) to be calibrated in the non-steady state

Geological data are read from 'FOR021.DAT' by GENE command.

Outputs are to be obtained at specified times.

Boundary conditions are to be changed at specified times

Boundary conditions are to be changed at time = 0.

```
43 , QT,   7,  SS, 0.0, SS
44 , QT,   8,  SS, 0.0, SS
72 , QT,   9,  SS, 0.0, SS
95 , QT,  10,  SS, 0.0, SS
109, QT,  11,  SS, 0.0, SS
110, QT,  12,  SS, 0.0, SS
111, QT,  13,  SS, 0.0, SS
162, QT,  14,  SS, 0.0, SS
196, QT,  15,  SS, 0.0, SS
209, QT,  16,  SS, 0.0, SS
239, QT,  17,  SS, 0.0, SS
304, QF,   0,  SS, 0.0, CG,  -411
306, QF,   0,  SS, 0.0, CG,  -548
314, QF,   0,  SS, 0.0, CG,  -767
NEWB,      1,  1095.0
22 , QT,   5,  SS, 0.0, SS
NEWB,     18,  3650.0
92 , QF,   0,  SS, 0.0, CG,  -685
93 , QF,   0,  SS, 0.0, CG,  -685
152, QF,   0,  SS, 0.0, CG,  -822
173, QF,   0,  SS, 0.0, CG,  -548
174, QF,   0,  SS, 0.0, CG,  -274
175, QF,   0,  SS, 0.0, CG,  -548
176, QF,   0,  SS, 0.0, CG,  -548
180, QF,   0,  SS, 0.0, CG,  -466
181, QF,   0,  SS, 0.0, CG,  -274
182, QF,   0,  SS, 0.0, CG,     0
183, QF,   0,  SS, 0.0, CG,  -548
193, QF,   0,  SS, 0.0, CG,  -685
194, QF,   0,  SS, 0.0, CG,  -685
195, QF,   0,  SS, 0.0, CG,  -685
282, QF,   0,  SS, 0.0, CG,  -548
283, QF,   0,  SS, 0.0, CG,  -548
345, QF,   0,  SS, 0.0, CG,  -274
346, QF,   0,  SS, 0.0, CG,  -274
```

QT :
To refer the T-Q table

Boundary conditions are to be changed at time = 1095.

Boundary conditions are to be changed at time = 3650.

3) Press **PF4** function key (at the end of edit)
4) Command : **EXIT** [enter] (save the data)

5. Operation

(1) Data Check

1) **$ ED MODEL4.DAT** [enter]

   1st line of the data to be changed

```
SETTING, RUN ,  100
      ↓
SETTING, CHEC,  100
```

2) **$ UNISSF** [enter]

3) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> M [enter] ('M' for **UNISSF2**)

4) RESTART ? (Y/N) N [enter]

5) FILE NAME(?.dat) MODEL4 [enter]

   .
   .
   (checking the data)
   .
   .

   FORTRAN STOP

   UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> E [enter] ('E' for end)

6) **$ ED MODEL4.PRN** [enter] (print output to be checked)

7) Press **PF4** function key (at the end of check)
8) Command : **QUIT** [enter]

(2) FEM Calculation

1) **$ ED MODEL4.DAT** [enter]

1st line of the data to be changed

```
SETTING, CHEC,  100
        ↓
SETTING, RUN ,  100
          ↑
```

(RUN + one blank)

2) Press PF4 key (at the end of edit)
3) Command : EXIT [enter] (save the data)

4) $ UNISSF [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> M [enter] ('M' for UNISSF2)

6) RESTART ? (Y/N) N

7) FILENAME (?.dat) MODEL4

.
.
.
(processing) It takes about 4 hours by VAX 8200
.
.
.

FORTRAN STOP

8) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> E [enter]

9) **$ ED MODEL4.PRN** [enter]

10) Press PF4 function key
11) Command: QUIT [enter]

(3) Post-processing

1) $ **UNISSF** [enter]

2) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

   PLEASE ENTER ---> **P** [enter] ('M' for **UNISSF2/P**)

3) FILENAME (?.dat) **CONT**

4) FILENAME (FT10) **MODEL4.FT10** [enter]

5) FILENAME (FT11) **MODEL4.FT11** [enter]

   .
   .
   .
   (processing)
   .
   .
   .
   FORTRAN STOP

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

   PLEASE ENTER ---> **E** [enter]

5) $ **ED CONT.PRN** [enter] (print output to be checked)

6) Press **PF4** function key (at the end of check)
7) Command: **QUIT** [enter]

(4) Graphic on TEXTRONIX Terminal

1) Press **SET UP** key
2) * **CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) **$ UNISSF** [enter]

5) UNISSF2 <M>
UNISSF2/G <G>
UNISSF2/P <P>
DISPLAY <D>
XYPLOT <X>
END <E>

PLEASE ENTER ----> **D** [enter] ('D' for **DISPLAY**)

6) FILE NAME : **FOR040.DAT** [enter]

7) press **CLEAR** key

(graphic 1) (Press [enter] to show the next graphic)
(graphic 2) (Press 'E' for end of graphic)
.
.
.

8) At the end of graphic (no graphic on display), Press **CLEAR** key

9) UNISSF2 <M>
UNISSF2/G <G>
UNISSF2/P <P>
DISPLAY <D>
XYPLOT <X>
END <E>

PLEASE ENTER ----> **E** [enter] ('E' for end)

10) Press **SET UP** key
11) * **CODE ANSI** [enter]
12)) Press **SET UP** key, and [enter]

(5) Plotting

1) Plotter set up
2) Paper set
3) Press '**On-line**' soft key

4) $ UNISSF [enter]

5) UNISSF2 <M>
UNISSF2/G <G>
UNISSF2/P <P>
DISPLAY <D>
XYPLOT <X>
END <E>

PLEASE ENTER ----> X [enter] ('X' for XYPLOT)

6) FILE NAME : FOR040.DAT [enter]

.
.
.
(plotting)
.
.
.

7) If there are more than 2 drawings, the plotting is stopped and the message 'HALT RECIEVED...' is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press '**On-line**' soft key.

8) At the end of plotting, the message 'PLOT COMPLETE' is shown in the plotter window.

9) UNISSF2 <M>
UNISSF2/G <G>
UNISSF2/P <P>
DISPLAY <D>
XYPLOT <X>
END <E>

PLEASE ENTER ----> E [enter]

5. *Items to be Checked*

(1) Piezometric Level in the Groundwater Monitoring Wells

The calculated head is needed to be calibrated by comparing the piezometric head in the groundwater monitoring well. The 10 monitoring wells are selected and specified at the nodes in the FEM mesh as shown in Fig. 22. At these nodes, the calculated head is needed to be reasonably adjusted to match with the piezometric head in the monitoring well.

In the monitoring well of S-121 (at node 94), the record shows that the piezometric head has been decreased by 8.4 m from 1973 to 1988. The calculated head at node 94 is needed to be adjusted to the monitoring record at S-121 by 'Trial and Error' to estimate the coefficient of storage.

(2) Piezometric Surface

The piezometric surface which was estimated by the field investigation and the studies prior to the groundwater model analysis is shown on Fig. 21. The contour map of piezometric surface which is calculated by the model is need to coincide with the measured one.

(3) Groundwater Flow Path

The direction of groundwater flow in the B2/A7 aquifer was estimated as follows;

Western Highlands → South Hasa → Hasa
Western Highlands → Ma'an → Jafr

(4) Water Balance

Water Balance through the boundaries in the B2/A7 aquifer was estimated to be +/- 15 through 20 MCM/y. The calculated result of total recharge (+) / discharge (-) is need to be match with the range above.

6. Convergence of Solution

The problem of convergence is mainly depend on the time-step. If the solution is not converged, calculation is to stop on the way. For this case, the time-step is needed to be shorter, mainly in early stage. The stability of solution is improved by adopting the shorter time-step,but it takes longer time to calculate.

7. Data Modification for Calibration

The model calibration is carried out by Trial and Error. After FEM calculation by 'UNISSF2' and post-processing by 'UNISSF2/P', the calculated results are delivered by print output and graphics and plotting. These outputs are compared with the estimated actual groundwater condition. If the calculated results do not coincide reasonably, the data in 'FOR021.DAT' and 'MODEL4.DAT' are needed to be modified, and the next trial of calculation is to be performed. The data modification and the trial of calculation are to be repeated until the reasonable results are obtained. Procedures of the modification of data to next trial are described below;

1) **$ ED MODEL4.DAT** [enter]

2) (Data modification)

   - Coefficient of Storage (S)
   - Abstractions
   - Time for outputs to be obtained

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) FEM Calculation ⟶ Refer to Page 88
5) Post-processing ⟶ Refer to Page 89
6) Graphic or Plotting ⟶ Refer to Page 90 or 91

Note : If the other data which are calibrated in the steady state is needed to be modified, the steady state calibration is carried out again.

Table 11 Calibrated Piezometric Level (Non-steady State Calibration)

Well no.	Node	Piezometric Level (as of 1988, El m)	Calculated (EL m)
H-15	16	783.00	784
JO-5	50	724.00	739
JT-4	87	785.17	748
S-121	94	988.49	984
JT-1	114	880.03	887
JO-3	128	790.28	778
JT-2	160	794.47	807
S-111	185	1179.29	1167
S-65	197	1192.82	1193
S-118	214	1270.67	1276

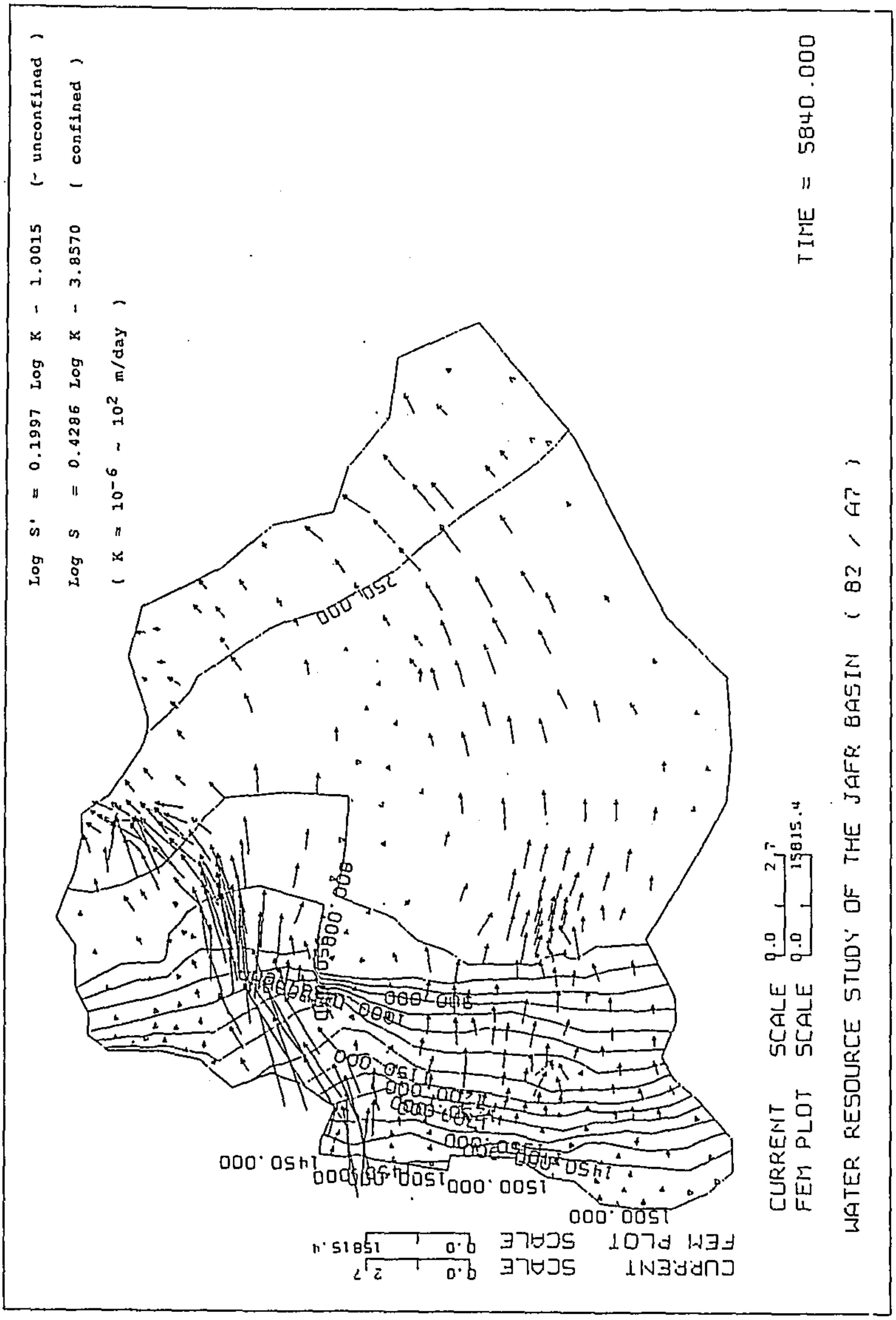


Fig. 27 Calibratied Piezometric Surface by the year 1988

CHAPTER VII
MODEL SIMULATION

1. Summary of Model Simulation

(1) Puropse

After the model is reasonably calibrated, the piezomertic surface in the future is predicted by using the model. The purpose of the prediction is mainly to estimate the appropriate scale of the abstraction in the region. The groundwater condition in the future is predicted by the simulation model for the serveral case of abstractions, including the existing and the newly planned.

(2) Proposed Wellfields

The simulation model predicts the influences of future groundwater exploitation such as 'South Hasa' and 'Ease Ma'an' on the regional groundwater flows. Each expermental wellfield assumes the prodution wells of 10 to 20 in number with a unit pumping rate at 0.5 to 1 MCM/y which are located at a distance 1 to 2 km.

(3) Recharge Dams

The model prediction also includes the alternative studies on the groundwater recharge dam. The conjunctive development study is also carried out by using the simulation model. The models based on groundwater exploitation by coupling with the two groups of recharge dams such as A1-2-3 and B1-2-3 which assume the commencement of the impounding in 1993 with net infiltration capacity of 5.4 MCM and 3.3 MCM per annum respectively.

(4) Regional Effect of the Recharge Dam in the Shoubak Area

The regional effect of the groundwater recharge dam in the Shoubak area is evaluated by using the simulation model. From priority ranking study for the proposed recharge dams, the A-2 recharge dam is selected to evaluated the efftects of infiltration on the unconfined aquifer in the Shoubak area, where the piezometric surface is being lowered by the intensive groundwater irrigation.

2. Data Input

Example : Each 5 MCM/y of abstraction in South Hasa and East Ma'an

Each 10 of production wells are assumed for two proposed wellfields with a unit pumping rate of 0.5 MCM/y. The calibrated model is composed of 'FOR021.DAT' and 'MODEL4.DAT'. In addtion to the data in 'MODEL4.DAT', the following data are given to the model;

- Time stage and step after 200 years
- Pumping rate for each production well in the two wellfields
- Assumption that outflow from the study area is decreasing along the eastern boundary due to drawdown in the model

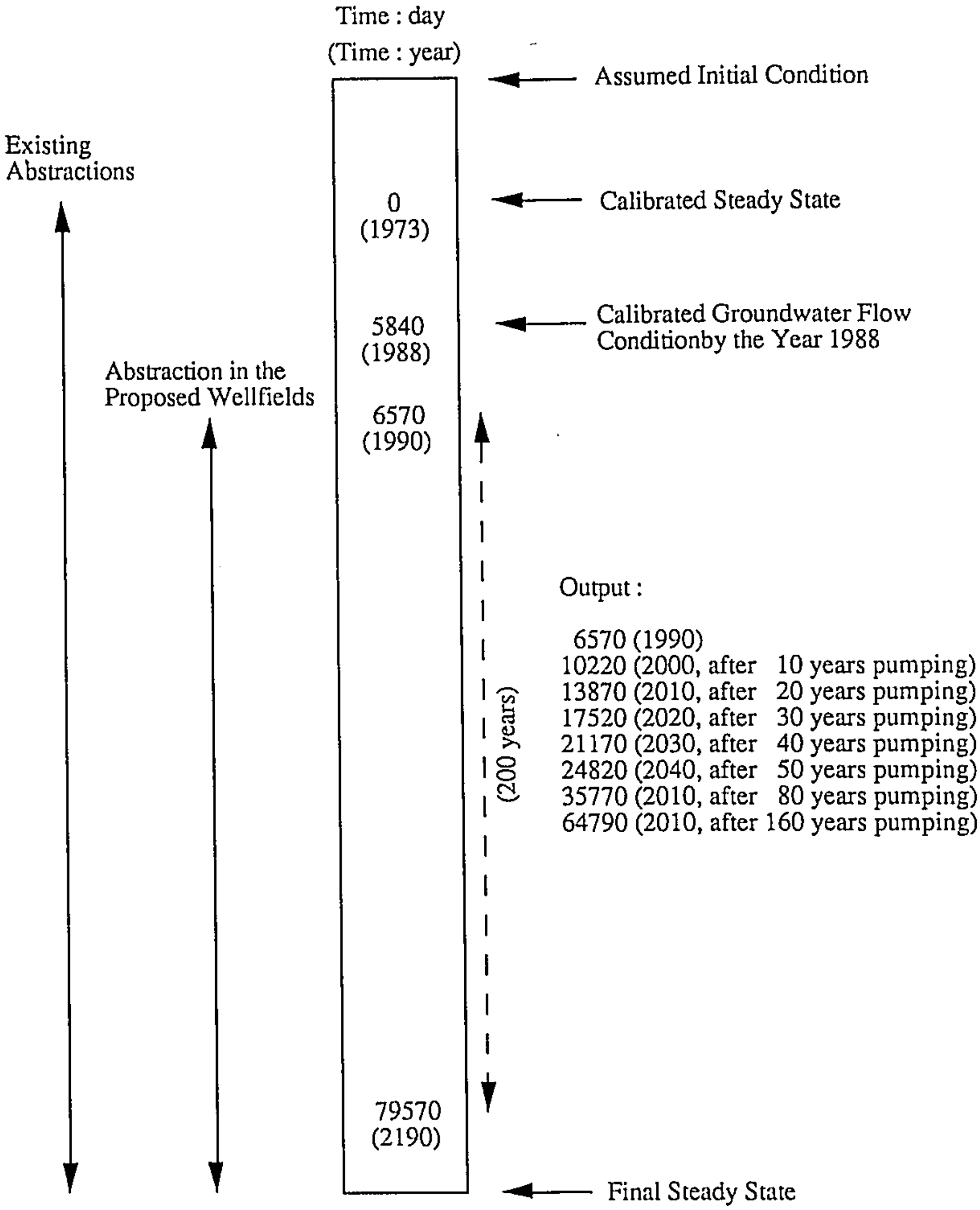
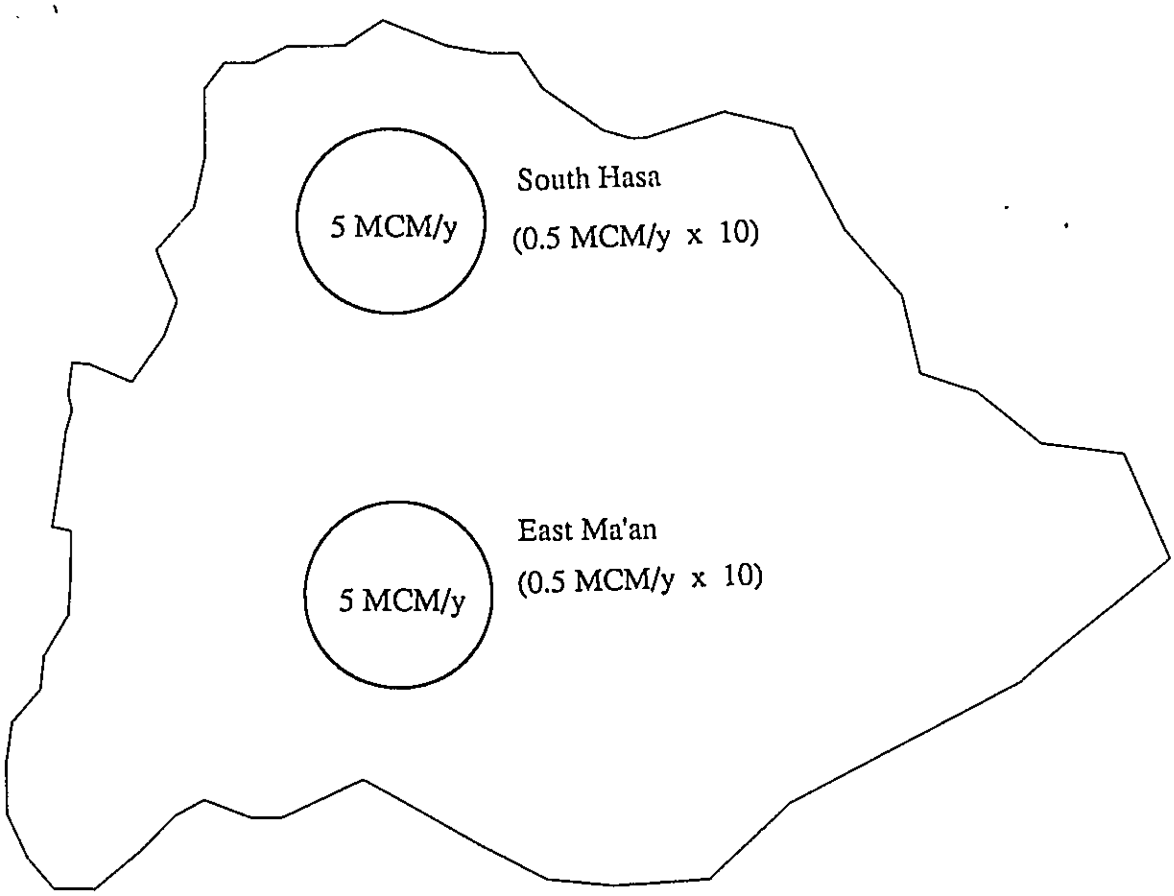


Fig. 28 Procedure of Calculation in Model Simulation

Fig. 29 Abstraction in the Proposed Wellfields



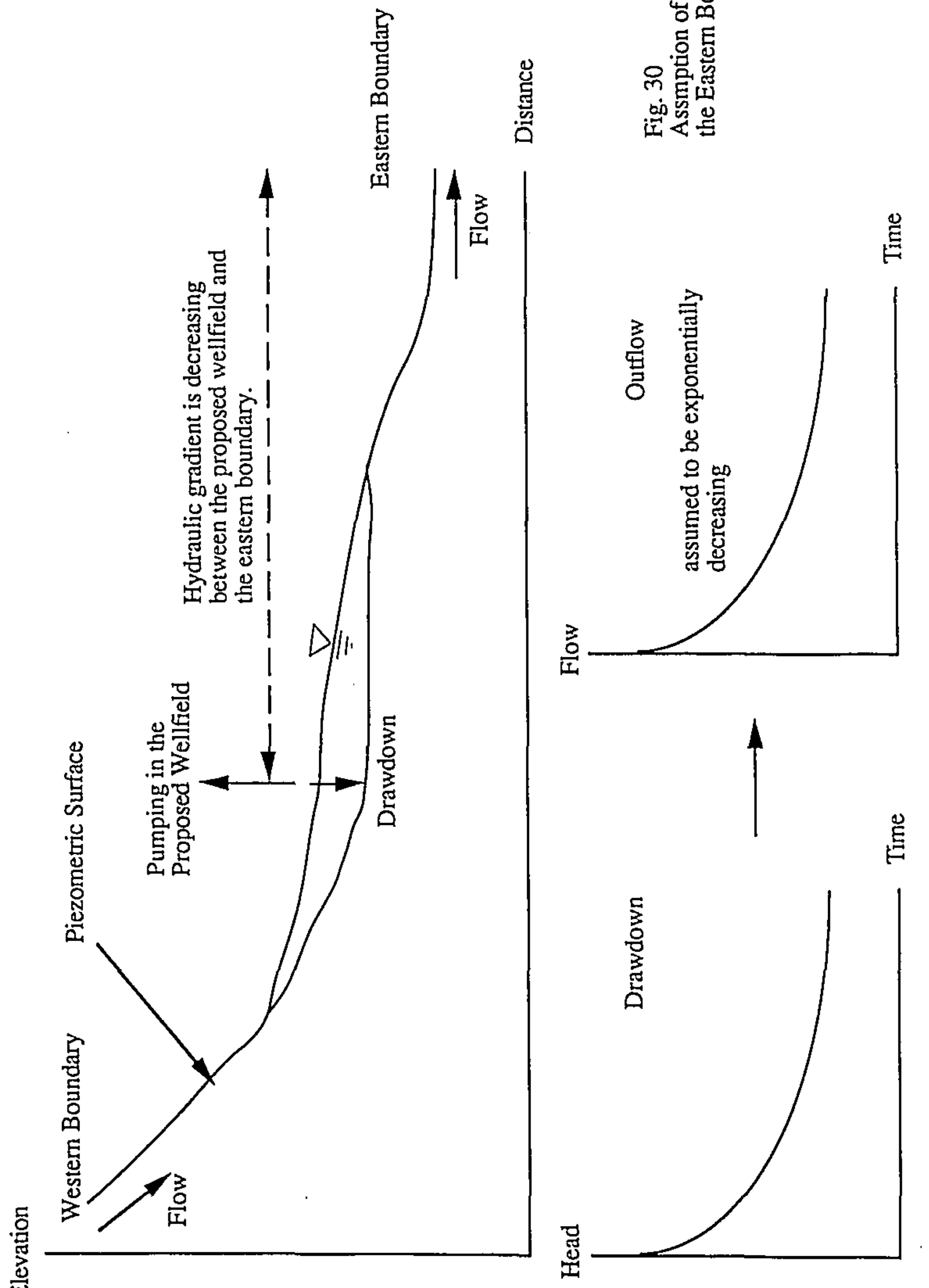


Fig. 30
Assmption of Outflow from
the Eastern Boundary

Pumping rate of existing abstraction is assmued not to be changed after the end of 1988. Data input for the case above, each 5 MCM/y of abstraction in South Hasa and East Ma'an, is described below;

1) COPY MODEL4.DAT 10MCM.DAT [enter]
2) ED 10MCM.DAT [enter]

```
SETTING,  RUN ,  3600,    0
TITLE
     WATER RESOURCES STUDY OF THE JAFR BASIN   ( B2 / A7 )
1ST ,  361,  386,    8,  361,    3
2ND ,    2,    0,    0,    0,    0
3RD ,    0,    0,    0,    0,   32,    8
4TH ,    0,    0
*
*    --- MESH ---
*
*
GENE
*
*
*    --- TIME STEP ---
*
TIME, 10
STEP,  1,   9.125,   365
STEP,  2,  18.25 ,   730
STEP,  3,  36.5  ,  1095
STEP,  4,  73.0  ,  1460
STEP,  5,  91.25 ,  1825
STEP,  6, 182.5  ,  5840
STEP,  7, 365.0  , 10220
STEP,  8, 730.0  , 13870
STEP,  9,1460.0  , 35770
STEP, 10,2920.0  , 79570
*
UNIT,  ME    ,  DAY , 25,  1.0E-01
CONT,  STUN  ,  SURF  , FLUX
*
*
```

Mesh data are read from 'FOR021.DAT' by GENE Command.

Time stage and step

(after 10-year)
(after 20-year)
(after 80-year)
(after 200-year)

.
.
(same as 'MODEL4.DAT')
.
.

```
*    --- ABSTRACTIONS ---
*
* NODE 14 ( H - 23 )
*
QTIME,  1, 1,     0.0,  -948
QTIME,  1, 2, 5840.0, -2027
QTIME,  1, 3,79570.0, -2027
*
* NODE 16 ( H - 15 )
*
```

Relationships of time and pumping (T-Q tables)

Number of T-Q tables : 32

Maximum number of data in T-Q table : 8

(Refer to 4th command)

```
QTIME,  2, 1,     0.0,   -51
QTIME,  2, 2, 5840.0,  -110
QTIME,  2, 3,79570.0,  -110
*
* NODE 19 ( H - 20 )
*
QTIME,  3, 1,     0.0, -1192
QTIME,  3, 2, 5840.0, -2548
QTIME,  3, 3,79570.0, -2548
*
* NODE 20 ( H - 17 )
*
QTIME,  4, 1,     0.0,  -577
QTIME,  4, 2, 5840.0, -1233
QTIME,  4, 3,79570.0, -1233
*
* NODE 22 ( H - 21 )
*
QTIME,  5, 1, 1095.0, -2103
QTIME,  5, 2, 5840.0, -3863
QTIME,  5, 3,79570.0, -3863
*
* NODE 41 ( H - 12 )
*
QTIME,  6, 1,     0.0, -1640
QTIME,  6, 2, 5840.0, -3507
QTIME,  6, 3,79570.0, -3507
*
* NODE 43 ( H - 11 )
*
QTIME,  7, 1,     0.0,  -295
QTIME,  7, 2, 5840.0,  -630
QTIME,  7, 3,79570.0,  -630
*
* NODE 44 ( H - 15 )
*
QTIME,  8, 1,     0.0,  -115
QTIME,  8, 2, 5840.0,  -247
QTIME,  8, 3,79570.0,  -247
*
* NODE 72 ( H - 6 )
*
QTIME,  9, 1,     0.0, -1435
QTIME,  9, 2, 5840.0, -3068
QTIME,  9, 3,79570.0, -3068
*
* NODE 95
*
QTIME, 10, 1,     0.0,  -159
QTIME, 10, 2, 5840.0,  -274
QTIME, 10, 3,79570.0,  -274
*
* NODE 109
*
QTIME, 11, 1,     0.0,  -159
QTIME, 11, 2, 5840.0,  -274
QTIME, 11, 3,79570.0,  -274
*
* NODE 110
*
QTIME, 12, 1,     0.0,  -159
QTIME, 12, 2, 5840.0,  -274
QTIME, 12, 3,79570.0,  -274
```

```
*
* NODE 111
*
QTIME, 13, 1,     0.0,  -159
QTIME, 13, 2, 5840.0,  -274
QTIME, 13, 3,79570.0,  -274
*
* NODE 162
*
QTIME, 14, 1,     0.0,  -944
QTIME, 14, 2, 5840.0, -2877
QTIME, 14, 3,79570.0, -2877
*
* NODE 196
*
QTIME, 15, 1,     0.0,    88
QTIME, 15, 2, 5840.0,  -685
QTIME, 15, 3,79570.0,  -685
*
* NODE 209
*
QTIME, 16, 1,     0.0,   430
QTIME, 16, 2, 5840.0,  -548
QTIME, 16, 3,79570.0,  -548
*
* NODE 239
*
QTIME, 17, 1,     0.0, -2145
QTIME, 17, 2, 5840.0, -3699
QTIME, 17, 3,79570.0, -3699
*
* NODE   7
*
QTIME, 18, 1, 6570.0, -1800
QTIME, 18, 2 10220.0, -1347
QTIME, 18, 3,13870.0, -1242
QTIME, 18, 4,17520.0, -1171
QTIME, 18, 5,21170.0, -1112
QTIME, 18, 6,35770.0,  -938
QTIME, 18, 7,64970.0,  -756
QTIME, 18, 8,79570.0,  -756
*
* NODE   8
*
QTIME, 19, 1, 6570.0, -2400
QTIME, 19, 2 10220.0, -1795
QTIME, 19, 3,13870.0, -1656
QTIME, 19, 4,17520.0, -1562
QTIME, 19, 5,21170.0, -1482
QTIME, 19, 6,35770.0, -1251
QTIME, 19, 7,64970.0, -1009
QTIME, 19, 8,79570.0, -1009
*
* NODE  9
*
QTIME, 20, 1, 6570.0, -2400
QTIME, 20, 2 10220.0, -1795
QTIME, 20, 3,13870.0, -1656
QTIME, 20, 4,17520.0, -1562
QTIME, 20, 5,21170.0, -1482
QTIME, 20, 6,35770.0, -1251
QTIME, 20, 7,64970.0, -1009
```

Assumption that outflow from the study area is decreasing along the eastern boundary due to drawdown in the model.
Node:
7, 8, 9, 26, 46, 47, 48,
51, 52, 89, 132, 139,
300, 343, 358

```
QTIME, 20, 8,79570.0, -1009
*
* NODE 26
*
QTIME, 21, 1, 6570.0, -2400
QTIME, 21, 2 10220.0, -1795
QTIME, 21, 3,13870.0, -1656
QTIME, 21, 4,17520.0, -1562
QTIME, 21, 5,21170.0, -1482
QTIME, 21, 6,35770.0, -1251
QTIME, 21, 7,64970.0, -1009
QTIME, 21, 8,79570.0, -1009
*
* NODE 46
*
QTIME, 22, 1, 6570.0, -2400
QTIME, 22, 2 10220.0, -1795
QTIME, 22, 3,13870.0, -1656
QTIME, 22, 4,17520.0, -1562
QTIME, 22, 5,21170.0, -1482
QTIME, 22, 6,35770.0, -1251
QTIME, 22, 7,64970.0, -1009
QTIME, 22, 8,79570.0, -1009
*
* NODE  47
*
QTIME, 23, 1, 6570.0, -1400
QTIME, 23, 2 10220.0, -1047
QTIME, 23, 3,13870.0,  -966
QTIME, 23, 4,17520.0,  -911
QTIME, 23, 5,21170.0,  -865
QTIME, 23, 6,35770.0,  -730
QTIME, 23, 7,64970.0,  -588
QTIME, 23, 8,79570.0,  -588
*
* NODE 48
*
QTIME, 24, 1, 6570.0, -1400
QTIME, 24, 2 10220.0, -1047
QTIME, 24, 3,13870.0,  -966
QTIME, 24, 4,17520.0,  -911
QTIME, 24, 5,21170.0,  -865
QTIME, 24, 6,35770.0,  -730
QTIME, 24, 7,64970.0,  -588
QTIME, 24, 8,79570.0,  -588
*
* NODE 51
*
QTIME, 25, 1, 6570.0, -2800
QTIME, 25, 2 10220.0, -2095
QTIME, 25, 3,13870.0, -1932
QTIME, 25, 4,17520.0, -1822
QTIME, 25, 5,21170.0, -1729
QTIME, 25, 6,35770.0, -1459
QTIME, 25, 7,64970.0, -1177
QTIME, 25, 8,79570.0, -1177
*
* NODE 52
*
QTIME, 26, 1, 6570.0, -2800
QTIME, 26, 2 10220.0, -2095
QTIME, 26, 3,13870.0, -1932
QTIME, 26, 4,17520.0, -1822
```

```
QTIME, 26, 5,21170.0, -1729
QTIME, 26, 6,35770.0, -1459
QTIME, 26, 7,64970.0, -1177
QTIME, 26, 8,79570.0, -1177
*
* NODE  89
*
QTIME, 27, 1, 6570.0, -4000
QTIME, 27, 2 10220.0, -2992
QTIME, 27, 3,13870.0, -2760
QTIME, 27, 4,17520.0, -2603
QTIME, 27, 5,21170.0, -2470
QTIME, 27, 6,35770.0, -2085
QTIME, 27, 7,64970.0, -1681
QTIME, 27, 8,79570.0, -1681
*
* NODE 132
*
QTIME, 28, 1, 6570.0, -4800
QTIME, 28, 2 10220.0, -3591
QTIME, 28, 3,13870.0, -3311
QTIME, 28, 4,17520.0, -3124
QTIME, 28, 5,21170.0, -2965
QTIME, 28, 6,35770.0, -2502
QTIME, 28, 7,64970.0, -2017
QTIME, 28, 8,79570.0, -2017
*
* NODE 139
*
QTIME, 29, 1, 6570.0, -5600
QTIME, 29, 2 10220.0, -3933
QTIME, 29, 3,13870.0, -3614
QTIME, 29, 4,17520.0, -3337
QTIME, 29, 5,21170.0, -3199
QTIME, 29, 6,35770.0, -2807
QTIME, 29, 7,64970.0, -2643
QTIME, 29, 8,79570.0, -2643
*
* NODE 300
*
QTIME, 30, 1, 6570.0, -5600
QTIME, 30, 2 10220.0, -3933
QTIME, 30, 3,13870.0, -3614
QTIME, 30, 4,17520.0, -3337
QTIME, 30, 5,21170.0, -3199
QTIME, 30, 6,35770.0, -2807
QTIME, 30, 7,64970.0, -2643
QTIME, 30, 8,79570.0, -2643
*
* NODE 343
*
QTIME, 31, 1, 6570.0, -4800
QTIME, 31, 2 10220.0, -3372
QTIME, 31, 3,13870.0, -3098
QTIME, 31, 4,17520.0, -2860
QTIME, 31, 5,21170.0, -2742
QTIME, 31, 6,35770.0, -2406
QTIME, 31, 7,64970.0, -2265
QTIME, 31, 8,79570.0, -2265
*
* NODE 358
*
QTIME, 32, 1, 6570.0, -4800
```

```
QTIME, 32, 2 10220.0, -3372
QTIME, 32, 3,13870.0, -3098
QTIME, 32, 4,17520.0, -2860
QTIME, 32, 5,21170.0, -2742
QTIME, 32, 6,35770.0, -2406
QTIME, 32, 7,64970.0, -2265
QTIME, 32, 8,79570.0, -2265
*
*
```

.

.

(same as MODEL4.DAT)

.

.

```
*
PRTIME,  6570, 10220, 13870, 17520, 21170, 24820, 35770, 64970
PLTIME,  6570, 10220, 13870, 17520, 21170, 24820, 35770, 64970
*
NBTIME,   0.0,  1095.0,   3650.0,   6570.0
*
ENDD
NEWB,     19,  0.0
14 , QT,   1,  SS, 0.0, SS
16 , QT,   2,  SS, 0.0, SS
19 , QT,   3,  SS, 0.0, SS
20 , QT,   4,  SS, 0.0, SS
41 , QT,   6,  SS, 0.0, SS
43 , QT,   7,  SS, 0.0, SS
44 , QT,   8,  SS, 0.0, SS
72 , QT,   9,  SS, 0.0, SS
95 , QT,  10,  SS, 0.0, SS
109, QT,  11,  SS, 0.0, SS
110, QT,  12,  SS, 0.0, SS
111, QT,  13,  SS, 0.0, SS
162, QT,  14,  SS, 0.0, SS
196, QT,  15,  SS, 0.0, SS
209, QT,  16,  SS, 0.0, SS
239, QT,  17,  SS, 0.0, SS
304, QF,   0,  SS, 0.0, CG,  -411
306, QF,   0,  SS, 0.0, CG,  -548
314, QF,   0,  SS, 0.0, CG,  -767
NEWB,      1,  1095.0
22 , QT,   5,  SS, 0.0, SS
NEWB,     18,  3650.0
92 , QF,   0,  SS, 0.0, CG,  -685
93 , QF,   0,  SS, 0.0, CG,  -685
152, QF,   0,  SS, 0.0, CG,  -822
173, QF,   0,  SS, 0.0, CG,  -548
174, QF,   0,  SS, 0.0, CG,  -274
175, QF,   0,  SS, 0.0, CG,  -548
176, QF,   0,  SS, 0.0, CG,  -548
180, QF,   0,  SS, 0.0, CG,  -466
181, QF,   0,  SS, 0.0, CG,  -274
182, QF,   0,  SS, 0.0, CG,     0
183, QF,   0,  SS, 0.0, CG,  -548
193, QF,   0,  SS, 0.0, CG,  -685
194, QF,   0,  SS, 0.0, CG,  -685
195, QF,   0,  SS, 0.0, CG,  -685
282, QF,   0,  SS, 0.0, CG,  -548
283, QF,   0,  SS, 0.0, CG,  -548
```

Boundary conditions are to be changed at time = 0 day.

QT : To refer T-Q table

Boundary condition is to be changed at time = 1095 day.

Boundary conditions are to be changed at time = 3650 day.

```
345, QF,  0,  SS, 0.0, CG,  -274
346, QF,  0,  SS, 0.0, CG,  -274
NEWB,    38,  6570.0
66 , QF,  0,  SS, 0.0, CG,  -1370
67 , QF,  0,  SS, 0.0, CG,  -1370
68 , QF,  0,  SS, 0.0, CG,  -1370
76 , QF,  0,  SS, 0.0, CG,  -1370
77 , QF,  0,  SS, 0.0, CG,  -1370
78 , QF,  0,  SS, 0.0, CG,  -1370
79 , QF,  0,  SS, 0.0, CG,  -1370
100, QF,  0,  SS, 0.0, CG,  -1370
101, QF,  0,  SS, 0.0, CG,  -1370
102, QF,  0,  SS, 0.0, CG,  -1370
255, QF,  0,  SS, 0.0, CG,  -1370
256, QF,  0,  SS, 0.0, CG,  -1370
257, QF,  0,  SS, 0.0, CG,  -1370
264, QF,  0,  SS, 0.0, CG,  -1370
265, QF,  0,  SS, 0.0, CG,  -1370
266, QF,  0,  SS, 0.0, CG,  -1370
267, QF,  0,  SS, 0.0, CG,  -1370
272, QF,  0,  SS, 0.0, CG,  -1370
273, QF,  0,  SS, 0.0, CG,  -1370
274, QF,  0,  SS, 0.0, CG,  -1370
345, QF,  0,  SS, 0.0, CG,  -1000
346, QF,  0,  SS, 0.0, CG,  -1000
7  , QT, 18,  SS, 0.0, SS
8  , QT, 19,  SS, 0.0, SS
9  , QT, 20,  SS, 0.0, SS
26 , QT, 21,  SS, 0.0, SS
46 , QT, 22,  SS, 0.0, SS
47 , QT, 23,  SS, 0.0, SS
48 , QT, 24,  SS, 0.0, SS
49 , QT, 25,  SS, 0.0, SS
51 , QT, 26,  SS, 0.0, SS
52 , QT, 27,  SS, 0.0, SS
89 , QT, 28,  SS, 0.0, SS
132, QT, 29,  SS, 0.0, SS
139, QT, 30,  SS, 0.0, SS
300, QT, 31,  SS, 0.0, SS
343, QT, 32,  SS, 0.0, SS
358, QT, 33,  SS, 0.0, SS
```

Boundary conditions are to be changed at time = 6570 day.

South Hasa :
Node 66, 67, 68, 76, 77
78, 79, 100, 101, 102

East Ma'an :
Node 255, 256, 257, 264, 265
266, 267, 272, 273, 274

Shidya Mine :
Node 345, 346

3) Press **PF4** function key (at the end of edit)
4) Command : EXIT (save the data)

4. Operation

(1) Data Check

1) **$ ED 10MCM.DAT** [enter]

   1st line of the data to be changed

```
SETTING, RUN ,  100

SETTING, CHEC,  100
```

2) **$ UNISSF** [enter]

3)
```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

   PLEASE ENTER ----> M [enter] ('M' for UNISSF2)

4) RESTART ? (Y/N) N [enter]

5) FILE NAME(?.dat) **10MCM** [enter]

   .
   .
   .
   (checking the data)
   .
   .
   .

   FORTRAN STOP

```
UNISSF2      < M >
UNISSF2/G    < G >
UNISSF2/P    < P >
DISPLAY      < D >
XYPLOT       < X >
END          < E >
```

   PLEASE ENTER ----> E [enter] ('E' for end)

6) **$ ED 10MCM.PRN** [enter] (print output to be checked)

7) Press **PF4** function key (at the end of check)
8) Command : **QUIT** [enter]

(2) **FEM Calculation**

1) **$ ED 10MCM.DAT** [enter]

1st line of the data to be changed

```
SETTING, CHEC,  100
    |
    v
SETTING, RUN ,  100
          ^
          |
```

(RUN + one blank)

2) Press **PF4** function key (at the end of edit)
3) Command : **EXIT** [enter] (save the data)

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> M [enter] ('M' for UNISSF2)

6) RESTART ? (Y/N) **N**

7) FILENAME (?.dat) **10MCM**

.
.
.
(processing) It takes about 8 hours by VAX 8200
.
.
.
FORTRAN STOP

8) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> E [enter]

9) **$ ED 10MCM.PRN** [enter]

10) Press **PF4** function key
11) Command: **QUIT** [enter]

(3) Post-processing to deliver the contour diagram

1) **$ ED CONT.DAT** [enter]

2) Input data

```
START,2,TP
PLTIME,  13870, 24820
SUBTITLE

NNUM, OFF
ENUM, OFF
DIVI, OFF
DOWN, OFF
MESH, OFF
FPRI, ON
SCAL, A1
CONT, MANU
 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950,
1000,1050,1100,1150,1200,1250,1300,1350,1400,1450,1500,1550,
1600,1650
VECT, 25
PLOT, ALL
END
```

Contour diagrams after 20 years and 50 years are to be shown

3) **$ UNISSF** [enter]

4)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
```

PLEASE ENTER ---> **P** [enter] ('M' for **UNISSF2/P**)

5) FILENAME (?.dat) **CONT**

6) FILENAME (FT10) **10MCM.FT10** [enter]

7) FILENAME (FT11) **10MCM.FT11** [enter]

.
.
.

(processing)

.
.
.

FORTRAN STOP

8)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
```

PLEASE ENTER ---> **E** [enter]

9) **$ ED CONT.PRN** [enter] (print output to be checked)

10) Press **PF4** key (at the end of check)
11) Command: **QUIT** [enter]

(5) Post-processing to deliver the drawdown contour diagram

1) **$ ED DOWN.DAT** [enter]

2) Input data

```
START,2,TP
PLTIME, 6570, 13870, 24820
SUBTITLE

NNUM, OFF
ENUM, OFF
DIVI, OFF
DOWN, OFF
MESH, OFF
FPRI, ON
SCAL, A1
CONT, MANU
 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950,
1000,1050,1100,1150,1200,1250,1300,1350,1400,1450,1500,1550,
1600,1650
VECT, 25
PLOT, ALL
END
```

Drawdown contour diagrams after 20 years and 50 years are to be shown./1

3) **$ UNISSF** [enter]

4)
UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **P** [enter] ('M' for UNISSF2/P)

5) FILENAME (?.dat) CONT

6) FILENAME (FT10) 10MCM.FT10 [enter]

7) FILENAME (FT11) 10MCM.FT11 [enter]

.
.
.
(processing)
.
.
.
FORTRAN STOP

8)
UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **E** [enter]

9) **$ ED CONT.PRN** [enter] (print output to be checked)

10) Press **PF4** function key (at the end of check)
11) Command: **QUIT** [enter]

Note : /1 Drawdown is calculated as follows;
(Drawdown at time = 13870)
= (Piezometric level at time = 13870) - (Piezometric level at time = 6570)

(6) Graphic on TEXTRONIX Terminal

1) Press **SET UP** key
2) * **CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **D** [enter] ('D' for **DISPLAY**)

6) FILE NAME : **FOR040.DAT** [enter]

7) press **CLEAR** key

(graphic 1) (Press [enter] to show the next graphic)
(graphic 2) (Press 'E' for end of graphic)
.
.
.

8) At the end of graphic (no graphic on display), Press **CLEAR** key

9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter] ('E' for end)

10) Press **SET UP** key
11) * **CODE ANSI** [enter]
12)) Press **SET UP** key, and [enter]

(5) Plotting

1) Plotter set up
2) Paper set
3) Press '**On-line**' soft key

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> X [enter] ('X' for XYPLOT)

6) FILE NAME : **FOR040.DAT** [enter]

.
.
.
(plotting)
.
.
.

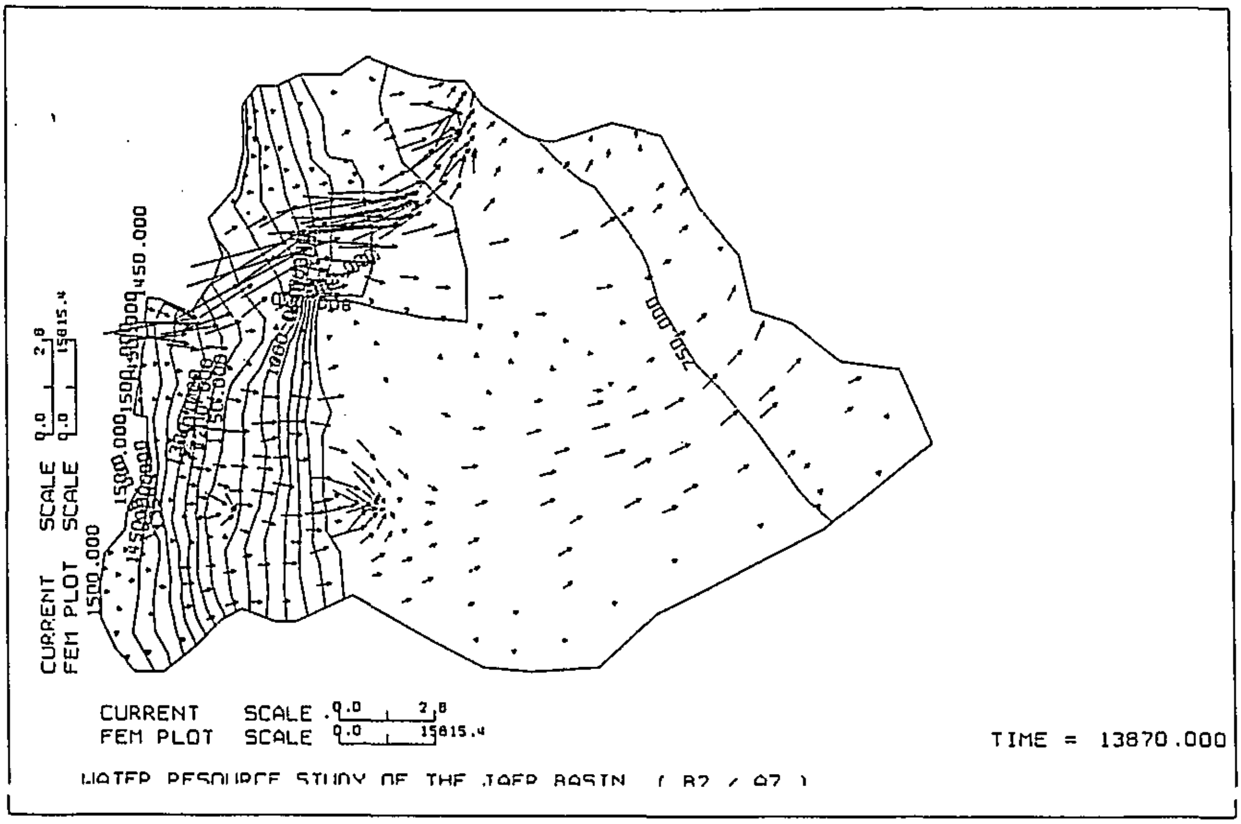
7) If there are more than 2 drawings, the plotting is stopped and the message **'HALT RECIEVED...'** is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press '**On-line**' soft key.

8) At the end of plotting, the message 'PLOT COMPLETE' is shown in the plotter window.

9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter]

Fig. 31 Predicted Piezometric Surface and Drawdown after 20 years Pumping



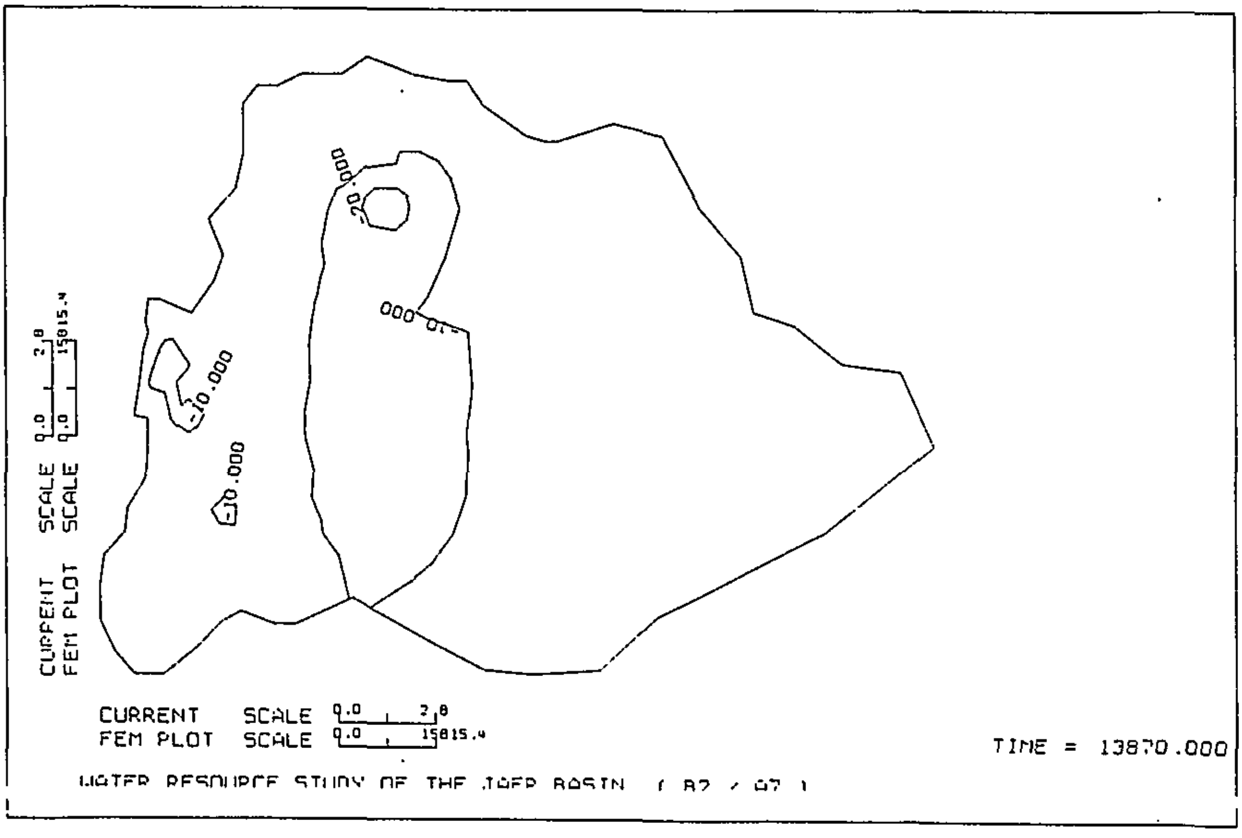
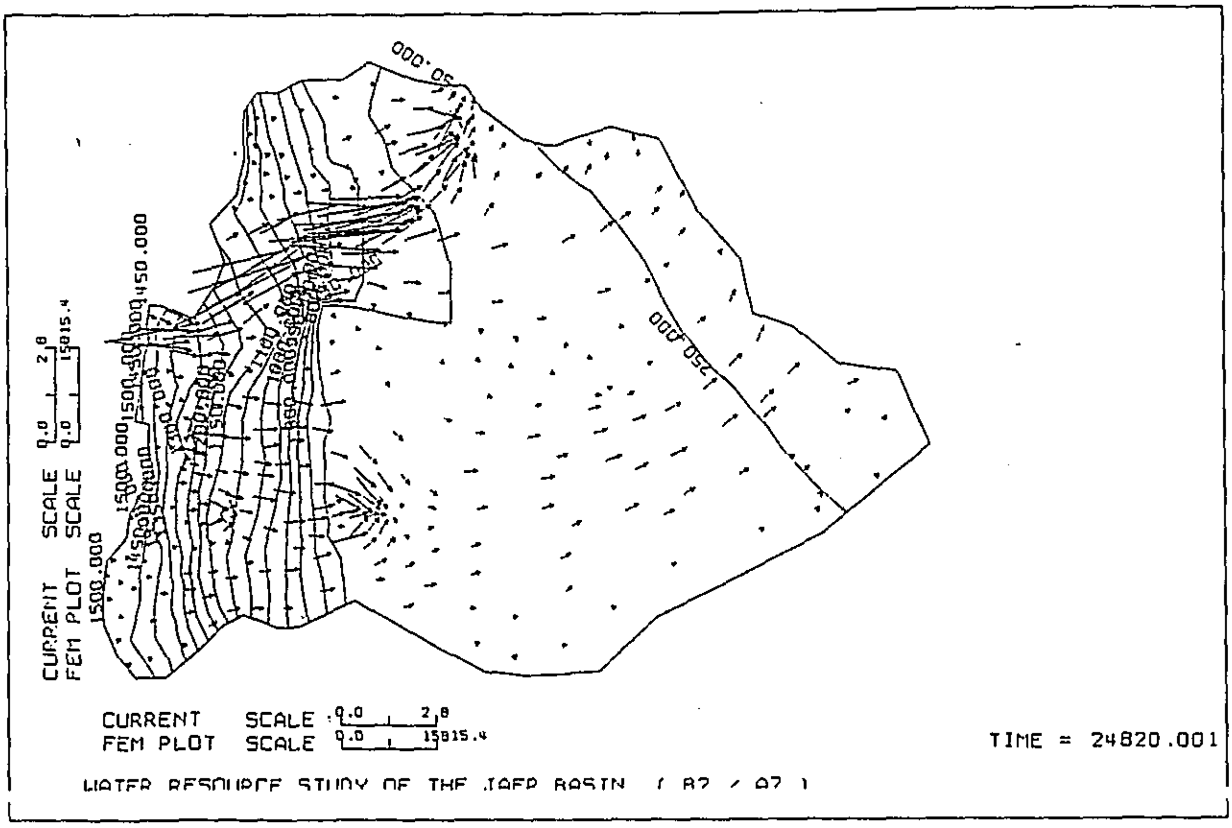
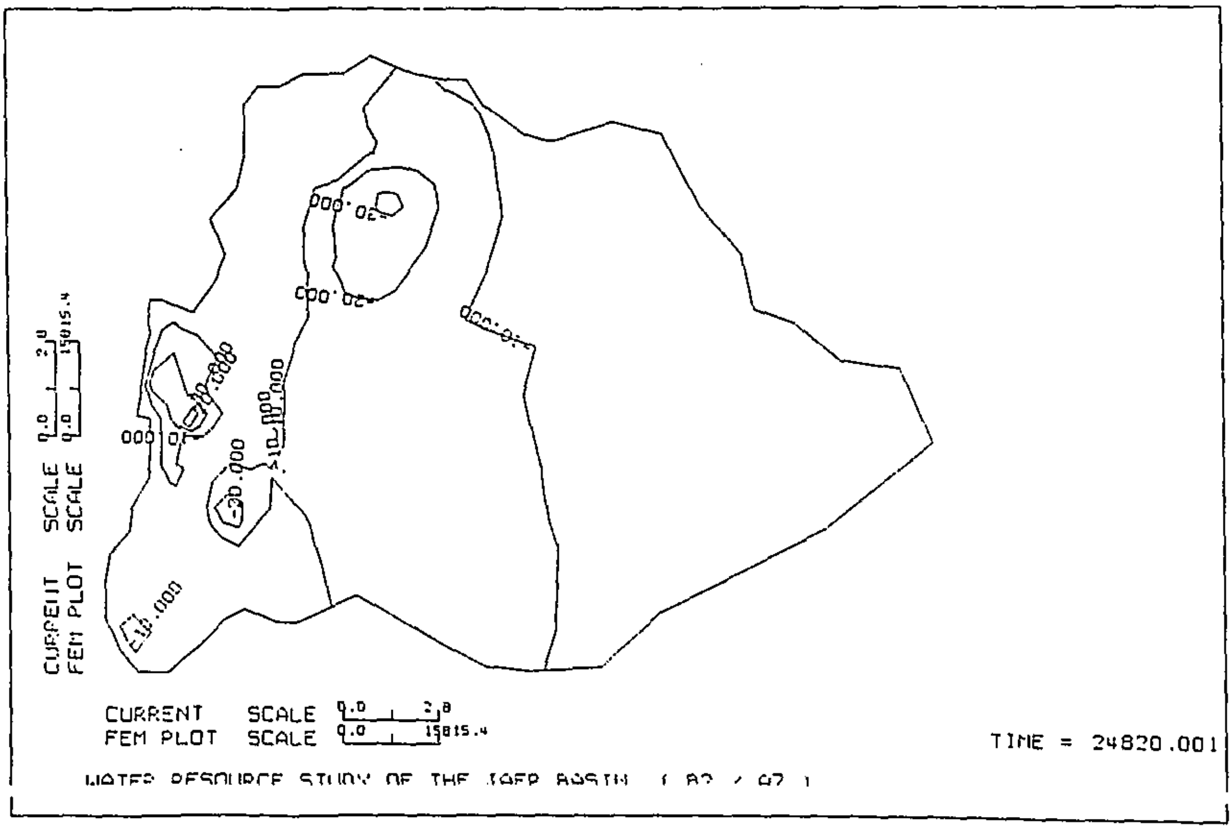


Fig. 32 Predicted Piezometric Surface and Drawdown after 50 years Pumping





CHAPTER VIII
CASE STUDIES

1. Proposed Wellfields

The simulation model predicts the influences of future groundwater exploitation such as 'South Hasa' and 'East Ma'an' on the regional groundwater flows. Each experimental wellfield assumes the production wells of 10 to 20 in number with a unit pumping rate at 0.5 to 1 MCM/y which are located at a distance from 1 to 2 km.

(1) Case 1-1 :
Each 5 MCM/y of abstraction in South Hasa and East Ma'an

Production wells of 10 in number are located in the two proposed wellfields, assuming a unit pumping rate of 0.5 MCM/y. This is the same case as shown in CHAPTER VII MODEL SIMUALTION.

(2) Case 1-2 : Each 10 MCM/y of abstraction in South Hasa and East Ma'an

Production wells of 10 in number are located in the two proposed wellfields, assuming a unit pumping rate of 1.0 MCM/y.

1) COPY 10MCM.DAT 20MCM.DAT [enter]
2) ED 20MCM.DAT [enter]

(same as 10MCM.DAT except following)

.
.
.

```
*
NBTIME,    0.0,  1095.0,   3650.0,   6570.0
*
ENDD
NEWB,     19,  0.0
14 , QT,   1,  SS, 0.0, SS
16 , QT,   2,  SS, 0.0, SS
19 , QT,   3,  SS, 0.0, SS
20 , QT,   4,  SS, 0.0, SS
41 , QT,   6,  SS, 0.0, SS
43 , QT,   7,  SS, 0.0, SS
44 , QT,   8,  SS, 0.0, SS
72 , QT,   9,  SS, 0.0, SS
95 , QT, 10,  SS, 0.0, SS
109, QT, 11,  SS, 0.0, SS
110, QT, 12,  SS, 0.0, SS
111, QT, 13,  SS, 0.0, SS
162, QT, 14,  SS, 0.0, SS
196, QT, 15,  SS, 0.0, SS
209, QT, 16,  SS, 0.0, SS
239, QT, 17,  SS, 0.0, SS
304, QF,  0,  SS, 0.0, CG,  -411
306, QF,  0,  SS, 0.0, CG,  -548
314, QF,  0,  SS, 0.0, CG,  -767
NEWB,      1,  1095.0
22 , QT,  5,  SS, 0.0, SS
NEWB,     18,  3650.0
92 , QF,  0,  SS, 0.0, CG,  -685
93 , QF,  0,  SS, 0.0, CG,  -685
152, QF,  0,  SS, 0.0, CG,  -822
173, QF,  0,  SS, 0.0, CG,  -548
174, QF,  0,  SS, 0.0, CG,  -274
175, QF,  0,  SS, 0.0, CG,  -548
176, QF,  0,  SS, 0.0, CG,  -548
180, QF,  0,  SS, 0.0, CG,  -466
181, QF,  0,  SS, 0.0, CG,  -274
182, QF,  0,  SS, 0.0, CG,     0
183, QF,  0,  SS, 0.0, CG,  -548
193, QF,  0,  SS, 0.0, CG,  -685
194, QF,  0,  SS, 0.0, CG,  -685
195, QF,  0,  SS, 0.0, CG,  -685
282, QF,  0,  SS, 0.0, CG,  -548
283, QF,  0,  SS, 0.0, CG,  -548
```

Boundary conditions are to be changed at time = 0.day. (NEWB, 19, 0.0)

Boundary condition is to be changed at time = 1095 day. (NEWB, 1, 1095.0)

Boundary conditions are to be changed at time = 3650 day. (NEWB, 18, 3650.0)

```
345, QF,  0,  SS, 0.0, CG,  -274
346, QF,  0,  SS, 0.0, CG,  -274
NEWB,    38,  6570.0
66 , QF,  0,  SS, 0.0, CG,  -2740
67 , QF,  0,  SS, 0.0, CG,  -2740
68 , QF,  0,  SS, 0.0, CG,  -2740
76 , QF,  0,  SS, 0.0, CG,  -2740
77 , QF,  0,  SS, 0.0, CG,  -2740
78 , QF,  0,  SS, 0.0, CG,  -2740
79 , QF,  0,  SS, 0.0, CG,  -2740
100, QF,  0,  SS, 0.0, CG,  -2740
101, QF,  0,  SS, 0.0, CG,  -2740
102, QF,  0,  SS, 0.0, CG,  -2740
255, QF,  0,  SS, 0.0, CG,  -2740
256, QF,  0,  SS, 0.0, CG,  -2740
257, QF,  0,  SS, 0.0, CG,  -2740
264, QF,  0,  SS, 0.0, CG,  -2740
265, QF,  0,  SS, 0.0, CG,  -2740
266, QF,  0,  SS, 0.0, CG,  -2740
267, QF,  0,  SS, 0.0, CG,  -2740
272, QF,  0,  SS, 0.0, CG,  -2740
273, QF,  0,  SS, 0.0, CG,  -2740
274, QF,  0,  SS, 0.0, CG,  -2740
345, QF,  0,  SS, 0.0, CG,  -1000
346, QF,  0,  SS, 0.0, CG,  -1000
7  , QT, 18,  SS, 0.0, SS
8  , QT, 19,  SS, 0.0, SS
9  , QT, 20,  SS, 0.0, SS
26 , QT, 21,  SS, 0.0, SS
46 , QT, 22,  SS, 0.0, SS
47 , QT, 23,  SS, 0.0, SS
48 , QT, 24,  SS, 0.0, SS
49 , QT, 25,  SS, 0.0, SS
51 , QT, 26,  SS, 0.0, SS
52 , QT, 27,  SS, 0.0, SS
89 , QT, 28,  SS, 0.0, SS
132, QT, 29,  SS, 0.0, SS
139, QT, 30,  SS, 0.0, SS
300, QT, 31,  SS, 0.0, SS
343, QT, 32,  SS, 0.0, SS
358, QT, 33,  SS, 0.0, SS
```

Boundary conditions are to be changed at time = 6570 day..

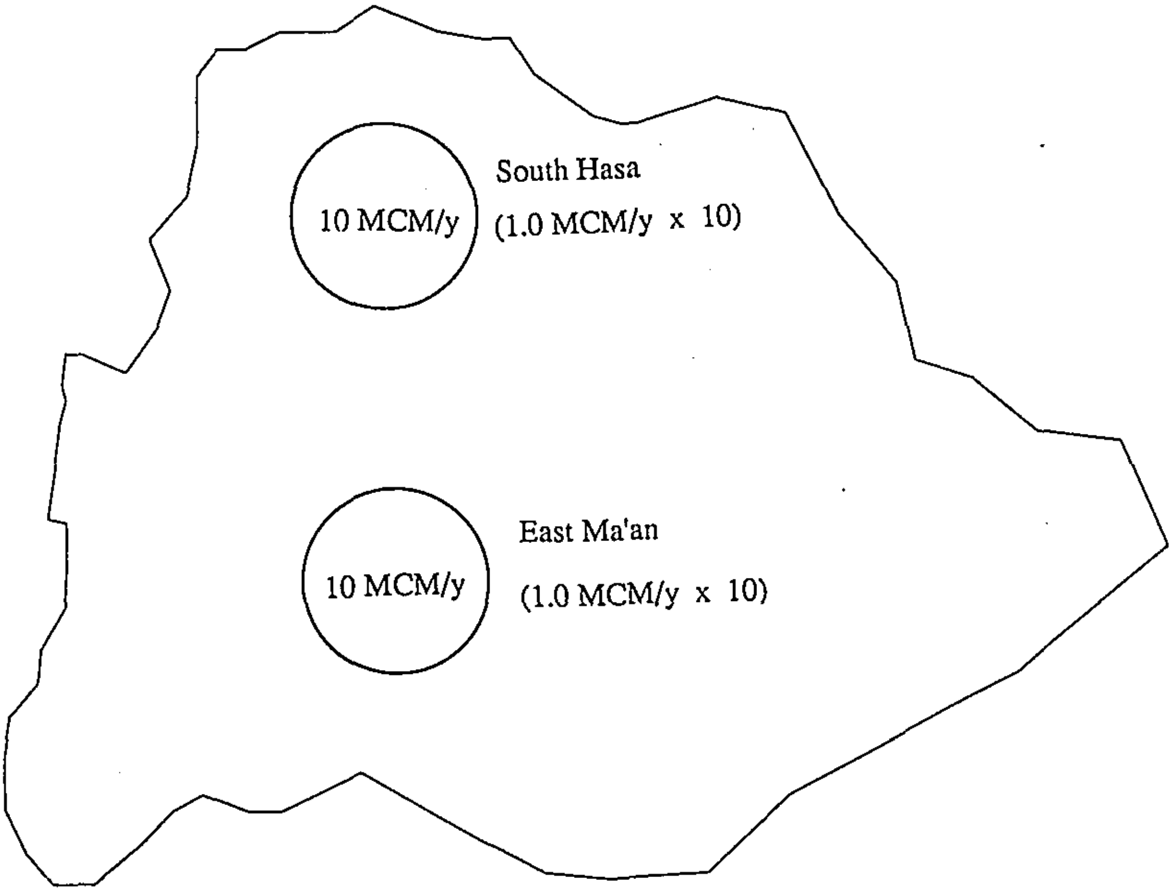
South Hasa :
Node 66, 67, 68, 76, 77
78, 79, 100, 101, 102

East Ma'an :
Node 255, 256, 257, 264, 265
266, 267, 272, 273, 274

Shidya Mine :
Node 345, 346

3) Press PF4 function key (at the end of edit)
4) Command : **EXIT** (save the data)

Fig. 33 Case 1-2 :
Each 10 MCM/y of abstraction in South Hasa and East Ma'an



2. Recharge Dams

The model prediction also includes the alternative studies on the groundwater recharge dam. The conjunctive development study is also carried out by using the simulation model. The models based on groundwater exploitation by coupling with the two groups of recharge dams such as A1-2-3 and B1-2-3 which assume the commencement of the impounding in 1993 with net infiltration capacity of 5.4 MCM and 3.3 MCM per annum respectively.

(1) Case 2-1 : Each 5 MCM/y of abstraction in South Hasa and East Ma'an with the recharge dams

Production wells of 10 in number are located in the two proposed wellfields, assuming a unit pumping rate of 0.5 MCM/y, which incorporate the two groups of recharge dams such as A1-2-3 and B1-2-3.

1) COPY 10MCM.DAT R10MCM.DAT [enter]
2) ED R10MCM.DAT [enter]

(same as 10MCM.DAT except following)

.
.
.

```
*
NBTIME,    0.0,   1095.0,    3650.0,    6570.0,    7665
*
ENDD
NEWB,      19,   0.0                          Boundary conditions are to be changed
14 , QT,    1,   SS, 0.0, SS                  at time = 0 day.
16 , QT,    2,   SS, 0.0, SS
19 , QT,    3,   SS, 0.0, SS
20 , QT,    4,   SS, 0.0, SS
41 , QT,    6,   SS, 0.0, SS
43 , QT,    7,   SS, 0.0, SS
44 , QT,    8,   SS, 0.0, SS
72 , QT,    9,   SS, 0.0, SS
95 , QT,  10,   SS, 0.0, SS
109, QT,  11,   SS, 0.0, SS
110, QT,  12,   SS, 0.0, SS
111, QT,  13,   SS, 0.0, SS
162, QT,  14,   SS, 0.0, SS
196, QT,  15,   SS, 0.0, SS
209, QT,  16,   SS, 0.0, SS
239, QT,  17,   SS, 0.0, SS
304, QF,    0,   SS, 0.0, CG,   -411
306, QF,    0,   SS, 0.0, CG,   -548
314, QF,    0,   SS, 0.0, CG,   -767
NEWB,       1,   1095.0                       Boundary condition is to be changed
22 , QT,    5,   SS, 0.0, SS                  at time = 1095 day.
NEWB,      18,   3650.0
```

Boundary conditions are to be changed at time = 3650 day.

```
92 , QF,  0,  SS, 0.0, CG,  -685
93 , QF,  0,  SS, 0.0, CG,  -685
152, QF,  0,  SS, 0.0, CG,  -822
173, QF,  0,  SS, 0.0, CG,  -548
174, QF,  0,  SS, 0.0, CG,  -274
175, QF,  0,  SS, 0.0, CG,  -548
176, QF,  0,  SS, 0.0, CG,  -548
180, QF,  0,  SS, 0.0, CG,  -466
181, QF,  0,  SS, 0.0, CG,  -274
182, QF,  0,  SS, 0.0, CG,     0
183, QF,  0,  SS, 0.0, CG,  -548
193, QF,  0,  SS, 0.0, CG,  -685
194, QF,  0,  SS, 0.0, CG,  -685
195, QF,  0,  SS, 0.0, CG,  -685
282, QF,  0,  SS, 0.0, CG,  -548
283, QF,  0,  SS, 0.0, CG,  -548
345, QF,  0,  SS, 0.0, CG,  -274
346, QF,  0,  SS, 0.0, CG,  -274
```

Boundary conditions are to be changed at time = 6570 day.

South Hasa :
Node 66, 67, 68, 76, 77
78, 79, 100, 101, 102

```
NEWB,    38,  6570.0
66 , QF,  0,  SS, 0.0, CG,  -1370
67 , QF,  0,  SS, 0.0, CG,  -1370
68 , QF,  0,  SS, 0.0, CG,  -1370
76 , QF,  0,  SS, 0.0, CG,  -1370
77 , QF,  0,  SS, 0.0, CG,  -1370
78 , QF,  0,  SS, 0.0, CG,  -1370
79 , QF,  0,  SS, 0.0, CG,  -1370
100, QF,  0,  SS, 0.0, CG,  -1370
101, QF,  0,  SS, 0.0, CG,  -1370
102, QF,  0,  SS, 0.0, CG,  -1370
```

East Ma'an :
Node 255, 256, 257, 264, 265
266, 267, 272, 273, 274

```
255, QF,  0,  SS, 0.0, CG,  -1370
256, QF,  0,  SS, 0.0, CG,  -1370
257, QF,  0,  SS, 0.0, CG,  -1370
264, QF,  0,  SS, 0.0, CG,  -1370
265, QF,  0,  SS, 0.0, CG,  -1370
266, QF,  0,  SS, 0.0, CG,  -1370
267, QF,  0,  SS, 0.0, CG,  -1370
272, QF,  0,  SS, 0.0, CG,  -1370
273, QF,  0,  SS, 0.0, CG,  -1370
274, QF,  0,  SS, 0.0, CG,  -1370
```

Shidya Mine :
Node 345, 346

```
345, QF,  0,  SS, 0.0, CG,  -1000
346, QF,  0,  SS, 0.0, CG,  -1000
7  , QT, 18,  SS, 0.0, SS
8  , QT, 19,  SS, 0.0, SS
9  , QT, 20,  SS, 0.0, SS
26 , QT, 21,  SS, 0.0, SS
46 , QT, 22,  SS, 0.0, SS
47 , QT, 23,  SS, 0.0, SS
48 , QT, 24,  SS, 0.0, SS
49 , QT, 25,  SS, 0.0, SS
51 , QT, 26,  SS, 0.0, SS
52 , QT, 27,  SS, 0.0, SS
89 , QT, 28,  SS, 0.0, SS
132, QT, 29,  SS, 0.0, SS
139, QT, 30,  SS, 0.0, SS
300, QT, 31,  SS, 0.0, SS
343, QT, 32,  SS, 0.0, SS
358, QT, 33,  SS, 0.0, SS
```

Boundary conditions are to be changed at time = 7665 day.

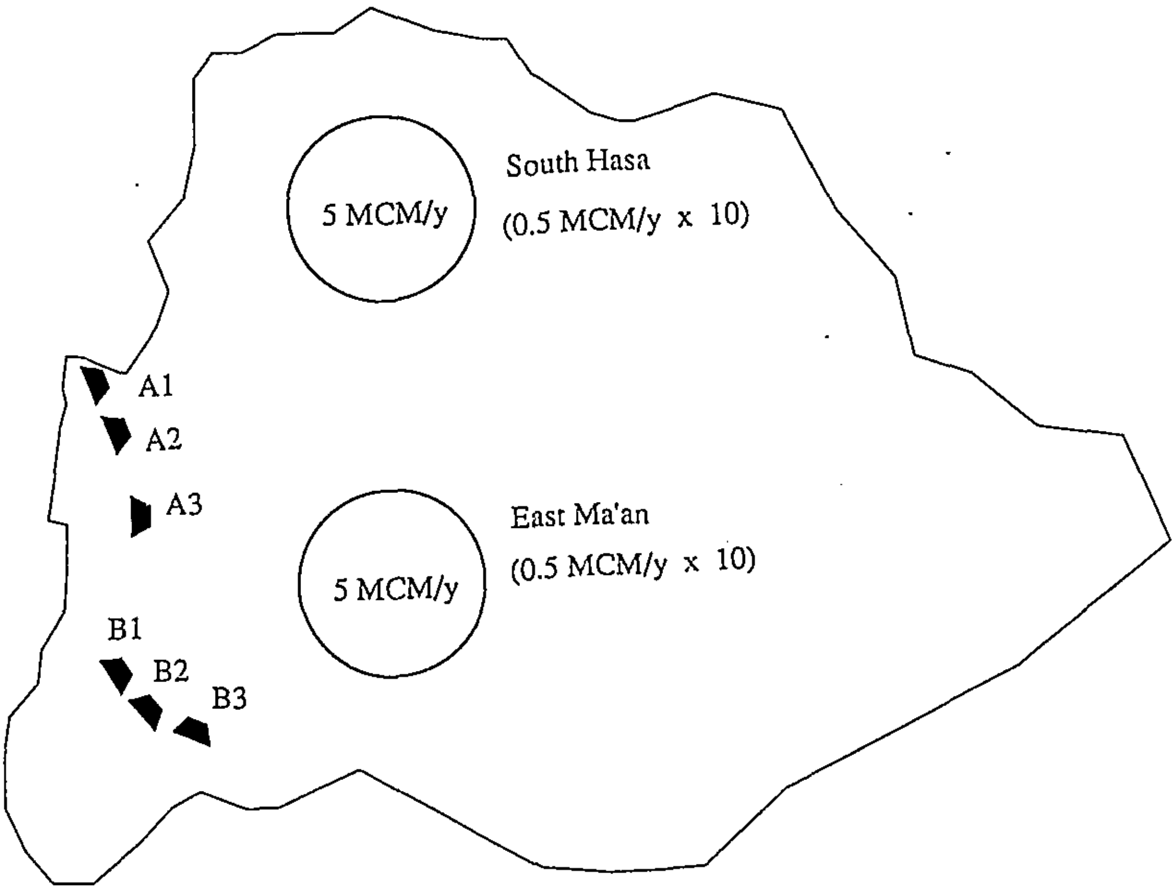
Recharge Dams :

```
NEWB,     6,  7665,0
163, QF,  0,  SS, 0.0, CG,   4219
164, QF,  0,  SS, 0.0, CG,   4411
194, QF,  0,  SS, 0.0, CG,   4658
```

279,	QF,	0,	SS;	0.0,	CG,	2521	Node 163 - A1	Node 279 - B1
305,	QF,	0,	SS,	0.0,	CG,	4603	Node 164 - A2	Node 305 - B2
312,	QF,	0,	SS,	0.0,	CG,	2438	Node 194 - A3	Node 312 - B3

3) Press **PF4** key (at the end of edit)
4) Command : **EXIT** (save the data)

Fig. 34 Case 2-1 :
Each 5 MCM/y of abstraction in South Hasa and East Ma'an with the recharge dams



Recharge Dam

Dam No.	Average Annual Inflow (MCM/y)	Annual Evapolation (MCM/y)	Recharge (MCM/y)
A1	1.5	0.06	1.44
A2	1.9	0.09	1.81
A3	2.0	0.05	1.95
B1	0.8	0.03	0.77
B2	1.6	0.07	1.53
B3	0.9	0.06	0.84

(2) Case 2-2 :
Each 10 MCM/y of abstraction in South Hasa and East Ma'an with the recharge dams

Production wells of 10 in number are located in the two proposed wellfields, assuming a unit pumping rate of 1.0 MCM/y, which incorporate the two groups of recharge dams such as A1-2-3 and B1-2-3.

1) COPY 20MCM.DAT R20MCM.DAT [enter]
2) ED R20MCM.DAT [enter]

(same as 20MCM.DAT except following)

```
             .
             .
             .
*
NBTIME,    0.0,  1095.0,   3650.0,   6570.0,   7665
*
ENDD
NEWB,     19,  0.0                      Boundary conditions are to be changed
14 , QT,   1,  SS, 0.0, SS              at time = 0 day.
16 , QT,   2,  SS, 0.0, SS
19 , QT,   3,  SS, 0.0, SS
20 , QT,   4,  SS, 0.0, SS
41 , QT,   6,  SS, 0.0, SS
43 , QT,   7,  SS, 0.0, SS
44 , QT,   8,  SS, 0.0, SS
72 , QT,   9,  SS, 0.0, SS
95 , QT,  10,  SS, 0.0, SS
109, QT,  11,  SS, 0.0, SS
110, QT,  12,  SS, 0.0, SS
111, QT,  13,  SS, 0.0, SS
162, QT,  14,  SS, 0.0, SS
196, QT,  15,  SS, 0.0, SS
209, QT,  16,  SS, 0.0, SS
239, QT,  17,  SS, 0.0, SS
304, QF,   0,  SS, 0.0, CG,  -411
306, QF,   0,  SS, 0.0, CG,  -548
314, QF,   0,  SS, 0.0, CG,  -767
NEWB,      1,  1095.0                   Boundary condition is to be changed
22 , QT,   5,  SS, 0.0, SS              at time = 1095 day.
NEWB,     18,  3650.0
92 , QF,   0,  SS, 0.0, CG,  -685       Boundary conditions are to be changed
93 , QF,   0,  SS, 0.0, CG,  -685       at time = 3650 day.
152, QF,   0,  SS, 0.0, CG,  -822
173, QF,   0,  SS, 0.0, CG,  -548
174, QF,   0,  SS, 0.0, CG,  -274
175, QF,   0,  SS, 0.0, CG,  -548
176, QF,   0,  SS, 0.0, CG,  -548
180, QF,   0,  SS, 0.0, CG,  -466
181, QF,   0,  SS, 0.0, CG,  -274
182, QF,   0,  SS, 0.0, CG,     0
183, QF,   0,  SS, 0.0, CG,  -548
193, QF,   0,  SS, 0.0, CG,  -685
194, QF,   0,  SS, 0.0, CG,  -685
```

```
195, QF,  0,  SS, 0.0, CG,   -685
282, QF,  0,  SS, 0.0, CG,   -548
283, QF,  0,  SS, 0.0, CG,   -548
345, QF,  0,  SS, 0.0, CG,   -274
346, QF,  0,  SS, 0.0, CG,   -274
NEWB,    38,  6570.0
66 , QF,  0,  SS, 0.0, CG,   -2740
67 , QF,  0,  SS, 0.0, CG,   -2740
68 , QF,  0,  SS, 0.0, CG,   -2740
76 , QF,  0,  SS, 0.0, CG,   -2740
77 , QF,  0,  SS, 0.0, CG,   -2740
78 , QF,  0,  SS, 0.0, CG,   -2740
79 , QF,  0,  SS, 0.0, CG,   -2740
100, QF,  0,  SS, 0.0, CG,   -2740
101, QF,  0,  SS, 0.0, CG,   -2740
102, QF,  0,  SS, 0.0, CG,   -2740
255, QF,  0,  SS, 0.0, CG,   -2740
256, QF,  0,  SS, 0.0, CG,   -2740
257, QF,  0,  SS, 0.0, CG,   -2740
264, QF,  0,  SS, 0.0, CG,   -2740
265, QF,  0,  SS, 0.0, CG,   -2740
266, QF,  0,  SS, 0.0, CG,   -2740
267, QF,  0,  SS, 0.0, CG,   -2740
272, QF,  0,  SS, 0.0, CG,   -2740
273, QF,  0,  SS, 0.0, CG,   -2740
274, QF,  0,  SS, 0.0, CG,   -2740
345, QF,  0,  SS, 0.0, CG,   -1000
346, QF,  0,  SS, 0.0, CG,   -1000
7  , QT, 18,  SS, 0.0, SS
8  , QT, 19,  SS, 0.0, SS
9  , QT, 20,  SS, 0.0, SS
26 , QT, 21,  SS, 0.0, SS
46 , QT, 22,  SS, 0.0, SS
47 , QT, 23,  SS, 0.0, SS
48 , QT, 24,  SS, 0.0, SS
49 , QT, 25,  SS, 0.0, SS
51 , QT, 26,  SS, 0.0, SS
52 , QT, 27,  SS, 0.0, SS
89 , QT, 28,  SS, 0.0, SS
132, QT, 29,  SS, 0.0, SS
139, QT, 30,  SS, 0.0, SS
300, QT, 31,  SS, 0.0, SS
343, QT, 32,  SS, 0.0, SS
358, QT, 33,  SS, 0.0, SS
NEWB,     6,  7665,0
163, QF,  0,  SS, 0.0, CG,   4219
164, QF,  0,  SS, 0.0, CG,   4411
194, QF,  0,  SS, 0.0, CG,   4658
279, QF,  0,  SS, 0.0, CG,   2521
305, QF,  0,  SS, 0.0, CG,   4603
312, QF,  0,  SS, 0.0, CG,   2438
```

Boundary conditions are to be changed at time = 6570 day.

South Hasa :
Node 66, 67, 68, 76, 77
78, 79, 100, 101, 102

East Ma'an :
Node 255, 256, 257, 264, 265
266, 267, 272, 273, 274

Shidya Mine :
Node 345, 346

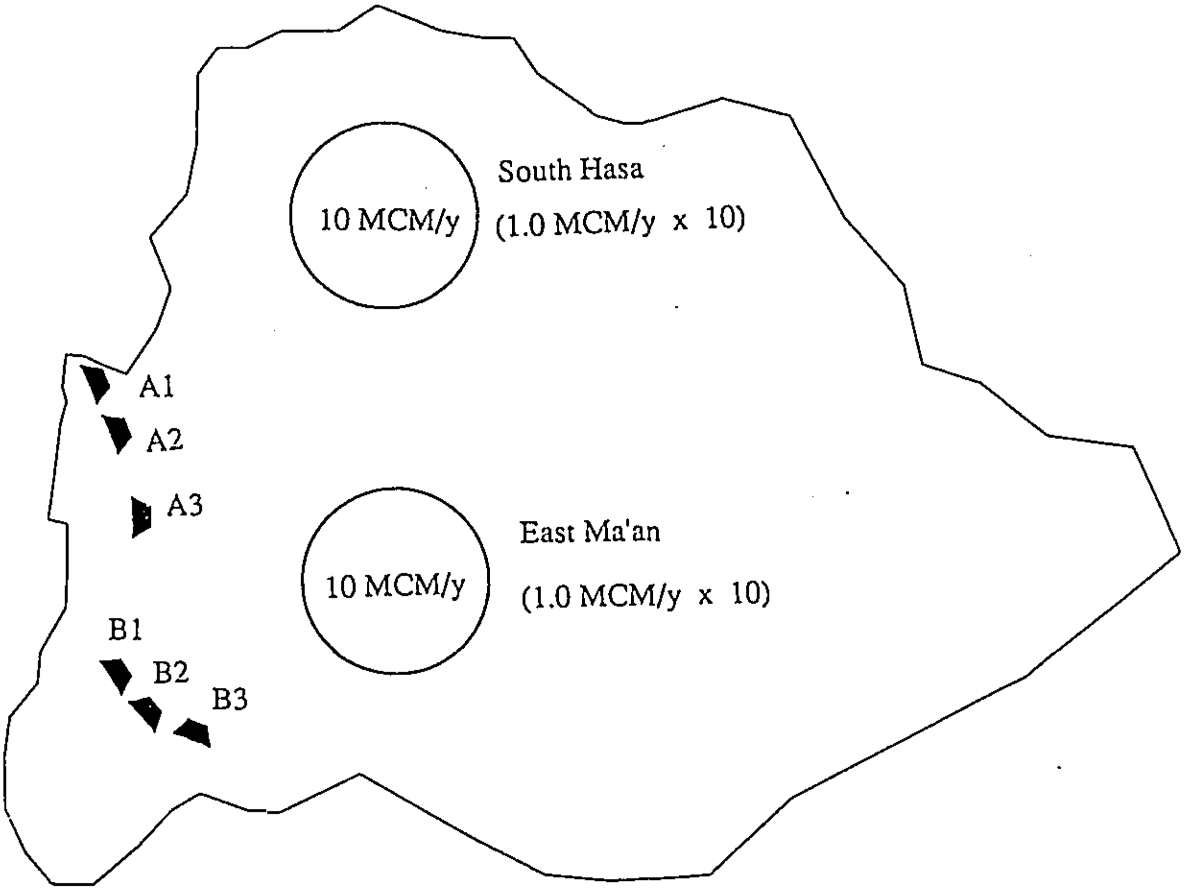
Boundary conditions are to be changed at time = 7665 day.

Recharge Dams :

Node 163 - A1	Node 279 - B1
Node 164 - A2	Node 305 - B2
Node 194 - A3	Node 312 - B3

3) Press **PF4** function key (at the end of edit)
4) Command : **EXIT** (save the data)

Fig. 35 Case 2-2 :
Each 10 MCM/y of abstraction in South Hasa and East Ma'an with the recharge dams



Recharge Dam

Dam No.	Average Annual Inflow (MCM/y)	Annual Evapolation (MCM/y)	Recharge (MCM/y)
A1	1.5	0.06	1.44
A2	1.9	0.09	1.81
A3	2.0	0.05	1.95
B1	0.8	0.03	0.77
B2	1.6	0.07	1.53
B3	0.9	0.06	0.84

4. Regional Effect of the Recharge Dam in the Shoubak Area

The regional effect of the groundwater recharge dam in the Shoubak area is evaluated by using the simulation model. From priority ranking study for the proposed recharge dams, the A-2 recharge dam is selected to evaluated the effects of infiltration on the unconfined aquifer in the Shoubak area, where the piezometric surface is being lowered by the intensive groundwater irrigation.

(1) Case 3-1 : 3.27 MCM/y of abstraction without recharge dam

The pumping rate for the existing groundwater irrigation in the Shoubak area is assumed at 3.27 MCM/y Abstraction of each proposed wellfield is assumed at 10 MCM/y which is the same abstraction as Case 1-2. This is the same case as Case 1-2.

COPY 20MCM.DAT SHOUBAK1.DAT [enter]

(2) **Case 3-2 :**
3.27 MCM/y of abstraction with the A-2 recharge dam

The pumping rate for the existing groundwater irrigation in the Shoubak area is assumed at 3.27 MCM/y. The A-2 recharge dam is considered to evaluate the effects of infiltration on the unconfined aquifer. Abstraction of each proposed wellfield is assumed at 10 MCM/y which is the same abstraction as Case 1-2.

1) $ COPY SHOUBAK1.DAT SHOUBAK2.DAT [enter]
2) $ ED SHOUBAK2.DAT [enter]

(same as SHOUBAK.DAT except following)

.
.
.

```
*
NBTIME,    0.0,  1095.0,   3650.0,    6570.0
*
ENDD
NEWB,     19,   0.0
14 , QT,  1,   SS, 0.0, SS
16 , QT,  2,   SS, 0.0, SS
19 , QT,  3,   SS, 0.0, SS
20 , QT,  4,   SS, 0.0, SS
41 , QT,  6,   SS, 0.0, SS
43 , QT,  7,   SS, 0.0, SS
44 , QT,  8,   SS, 0.0, SS
72 , QT,  9,   SS, 0.0, SS
95 , QT, 10,   SS, 0.0, SS
109, QT, 11,   SS, 0.0, SS
110, QT, 12,   SS, 0.0, SS
111, QT, 13,   SS, 0.0, SS
162, QT, 14,   SS, 0.0, SS
196, QT, 15,   SS, 0.0, SS
209, QT, 16,   SS, 0.0, SS
239, QT, 17,   SS, 0.0, SS
304, QF,  0,   SS, 0.0, CG,  -411
306, QF,  0,   SS, 0.0, CG,  -548
314, QF,  0,   SS, 0.0, CG,  -767
NEWB,      1,  1095.0
22 , QT,  5,   SS, 0.0, SS
NEWB,     18,  3650.0
92 , QF,  0,   SS, 0.0, CG,  -685
93 , QF,  0,   SS, 0.0, CG,  -685
152, QF,  0,   SS, 0.0, CG,  -822
173, QF,  0,   SS, 0.0, CG,  -548
174, QF,  0,   SS, 0.0, CG,  -274
175, QF,  0,   SS, 0.0, CG,  -548
176, QF,  0,   SS, 0.0, CG,  -548
180, QF,  0,   SS, 0.0, CG,  -466
181, QF,  0,   SS, 0.0, CG,  -274
182, QF,  0,   SS, 0.0, CG,     0
183, QF,  0,   SS, 0.0, CG,  -548
193, QF,  0,   SS, 0.0, CG,  -685
194, QF,  0,   SS, 0.0, CG,  -685
195, QF,  0,   SS, 0.0, CG,  -685
282, QF,  0,   SS, 0.0, CG,  -548
```

Boundary conditions are to be changed at time = 0 day.

Boundary condition is to be changed at time = 1095 day.

Boundary conditions are to be changed at time = 3650 day.

```
283, QF,  0,  SS, 0.0, CG,  -548
345, QF,  0,  SS, 0.0, CG,  -274
346, QF,  0,  SS, 0.0, CG,  -274
NEWB,    38,  6570.0
66 , QF,  0,  SS, 0.0, CG,  -2740
67 , QF,  0,  SS, 0.0, CG,  -2740
68 , QF,  0,  SS, 0.0, CG,  -2740
76 , QF,  0,  SS, 0.0, CG,  -2740
77 , QF,  0,  SS, 0.0, CG,  -2740
78 , QF,  0,  SS, 0.0, CG,  -2740
79 , QF,  0,  SS, 0.0, CG,  -2740
100, QF,  0,  SS, 0.0, CG,  -2740
101, QF,  0,  SS, 0.0, CG,  -2740
102, QF,  0,  SS, 0.0, CG,  -2740
255, QF,  0,  SS, 0.0, CG,  -2740
256, QF,  0,  SS, 0.0, CG,  -2740
257, QF,  0,  SS, 0.0, CG,  -2740
264, QF,  0,  SS, 0.0, CG,  -2740
265, QF,  0,  SS, 0.0, CG,  -2740
266, QF,  0,  SS, 0.0, CG,  -2740
267, QF,  0,  SS, 0.0, CG,  -2740
272, QF,  0,  SS, 0.0, CG,  -2740
273, QF,  0,  SS, 0.0, CG,  -2740
274, QF,  0,  SS, 0.0, CG,  -2740
345, QF,  0,  SS, 0.0, CG,  -1000
346, QF,  0,  SS, 0.0, CG,  -1000
7  , QT, 18,  SS, 0.0, SS
8  , QT, 19,  SS, 0.0, SS
9  , QT, 20,  SS, 0.0, SS
26 , QT, 21,  SS, 0.0, SS
46 , QT, 22,  SS, 0.0, SS
47 , QT, 23,  SS, 0.0, SS
48 , QT, 24,  SS, 0.0, SS
49 , QT, 25,  SS, 0.0, SS
51 , QT, 26,  SS, 0.0, SS
52 , QT, 27,  SS, 0.0, SS
89 , QT, 28,  SS, 0.0, SS
132, QT, 29,  SS, 0.0, SS
139, QT, 30,  SS, 0.0, SS
300, QT, 31,  SS, 0.0, SS
343, QT, 32,  SS, 0.0, SS
358, QT, 33,  SS, 0.0, SS
NEWB,     1,  7665,0
164, QF,  0,  SS, 0.0, CG,   4411
```

Boundary conditions are to be changed at time = 6570 day.

South Hasa :
Node 66, 67, 68, 76, 77
78, 79, 100, 101, 102

East Ma'an :
Node 255, 256, 257, 264, 265
266, 267, 272, 273, 274

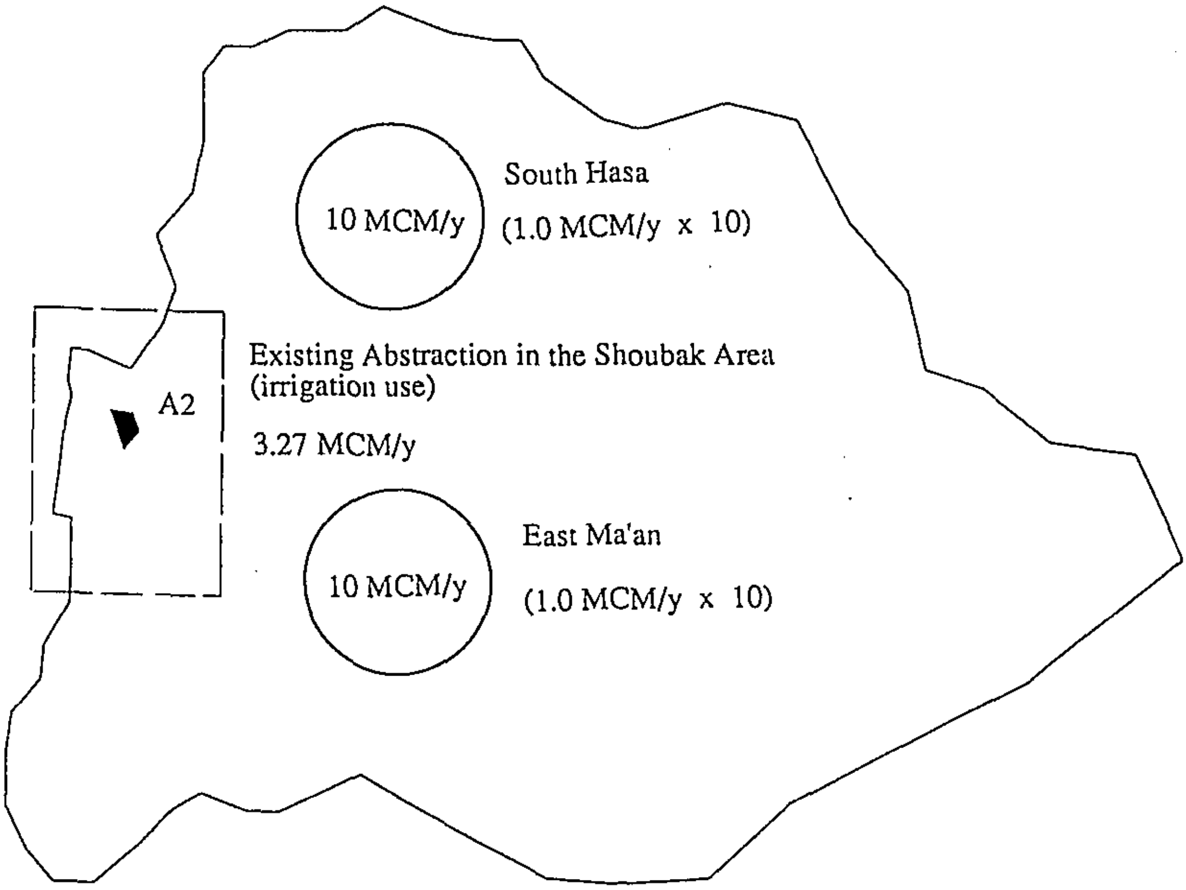
Shidya Mine :
Node 345, 346

Boundary conditions are to be changed at time = 7665 day.

A-2 Recharge Dam :
Node 164

3) Press PF4 key (at the end of edit)
4) Command : EXIT (save the data)

Fig. 36 Case 3-2 :
3.27 MCM/y of abstraction with the A-2 recharge dam



(3) Case 3-3 :
6.54 MCM/y of abstraction without recharge dam

The double pumping rate of 6.54 MCM/y is assumed to estimate the upper limit of pumping in the Shoubak wellfield. Abstraction of each proposed wellfield is assumed at 10 MCM/y which is the same abstraction as Case 1-2.

1) $ COPY SHOUBAK1.DAT SHOUBAK3.DAT [enter]
2) $ ED SHOUBAK3.DAT [enter]

(same as SHOUBAK1.DAT except following)

.
.
.

```
*
NBTIME,    0.0,  1095.0,   3650.0,    6570.0
*
ENDD
NEWB,      19,  0.0                          Boundary conditions are to be changed
14 , QT,   1,   SS, 0.0, SS                  at time = 0 day.
16 , QT,   2,   SS, 0.0, SS
19 , QT,   3,   SS, 0.0, SS
20 , QT,   4,   SS, 0.0, SS
41 , QT,   6,   SS, 0.0, SS
43 , QT,   7,   SS, 0.0, SS
44 , QT,   8,   SS, 0.0, SS
72 , QT,   9,   SS, 0.0, SS
95 , QT,  10,   SS, 0.0, SS
109, QT,  11,   SS, 0.0, SS
110, QT,  12,   SS, 0.0, SS
111, QT,  13,   SS, 0.0, SS
162, QT,  14,   SS, 0.0, SS
196, QT,  15,   SS, 0.0, SS
209, QT,  16,   SS, 0.0, SS
239, QT,  17,   SS, 0.0, SS
304, QF,   0,   SS, 0.0, CG,   -411
306, QF,   0,   SS, 0.0, CG,   -548
314, QF,   0,   SS, 0.0, CG,   -767
NEWB,       1,  1095.0                       Boundary condition is to be changed
22 , QT,   5,   SS, 0.0, SS                  at time = 1095 day.
NEWB,      18,  3650.0
92 , QF,   0,   SS, 0.0, CG,   -685          Boundary conditions are to be changed
93 , QF,   0,   SS, 0.0, CG,   -685          at time = 3650 day.
152, QF,   0,   SS, 0.0, CG,   -822
173, QF,   0,   SS, 0.0, CG,   -548
174, QF,   0,   SS, 0.0, CG,   -274
175, QF,   0,   SS, 0.0, CG,   -548
176, QF,   0,   SS, 0.0, CG,   -548
180, QF,   0,   SS, 0.0, CG,   -466
181, QF,   0,   SS, 0.0, CG,   -274
182, QF,   0,   SS, 0.0, CG,      0
183, QF,   0,   SS, 0.0, CG,   -548
193, QF,   0,   SS, 0.0, CG,   -685
194, QF,   0,   SS, 0.0, CG,   -685
195, QF,   0,   SS, 0.0, CG,   -685
282, QF,   0,   SS, 0.0, CG,   -548
283, QF,   0,   SS, 0.0, CG,   -548
```

```
345, QF,  0,  SS, 0.0, CG,  -274
346, QF,  0,  SS, 0.0, CG,  -274
NEWB,     50,  6570.0
```

Boundary conditions are to be changed at time = 6570 day.

South Hasa :
Node 66, 67, 68, 76, 77
78, 79, 100, 101, 102

```
66 , QF,  0,  SS, 0.0, CG,  -2740
67 , QF,  0,  SS, 0.0, CG,  -2740
68 , QF,  0,  SS, 0.0, CG,  -2740
76 , QF,  0,  SS, 0.0, CG,  -2740
77 , QF,  0,  SS, 0.0, CG,  -2740
78 , QF,  0,  SS, 0.0, CG,  -2740
79 , QF,  0,  SS, 0.0, CG,  -2740
100, QF,  0,  SS, 0.0, CG,  -2740
101, QF,  0,  SS, 0.0, CG,  -2740
102, QF,  0,  SS, 0.0, CG,  -2740
```

Double pumping rate in the Shoubak wellfield

Node 152, 173, 174, 175, 176,
180, 181, 182, 183, 193,
194, 195

```
152, QF,  0,  SS, 0.0, CG,  -1644
173, QF,  0,  SS, 0.0, CG,  -1370
174, QF,  0,  SS, 0.0, CG,  -1096
175, QF,  0,  SS, 0.0, CG,  -1096
176, QF,  0,  SS, 0.0, CG,  -1096
180, QF,  0,  SS, 0.0, CG,  -1205
181, QF,  0,  SS, 0.0, CG,  -1096
182, QF,  0,  SS, 0.0, CG,  -822
183, QF,  0,  SS, 0.0, CG,  -1096
193, QF,  0,  SS, 0.0, CG,  -1507
194, QF,  0,  SS, 0.0, CG,  -1507
195, QF,  0,  SS, 0.0, CG,  -1507
```

East Ma'an :
Node 255, 256, 257, 264, 265
266, 267, 272, 273, 274

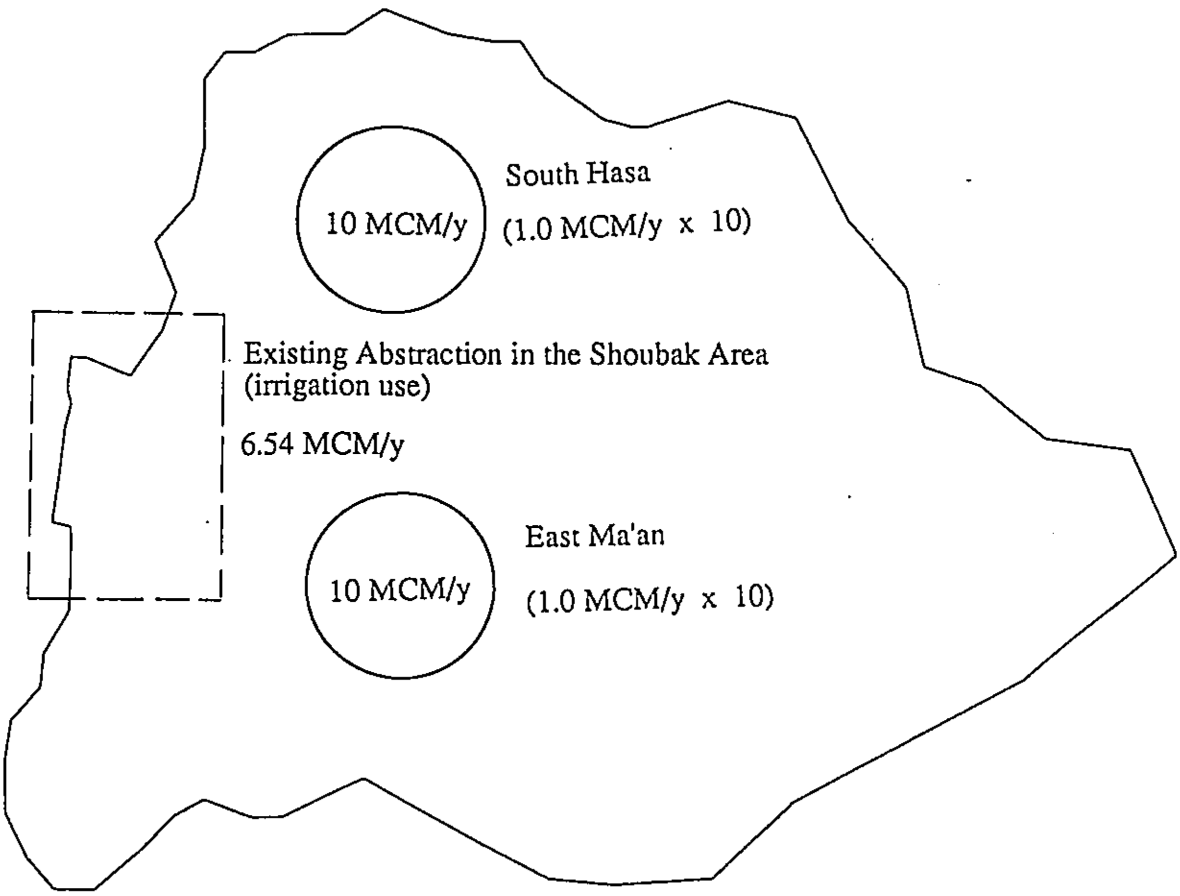
```
255, QF,  0,  SS, 0.0, CG,  -2740
256, QF,  0,  SS, 0.0, CG,  -2740
257, QF,  0,  SS, 0.0, CG,  -2740
264, QF,  0,  SS, 0.0, CG,  -2740
265, QF,  0,  SS, 0.0, CG,  -2740
266, QF,  0,  SS, 0.0, CG,  -2740
267, QF,  0,  SS, 0.0, CG,  -2740
272, QF,  0,  SS, 0.0, CG,  -2740
273, QF,  0,  SS, 0.0, CG,  -2740
274, QF,  0,  SS, 0.0, CG,  -2740
```

Shidya Mine :
Node 345, 346

```
345, QF,  0,  SS, 0.0, CG,  -1000
346, QF,  0,  SS, 0.0, CG,  -1000
7  , QT, 18,  SS, 0.0, SS
8  , QT, 19,  SS, 0.0, SS
9  , QT, 20,  SS, 0.0, SS
26 , QT, 21,  SS, 0.0, SS
46 , QT, 22,  SS, 0.0, SS
47 , QT, 23,  SS, 0.0, SS
48 , QT, 24,  SS, 0.0, SS
49 , QT, 25,  SS, 0.0, SS
51 , QT, 26,  SS, 0.0, SS
52 , QT, 27,  SS, 0.0, SS
89 , QT, 28,  SS, 0.0, SS
132, QT, 29,  SS, 0.0, SS
139, QT, 30,  SS, 0.0, SS
300, QT, 31,  SS, 0.0, SS
343, QT, 32,  SS, 0.0, SS
358, QT, 33,  SS, 0.0, SS
```

3) Press PF4 function key (at the end of edit)
4) Command : EXIT (save the data)

Fig. 37 Case 3-3 :
6.54 MCM/y of abstraction without recharge dam



(4) Case 3-4 : 6.54 MCM/y of abstraction without recharge dam

The double pumping rate of 6.54 MCM/y is assumed to estimate the upper limit of pumping in the Shoubak wellfield. The A-2 recharge dam is considered to evaluate the effects of infiltration on the unconfined aquifer. Abstraction of each proposed wellfield is assumed at 10 MCM/y which is the same abstraction as Case 1-2.

1) $ COPY SHOUBAK3.DAT SHOUBAK4.DAT [enter]
2) $ ED SHOUBAK4.DAT [enter]

(same as SHOUBAK3.DAT except following)

.
.
.

```
*
NBTIME,   0.0,  1095.0,   3650.0,   6570.0,   7665
*
ENDD
NEWB,     19,  0.0                         Boundary conditions are to be changed
14 , QT,   1,  SS, 0.0, SS                 at time = 0 day.
16 , QT,   2,  SS, 0.0, SS
19 , QT,   3,  SS, 0.0, SS
20 , QT,   4,  SS, 0.0, SS
41 , QT,   6,  SS, 0.0, SS
43 , QT,   7,  SS, 0.0, SS
44 , QT,   8,  SS, 0.0, SS
72 , QT,   9,  SS, 0.0, SS
95 , QT,  10,  SS, 0.0, SS
109, QT,  11,  SS, 0.0, SS
110, QT,  12,  SS, 0.0, SS
111, QT,  13,  SS, 0.0, SS
162, QT,  14,  SS, 0.0, SS
196, QT,  15,  SS, 0.0, SS
209, QT,  16,  SS, 0.0, SS
239, QT,  17,  SS, 0.0, SS
304, QF,   0,  SS, 0.0, CG,  -411
306, QF,   0,  SS, 0.0, CG,  -548
314, QF,   0,  SS, 0.0, CG,  -767
NEWB,      1,  1095.0                      Boundary condition is to be changed
22 , QT,   5,  SS, 0.0, SS                 at time = 1095 day.
NEWB,     18,  3650.0
92 , QF,   0,  SS, 0.0, CG,  -685          Boundary conditions are to be changed
93 , QF,   0,  SS, 0.0, CG,  -685          at time = 3650 day.
152, QF,   0,  SS, 0.0, CG,  -822
173, QF,   0,  SS, 0.0, CG,  -548
174, QF,   0,  SS, 0.0, CG,  -274          Existing pumping rate in the
175, QF,   0,  SS, 0.0, CG,  -548          Shoubak wellfield
176, QF,   0,  SS, 0.0, CG,  -548
180, QF,   0,  SS, 0.0, CG,  -466          Node 152, 173, 174, 175, 176,
181, QF,   0,  SS, 0.0, CG,  -274               180, 181, 182, 183, 193,
182, QF,   0,  SS, 0.0, CG,     0               194, 195
183, QF,   0,  SS, 0.0, CG,  -548
193, QF,   0,  SS, 0.0, CG,  -685
194, QF,   0,  SS, 0.0, CG,  -685
```

```
195, QF,  0,  SS, 0.0, CG,  -685
282, QF,  0,  SS, 0.0, CG,  -548
283, QF,  0,  SS, 0.0, CG,  -548
345, QF,  0,  SS, 0.0, CG,  -274
346, QF,  0,  SS, 0.0, CG,  -274
NEWB,    50,  6570.0
```

Boundary conditions are to be changed at time = 6570 day.

```
66 , QF,  0,  SS, 0.0, CG,  -2740
67 , QF,  0,  SS, 0.0, CG,  -2740
68 , QF,  0,  SS, 0.0, CG,  -2740
76 , QF,  0,  SS, 0.0, CG,  -2740
77 , QF,  0,  SS, 0.0, CG,  -2740
78 , QF,  0,  SS, 0.0, CG,  -2740
79 , QF,  0,  SS, 0.0, CG,  -2740
100, QF,  0,  SS, 0.0, CG,  -2740
101, QF,  0,  SS, 0.0, CG,  -2740
102, QF,  0,  SS, 0.0, CG,  -2740
```

South Hasa :
Node 66, 67, 68, 76, 77
78, 79, 100, 101, 102

```
152, QF,  0,  SS, 0.0, CG,  -1644
173, QF,  0,  SS, 0.0, CG,  -1370
174, QF,  0,  SS, 0.0, CG,  -1096
175, QF,  0,  SS, 0.0, CG,  -1096
176, QF,  0,  SS, 0.0, CG,  -1096
180, QF,  0,  SS, 0.0, CG,  -1205
181, QF,  0,  SS, 0.0, CG,  -1096
182, QF,  0,  SS, 0.0, CG,  -822
183, QF,  0,  SS, 0.0, CG,  -1096
193, QF,  0,  SS, 0.0, CG,  -1507
194, QF,  0,  SS, 0.0, CG,  -1507
195, QF,  0,  SS, 0.0, CG,  -1507
```

Double pumping rate in the Shoubak wellfield

Node 152, 173, 174, 175, 176,
180, 181, 182, 183, 193,
194, 195

```
255, QF,  0,  SS, 0.0, CG,  -2740
256, QF,  0,  SS, 0.0, CG,  -2740
257, QF,  0,  SS, 0.0, CG,  -2740
264, QF,  0,  SS, 0.0, CG,  -2740
265, QF,  0,  SS, 0.0, CG,  -2740
266, QF,  0,  SS, 0.0, CG,  -2740
267, QF,  0,  SS, 0.0, CG,  -2740
272, QF,  0,  SS, 0.0, CG,  -2740
273, QF,  0,  SS, 0.0, CG,  -2740
274, QF,  0,  SS, 0.0, CG,  -2740
```

East Ma'an :
Node 255, 256, 257, 264, 265
266, 267, 272, 273, 274

```
345, QF,  0,  SS, 0.0, CG,  -1000
346, QF,  0,  SS, 0.0, CG,  -1000
```

Shidya Mine :
Node 345, 346

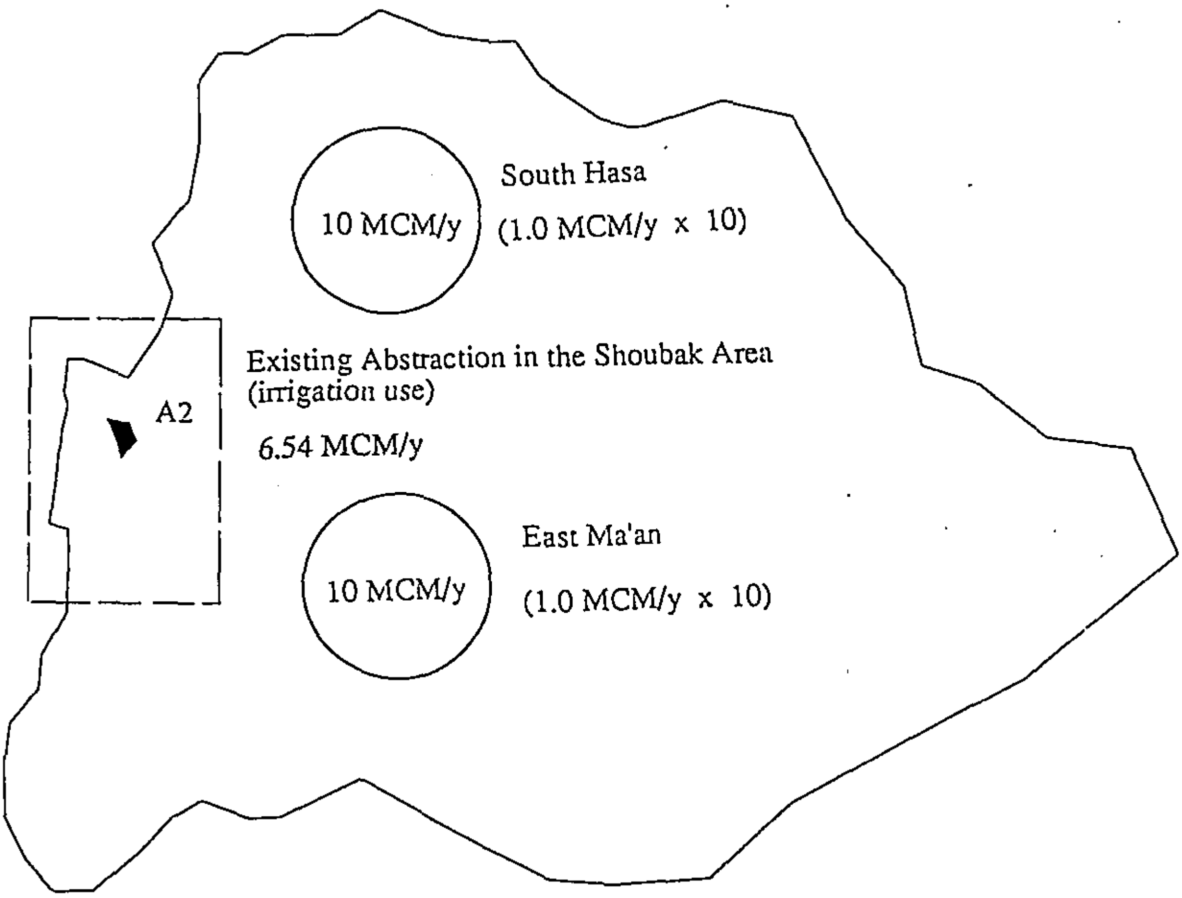
```
7  , QT, 18,  SS, 0.0, SS
8  , QT, 19,  SS, 0.0, SS
9  , QT, 20,  SS, 0.0, SS
26 , QT, 21,  SS, 0.0, SS
46 , QT, 22,  SS, 0.0, SS
47 , QT, 23,  SS, 0.0, SS
48 , QT, 24,  SS, 0.0, SS
49 , QT, 25,  SS, 0.0, SS
51 , QT, 26,  SS, 0.0, SS
52 , QT, 27,  SS, 0.0, SS
89 , QT, 28,  SS, 0.0, SS
132, QT, 29,  SS, 0.0, SS
139, QT, 30,  SS, 0.0, SS
300, QT, 31,  SS, 0.0, SS
343, QT, 32,  SS, 0.0, SS
358, QT, 33,  SS, 0.0, SS
NEWB,     1,  7665,0
164, QF,  0,  SS, 0.0, CG,   4411
```

Boundary conditions are to be changed at time = 7665 day.

A-2 Recharge Dam :
Node 164

3) Press **PF4** function key (at the end of edit)
4) Command : **EXIT** (save the data)

Fig. 38 Case 3-4 :
6.54 MCM/y of abstraction with the A-2 recharge dam



PART 4 GROUNDWATER SIMULATION OF THE JAFR BASIN (A1-6 AQUIFER)

PART 4 GROUNDWATER SIMULATION OF THE JAFR BASIN (A1-6 AQUIFER)

CONTENTS

CHAPTER I
MESH DATA PROCESSING

1. Data Input

The mesh division is made on the Jafr Basin and the Hasa Basin. The boundary of the mesh is extended to the edge of A1-6 aquifer in the north, the edge of saturated A1-6 aquifer in the south, the basin boundary in the east, and the edge of A1-6 outcrop in the west. The 223 nodes and 231 elements are defined considering following items;

- Geological structures: "Kalak - Wadi Al Fiha" fault
  "Salwan" fault
  "Arja - Uweina" flexure

- Proposed wellfield : East Hasa (around JT-3 test well)

The node coordinates are depend on Palestinian Grid. The element configuration is made by connecting the node numbers at vertexes of elements. The mesh data which include the node coordinates and the element connection is stored in the data file '**MESH.DAT**'. Input data is shown in PART 5.

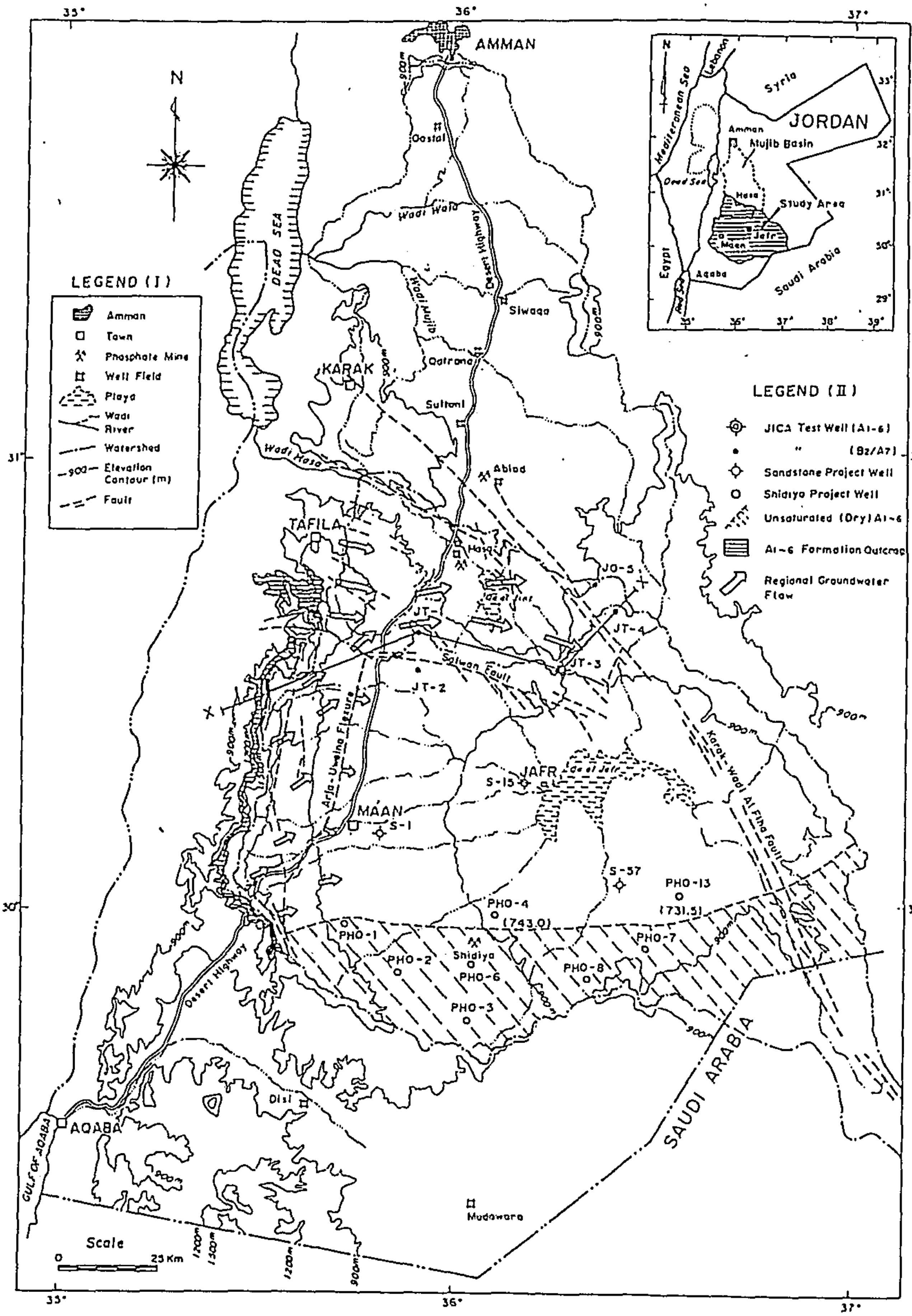


Fig. 1 Hydrogeological Map of Lower Ajlun (A1-6) Formation

2. Processing

The mesh data are processed by using the program '**UNISSF2/G**'. After processing, the mesh data are stored in the data file '**MESH.RST**' and the plotting data file of '**FOR040.DAT**'. The mesh diagram is shown on the graphic display by using the program '**DISPLAY**' with the data file 'FOR040.DAT'. The mesh diagram is also drawn by plotter with the program '**XYPLOT**'.

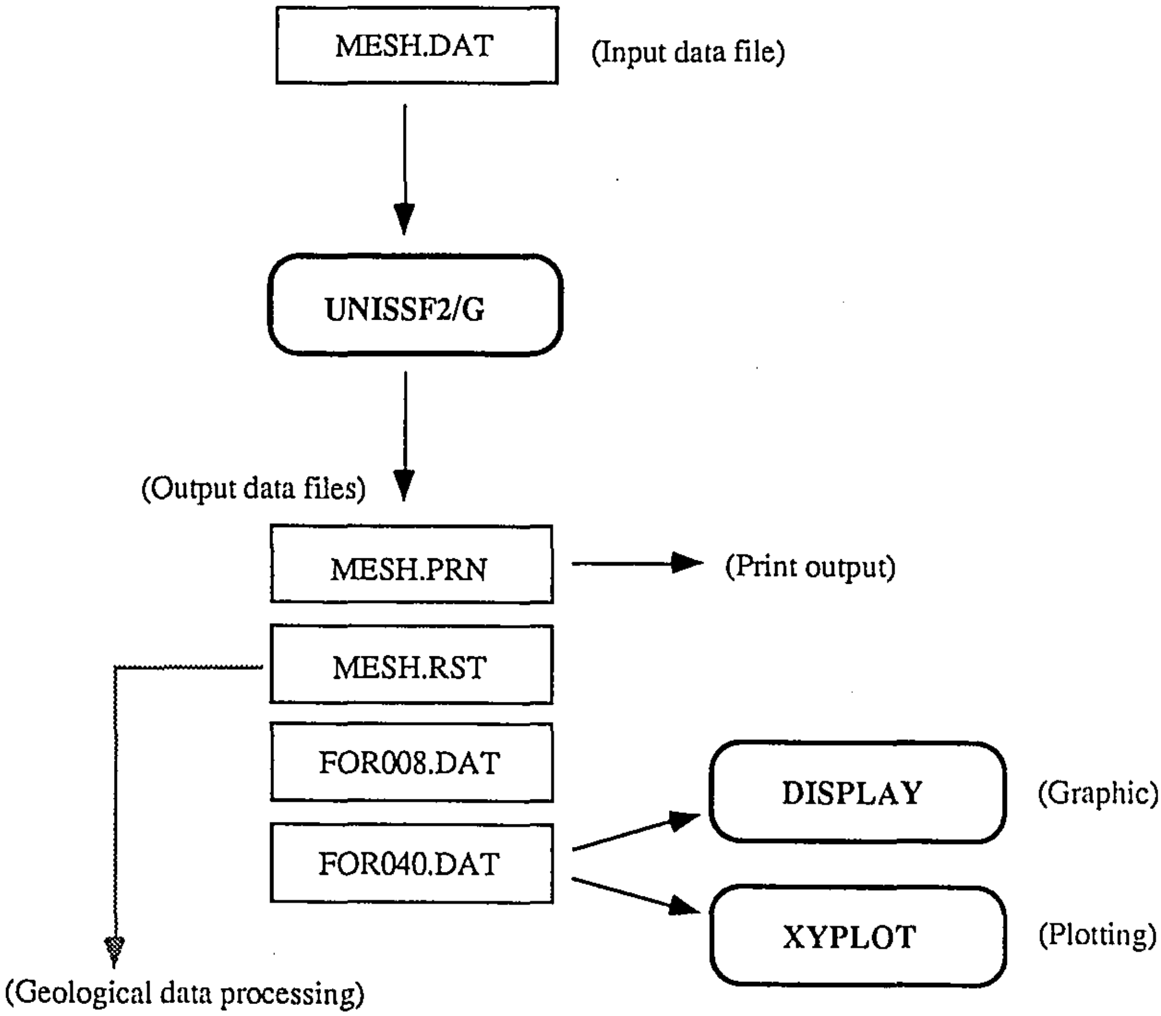


Fig. 2 Mesh Data Processing

3. Operation

(1) UNISSF2/G

1) $ **UNISSF** [enter]

2) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **G** [enter] ('G' for UNISSF2/G)

3) RESTART ? (Y/N) **N**

4) FILENAME (?.dat) **MESH**

.
.
.
(processing)
.
.
.
FORTRAN STOP

4) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **E** [enter] ('E' for end)

5) $ **ED MESH.PRN** [enter] (print output to be checked)

6) Press **PF4** function key (at the end of check)
7) Command : **QUIT** [enter]

(2) Graphic

1) Press **SET UP** key
2) *** CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **D** [enter] ('D' for **DISPLAY**)

6) FILE NAME : **FOR040.DAT** [enter]

7) Press **CLEAR** key

.
.
.

(Graphic1) (Press [enter] for next)
(Graphic2) (Press 'E' for end)

.
.
.

8) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **E** [enter] ('E' for end)

9) Press **SET UP** key
10) *** CODE ANSI** [enter]
11) Press **SET UP** key, and [enter]

(3) Plotting

1) Plotter set up
2) Paper set
3) Press '**On-line**' soft key

Note : Refer to **PLOTTER OPERATION GUIDANCE**

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **X** [enter] ('X' for **XYPLOT**)

6) FILE NAME : **FOR040.DAT** [enter]

.
.
.
(Plotting)
.
.
.

7) If there are more than 2 drawings, the plotting is stopped and the message '**HALT RECIEVED...**' is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press '**On-line**' soft key.

8) At the end of plotting, the message '**PLOT COMPLETE**' is shown on the plotter window.

9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter]

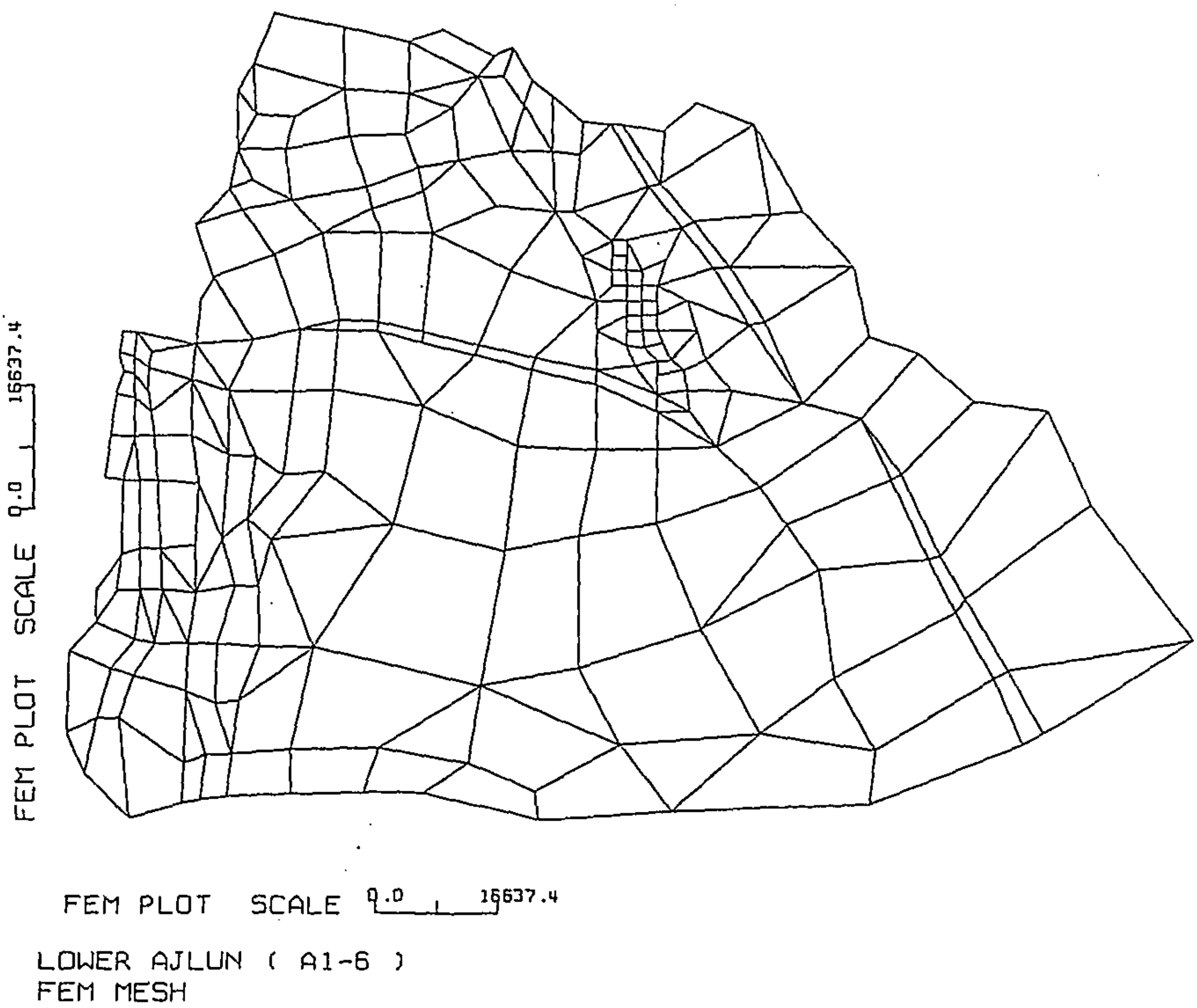


Fig. 3 Mesh Diagram

CHAPTER II
GEOLOGICAL DATA PROCESSING

1. Data Input

Geological data are necessary to demonstrate the geological structures in the study area. The geological data are composed of the following items:

- Elevation contour of the bottom of A1-6 aquifer
- Elevation contour of the top of A1-6 aquifer
- Elevation contour of ground surface

From the contour diagram above, the elevations are estimated for each node which is defined on the mesh diagram. The mesh diagram of the A1-6 aquifer includes 223 nodes. This number is too much to give the geological data for each node manually. In this case, the **auto generator** which is a function of the program **'UNISSF2/G'** is available.

The input data of using the auto genarator of 'UNISSF2/G' are composed of the geological data at several number of **key points**, which are selected nodes on the mesh diagram. The geological data of the nodes which are in the region enclosed by the four key points are interpolated with the data at key points.

The 33 key points are selected on the mesh diagram of A1-6 aquifer, and the 23 regions are defined on the mesh diagram. The mesh diagram is almost covered with the regions. Selected key points and geological data at key points are shown on Table 1. The regions defined on the mesh diagram are shown on Fig. 2. The data file named **'GEOL.DAT'** for the auto generator of 'UNISSF2/G' is shown in PART 5.

2. Processing

After mesh data processing, the mesh data are stored in the data file **'MESH.RST'**. Geological data are processed by using the auto generator of 'UNISSF2G' with the data files **'MESH.RST'** and **'GEOL.DAT'**. Generated geological data are entered into the data file **'GEOL.FT21'** and the plotting data file of **'FOR040.DAT'**.

Table 1 Key Points for Geological Data Processing

Key Points	Elevation (EL m)		
Node Number	Bottom of A1-6 (BASE)	Top of A1-6 (AQUI)	Ground Surface (SURF)
2	450	550	1000
4	450	600	1000
6	470	620	950
7	500	600	1000
23	440	540	1000
25	450	550	880
30	450	650	880
36	450	670	1000
37	1000	1100	1200
89	420	680	910
100	450	670	920
102	300	500	1200
103	300	500	1200
105	160	480	1100
121	850	1000	1450
132	160	480	910
149	330	500	1100
150	1150	1250	1650
155	1000	1100	1650
161	500	630	1100
163	280	480	880
179	600	750	1100
182	500	650	900
185	420	600	880
192	450	670	920
193	1050	1250	1700
202	1200	1350	1650
210	800	900	1100
216	690	800	890
221	550	700	880
223	690	800	890
230	500	670	930
231	680	750	920

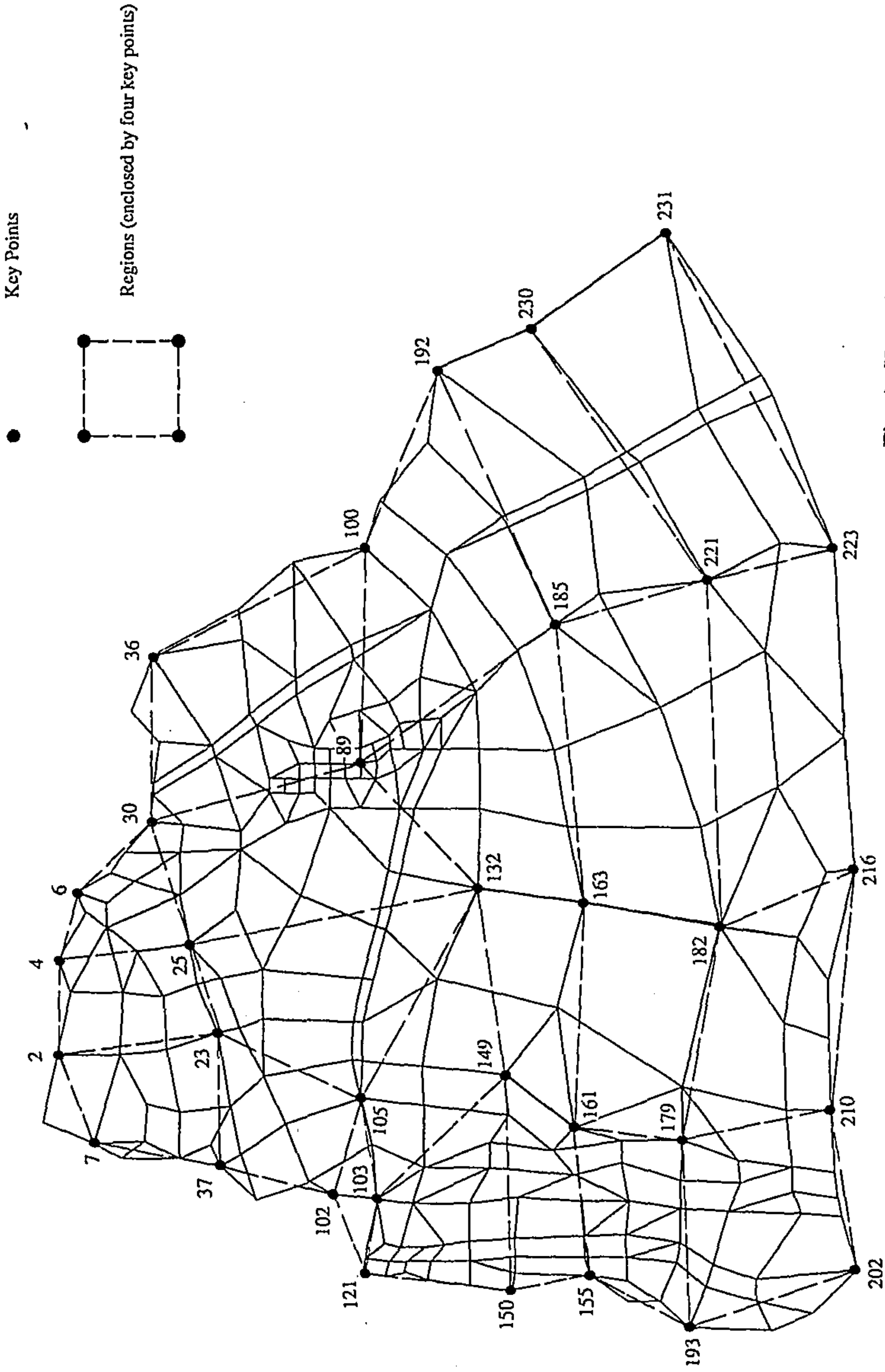


Fig. 4 Keypoints and Regions

The geological contour diagrams are shown on the graphic display by using the program **'DISPLAY'** with the data file 'FOR040.DAT'. The contour diagrams are also drawn by plotter with **'XYPLOT'**.

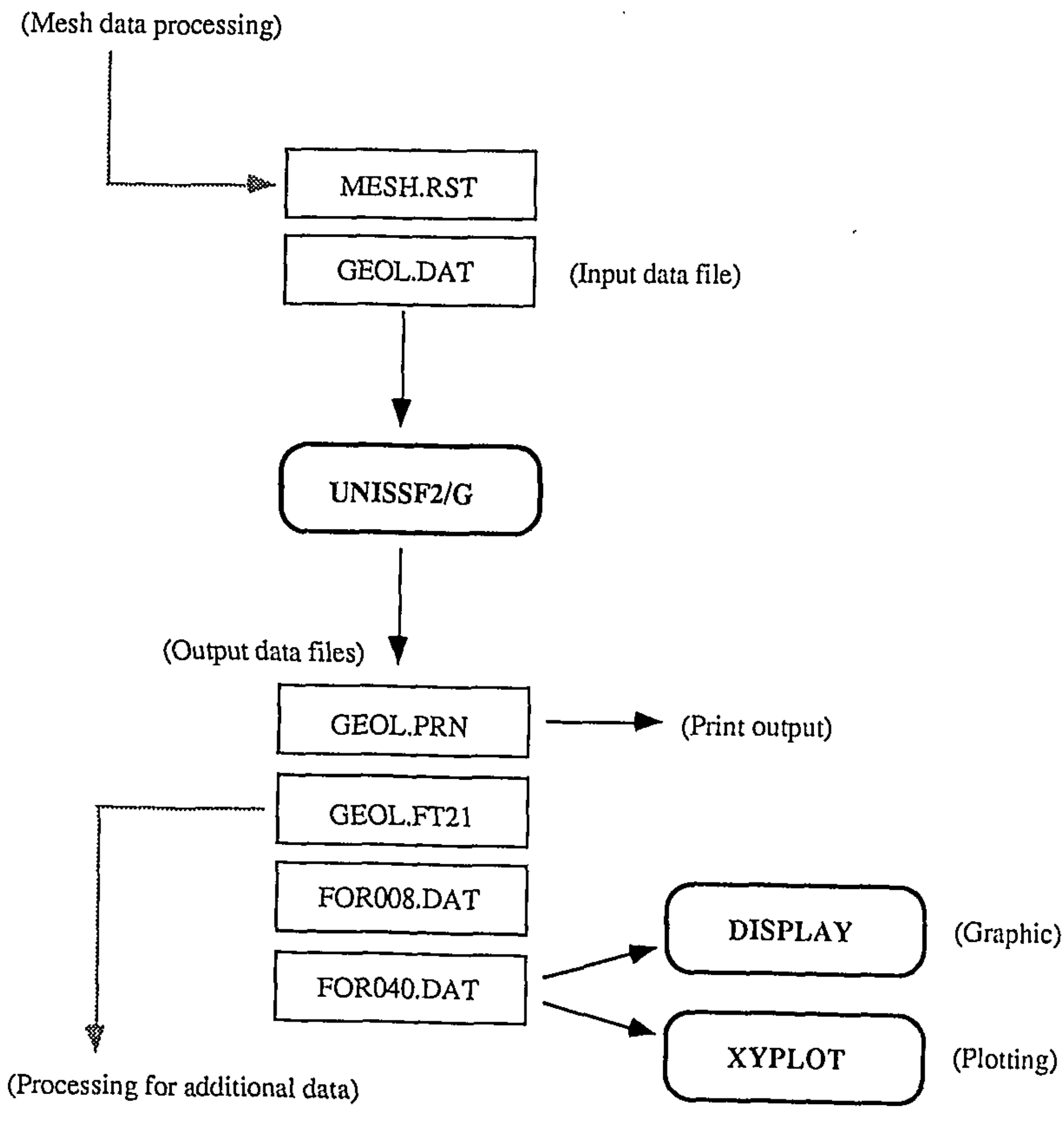


Fig. 5 Geological Data Processing

3. Operation

(1) UNISSF2/G

1) $ UNISSF [enter]

2) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **G** [enter] ('G' for UNISSF2/G)

3) RESTART ? (Y/N) **N**

4) FILENAME (?.dat) **GEOL**

5) RESTART FILENAME (?.dat) **MESH**

.
.
.
(processing)
.
.
.
FORTRAN STOP

4) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **E** [enter] ('E' for end)

5) **$ ED GEOL.PRN** [enter] (print output to be checked)

6) Press **PF4** function key (at the end of check)
7) Command: **QUIT** [enter]

(2) Graphic

1) Press **SET UP** key
2) * **CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> D [enter] ('D' for **DISPLAY**)

6) FILE NAME : **FOR040.DAT** [enter]

7) Press **CLEAR** key

.
.
.

(Graphic1) (Press [enter] for next)
(Graphic2) (Press 'E' for end)

.
.
.

8) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> E [enter] ('E' for end)

9) Press **SET UP** key
10) * **CODE ANSI** [enter]
11) Press **SET UP** key, and [enter]

(3) Plotting

1) Plotter set up
2) Paper set
3) Press **'On-line'** soft key

Note : Refer to **PLOTTER OPERATION GUIDANCE**

4) $ **UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

   PLEASE ENTER ----> **X** [enter] ('X' for **XYPLOT**)

6) FILE NAME : **FOR040.DAT** [enter]

   .
.
.
(Plotting)
.
.
.

7) If there are more than 2 drawings, the plotting is stopped and the message **'HALT RECIEVED...'** is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press 'On-line' soft key.

8) At the end of plotting, the message **'PLOT COMPLETE'** is shown in the plotter window.

9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

   PLEASE ENTER ----> **E** [enter]

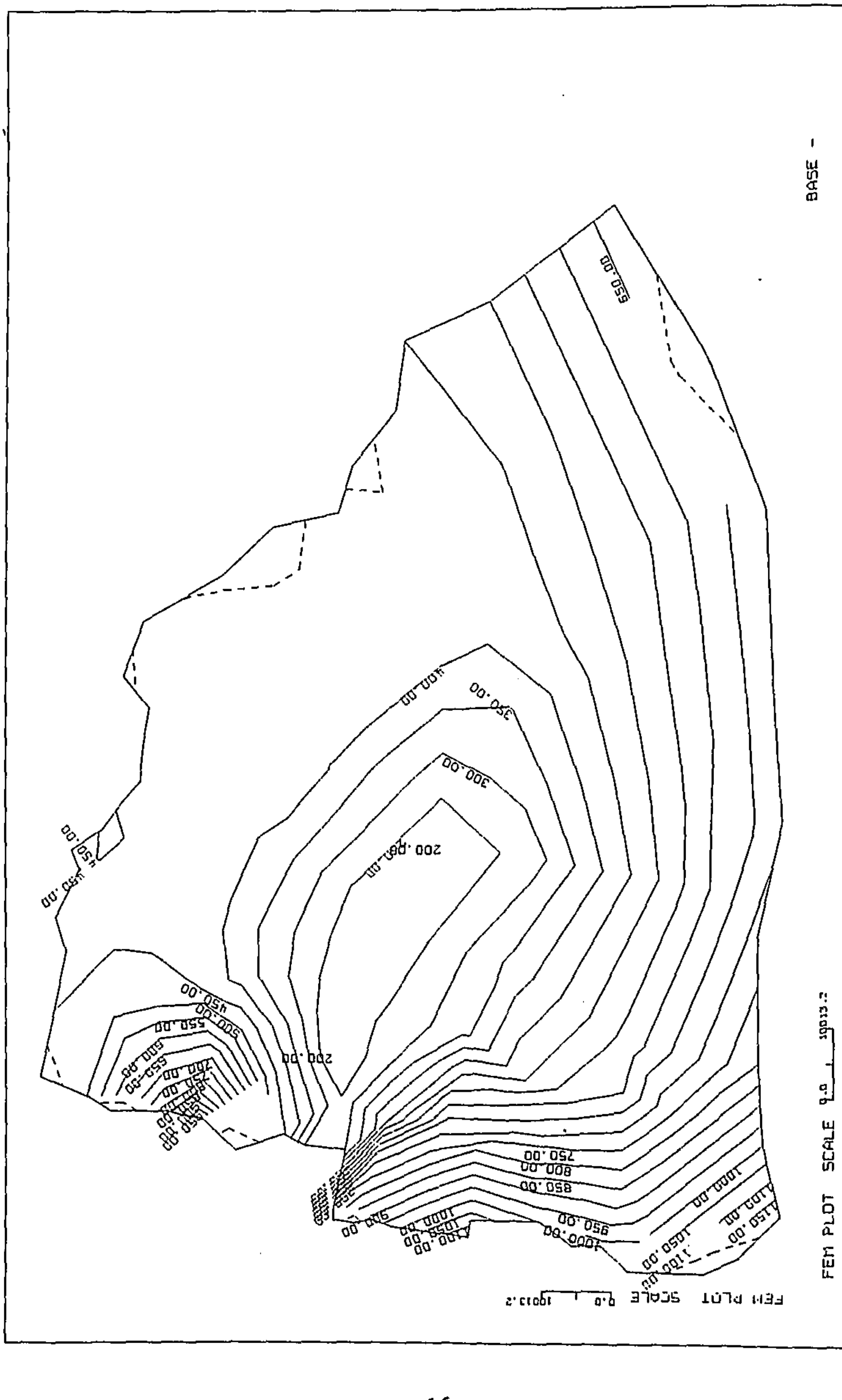


Fig. 6 Elevation Contour by Auto Generator (Bottom of A1-6)

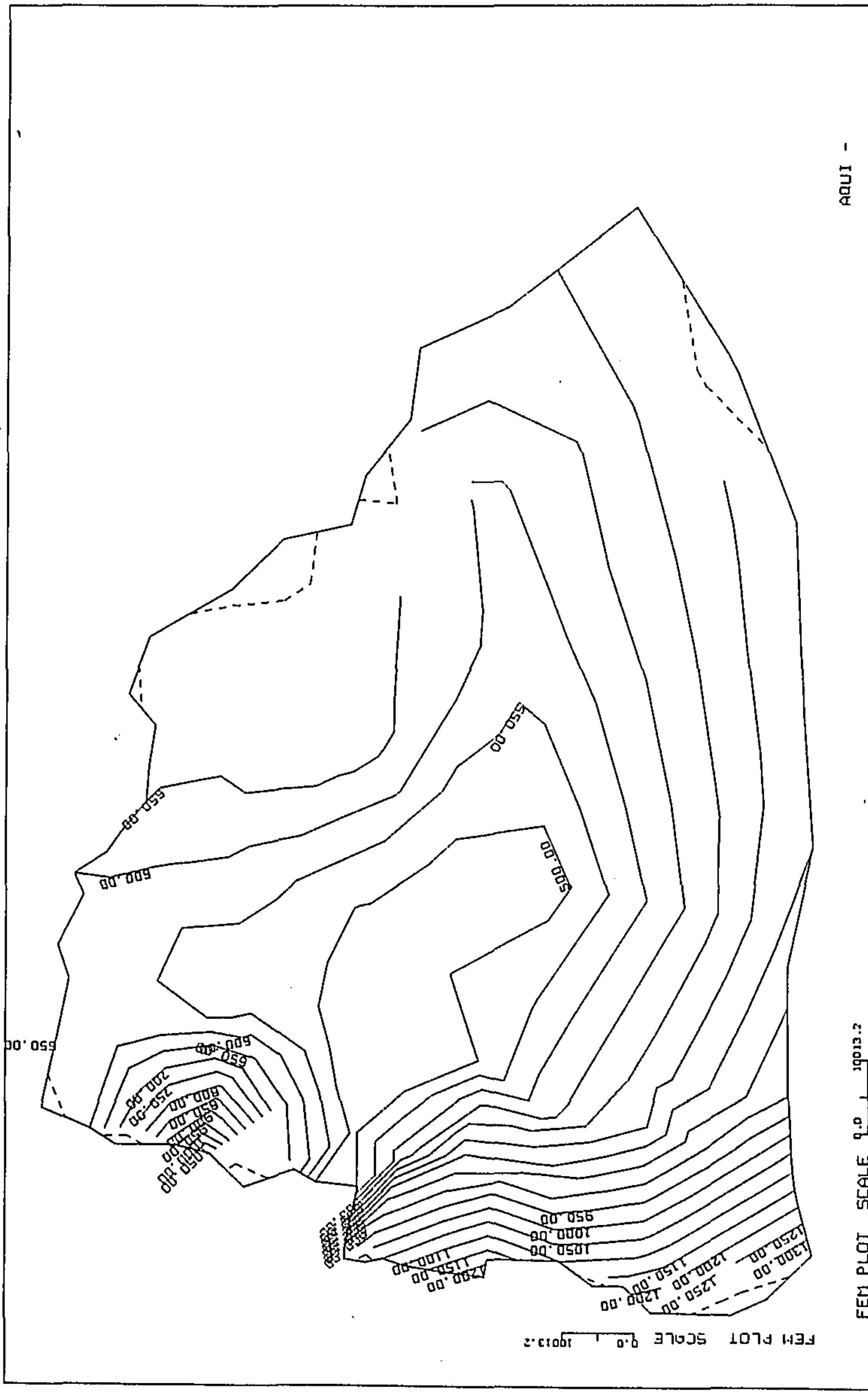


Fig. 7 Elevation Contour by Auto Generator (Top of A1-6)

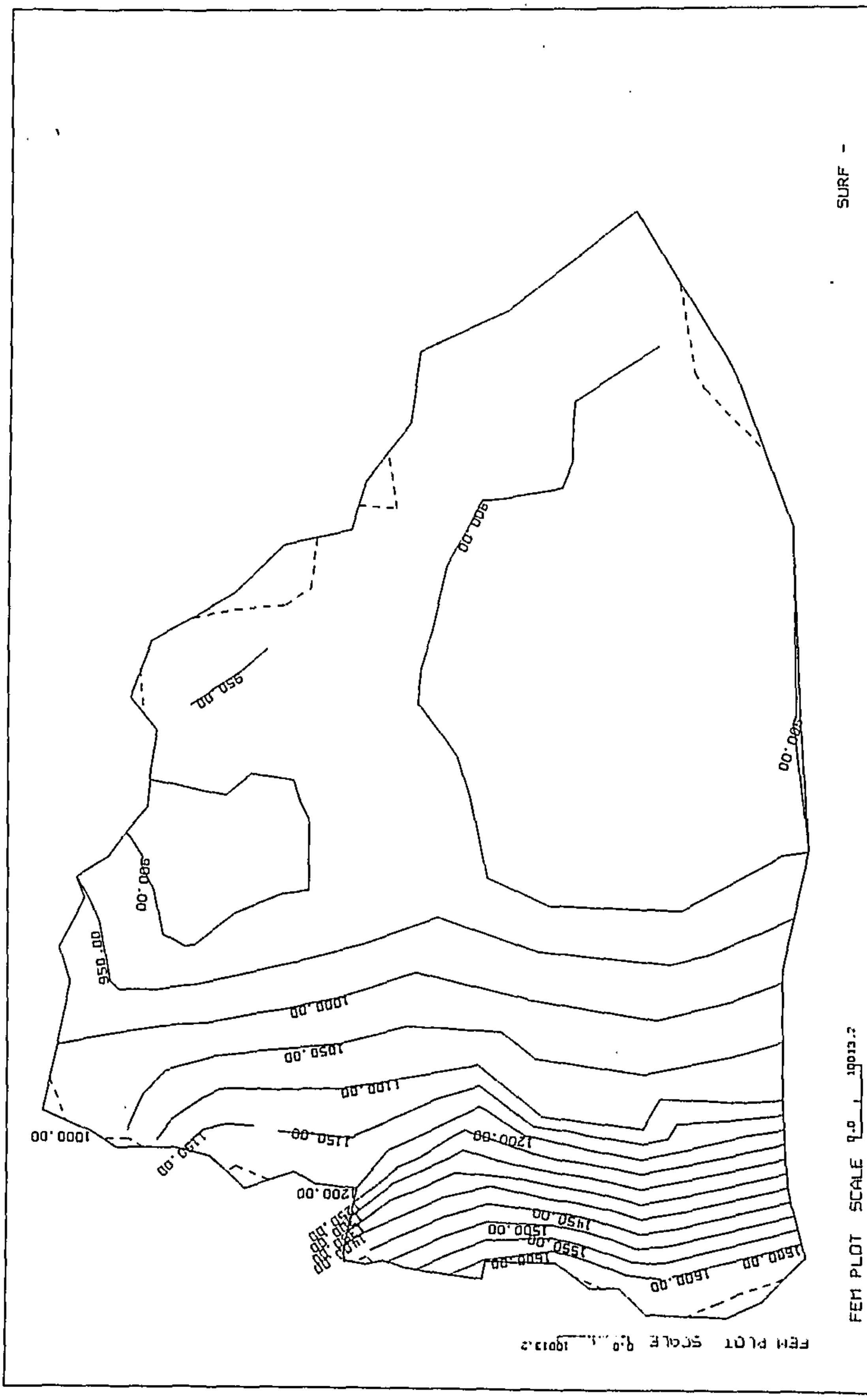


Fig. 8 Elevation Contour by Auto Generator (Ground Surface)

5. Additional Geological Data

The generated geological data are stored in the data file **'GEOL.FT21'**. But geological data at some nodes are nor incorporated in the 'GEOL.FT21'. These nodes are located outside of the regions enclosed by the key points so that the data are not generated by the auto generator of 'UNISSF2/G'. Nodes located outside of the regions are shown on Fig. 10. Geological data for these nodes are added to the data file 'GEOL.FT21' by using the program **'GADD'**. The additional data are shown on Table 2.

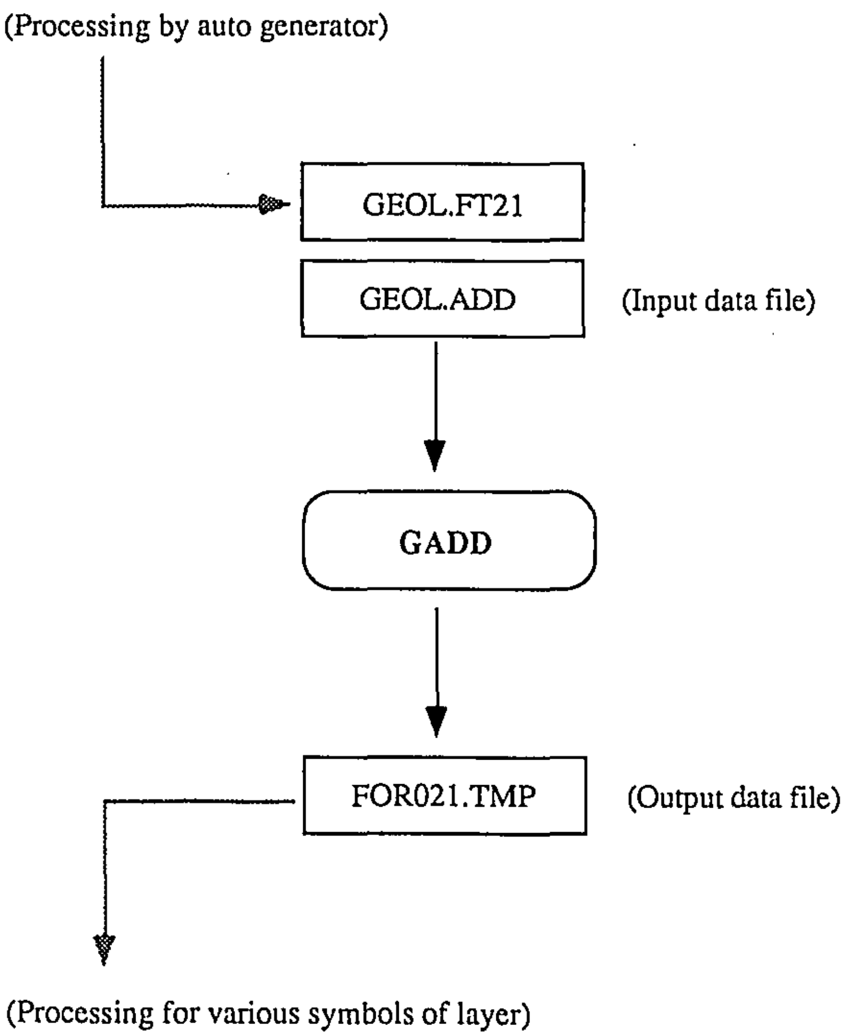


Fig. 9 Processing for Additional Geological Data

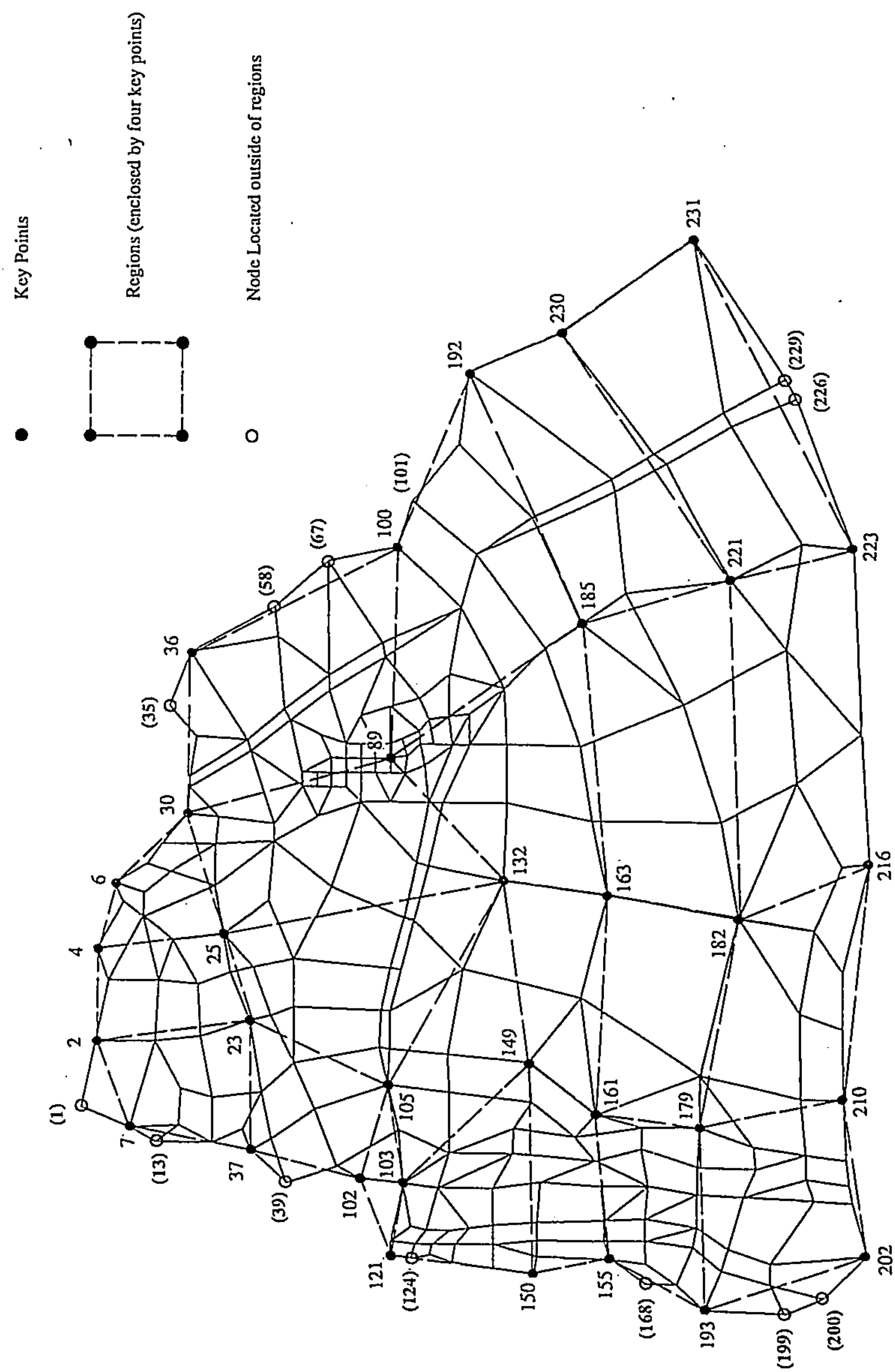


Fig. 10 Nodes Located outside of the Regions

The data file **'GEOL.ADD'** is prepared for the additional geological data (shown in APPENDIX A). By the program 'GADD', the data on 'GEOL.ADD' are combined with the data on 'GEOL.FT21'. The combined data are entered into the data file **'FOR021.TMP'** which includes the geological data for the all nodes. Operation of the program 'GADD' is described below.

1) $ **GADD** [enter]

2) Default File Name :

   UNIT 1 : GEOL.FT21
   UNIT 2 : GEOL.ADD
   UNIT 3 : FOR021.TMP (default only)

   Use Default ? (Y/N) **Y** [enter]

3) UNIT 1 : GEOL.FT21
   UNIT 2 : GEOL.ADD
   UNIT 3 : FOR021.TMP

   Press enter to continue [enter]

   .
   .
   .
   (processing)
   .
   .
   .
   FORTRAN STOP

Table 2 Additonal Geological Data

Node Number	Elevation (EL m) Bottom of A1-6 (BASE)	Top of A1-6 (AQUI)	Ground Surface (SURF)
1	450	550	1000
13	650	750	1200
35	450	670	1000
39	1000	1100	1200
58	450	650	950
67	450	650	950
101	450	650	1200
124	900	1050	1450
168	1050	1200	1680
199	1220	1300	1680
200	1220	1350	1680
226	690	800	900
229	690	800	900

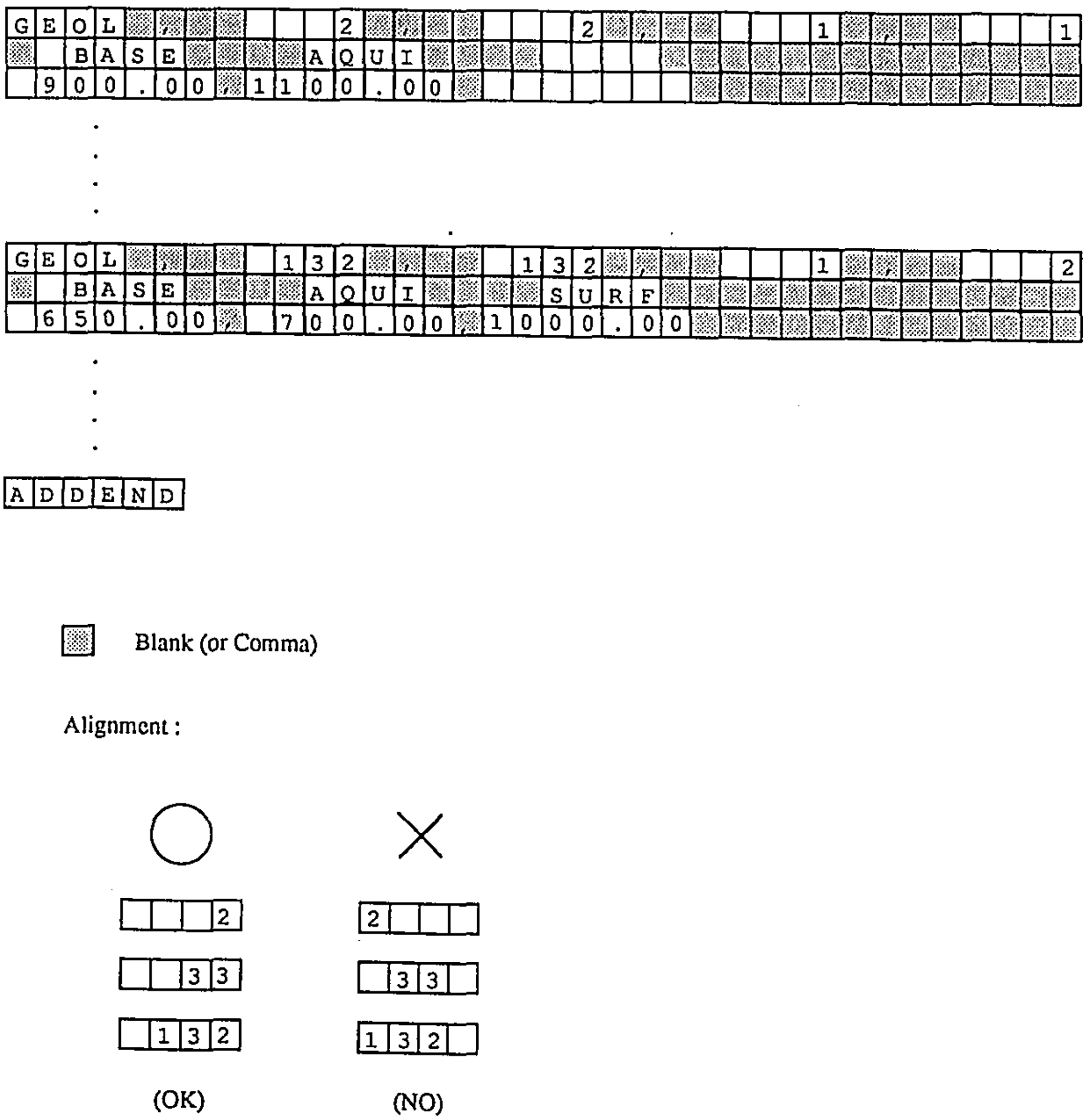


Fig. 11 Data Input Format for 'GEOL.ADD'

CHAPTER III
AQUIFER CONSTANTS

1. Aquifer Symbols and Constants

The data file 'FOR021.TMP' includes the geological data which are composed of the top elevation of the three layers symbolized '**BASE**', '**AQUI**' and '**SURF**'. The layer symbolized 'AQUI' is the A1-6 aquifer and the layer above the A1-6 is considered as less permeable layer, which is symbolized 'SURF'.

Aquifer constants, coefficient of permeability (K) and coefficient of storage (S), are various in the study area so that the various K and S are given as data for each node

For expression of this, several number of symbols are necessary for the A1-6 and the upper layer, instead of the symbols AQUI and SURF included in the geological data respectively.

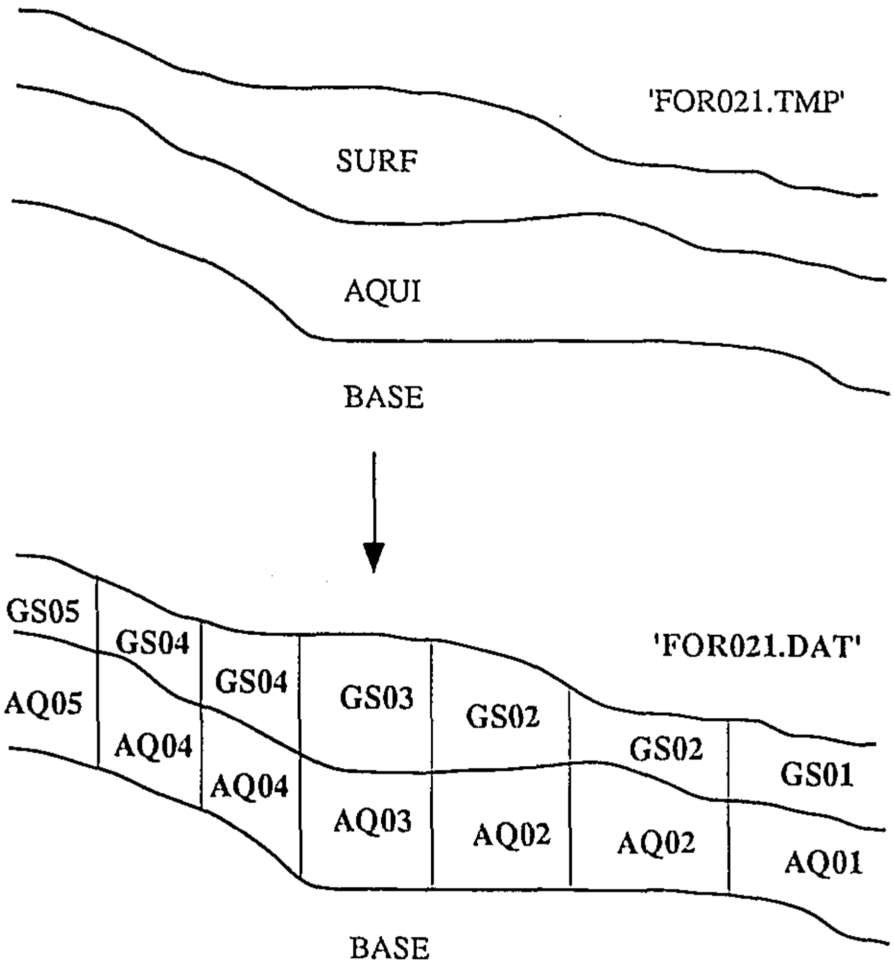


Fig. 12 Various Symbols

2. Processing

The data of various symbols for each node are prepared in the data file **'NMAT.DAT'**. The input format of 'NMAT.DAT' is illustrated in Fig. 14. By the program **'NMAT'**, the symbols 'AQUI' and 'SURF' in the data file 'FOR021.TMP' are revised according to the various symbols in the 'NMAT.DAT' and the revised geological data are stored in the data file **'FOR021.DAT'**

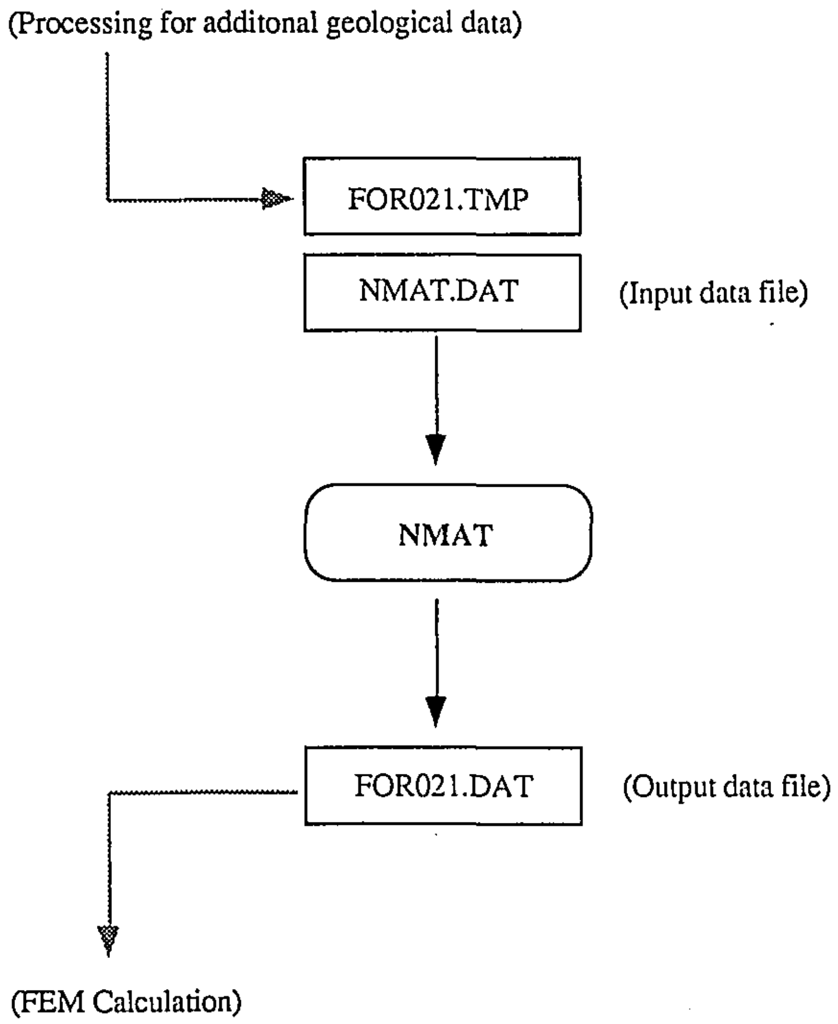


Fig. 13 Processing for Various Symbols of Layer

			1					A	Q	1	4
			2					A	Q	1	2
			3					A	Q	1	2

·
·
·

	3	5	9					A	Q	1	0
	3	6	0					A	Q	1	2
	3	6	1					A	Q	1	2
A	Q	E	N	D							

▒ Blank

Alignment :

○	○	○	○		×	×	×	×
			2		2			
		3	3			3	3	
	1	3	2		1	3	2	

(OK) (NO)

Fig. 14 Data Input Format for 'NMAT.DAT'

3. Operation

1) $ **NMAT** [enter]

2) Default File Name

   UNIT1 : NMAT.DAT
   UNIT2 : FOR021.TMP (default only)
   UNIT3 : FOR021.DAT (default only)

   Use Default ? (Y/N) **Y**

3) UNIT1 : NMAT.DAT
   UNIT2 : FOR021.TMP
   UNIT3 : FOR021.DAT

   Press enter to continue [enter]

   .
   .
   .

   (processing)

   .
   .
   .

   FORTRAN STOP

4. Data Preparation of K and S

The aquifer constants K and S are prepared for each symbol of layer included in the data file 'FOR021.DAT'. The 35 symbols are included in the 'FOR021.DAT', which require the 35 pair of the constants such as K and S are also prepared. Table 3 shows the symbols and aquifer constants.

Table 3 Symbols and Aquifer Constants

Symbol	K	S
GRSF	0.00001 /1	0.00001 /2
AQ01	10.0	0.20 /3
AQ02	8.0	0.197
AQ03	6.0	0.193
AQ04	4.0	0.187
AQ05	2.0	0.178
AQ06	1.5	0.174
AQ07	1.0	0.168
AQ08	0.80	0.165
AQ09	0.60	0.161
AQ10	0.40	0.156
AQ11	0.20	0.146
AQ12	0.10	0.137
AQ13	0.09	0.135
AQ14	0.08	0.134
AQ15	0.07	0.132
AQ16	0.06	0.130
AQ17	0.05	0.127
AQ18	0.04	0.124
AQ19	0.03	0.120
AQ20	0.02	0.115
AQ21	0.01	0.105
AQ22	0.009	0.104
AQ23	0.008	0.102
AQ24	0.007	0.100
AQ25	0.006	0.098
AQ26	0.005	0.096
AQ27	0.004	0.092
AQ28	0.003	0.088
AQ29	0.002	0.083
AQ30	0.001	0.073
AQ31	0.0005	0.064
AQ32	0.0001	0.042
AQ33	0.00005	0.032
AQ34	0.00001	0.010

Note : Maximum number of symbols is 40.

/1 Upper layer (symbol 'GRSF') is assumed to be impervious.

/2 Coefficent of storage for 'AQUI in the case of the confined aquifer

This value is given to the upper layer 'GRSF'.

Coefficient of Storage (S)

	Confined	Unconfined
AQUI	0.00001	(various)

↓

Input Data of S for GRSF

/3 Coefficient of storage in the case of unconfined aquifer

CHAPTER IV
FEM CALCULATION BY UNISSF2

1. Data Input

The mesh data and geological data are prepared in the data file 'FOR021.DAT' through the pre-processing. The data of boundary condition, initial condition and aquifer constants are stored in another data file which is used for FEM calculation by the program 'UNISSF2' with the data file 'FOR021.DAT'.

(1) Boundary Condition

The boundary conditions are either of the specified-head or specified flow type.Nodes along the western basin boundary, where average annual rainfall exceeds 150 mm in the outcrop area, are of specified-head type of boundary condition. The specified-flow of outflow type is given to the node along the eastern boundary of the model, where ground water flows out to further east to northeast. The northern boundary is along the edge of A1-6 aquifer and the southern boundary is along the edge of the saturated A1-6 aquifer. Both the northern and the southern boundary are considered as the boundary of no inflow/outflow type. The condition of nodes along the boundary is shown in Table 4 and Fig. 15.

Table 4 Boundary Conditions

	Western Boundary (Specified Head Type)		
Node	Specified Piezometric Head (EL m)	Node	Specified Flow (m3/day)
7	945.0	4	-600
13	950.0	6	-600
16	1000.0	12	-600
37	1030.0	29	-600
39	1000.0	30	-600
40	951.0	32	-400
102	951.0	33	-400
103	952.0	34	-600
121	965.0	35	-600
122	960.0	36	-600
124	975.0	58	-600
136	975.0	67	-600
139	1027.3	100	-2600
142	1171.2	101	-2600
150	1202.5	191	-880
151	1131.6	192	-880
155	1052.5	230	-550
168	1154.0		
169	1172.0		
193	1102.5		
199	1272.5		
200	1272.5		
202	1302.5		

Note : Minus (-) means outflow from the study area.

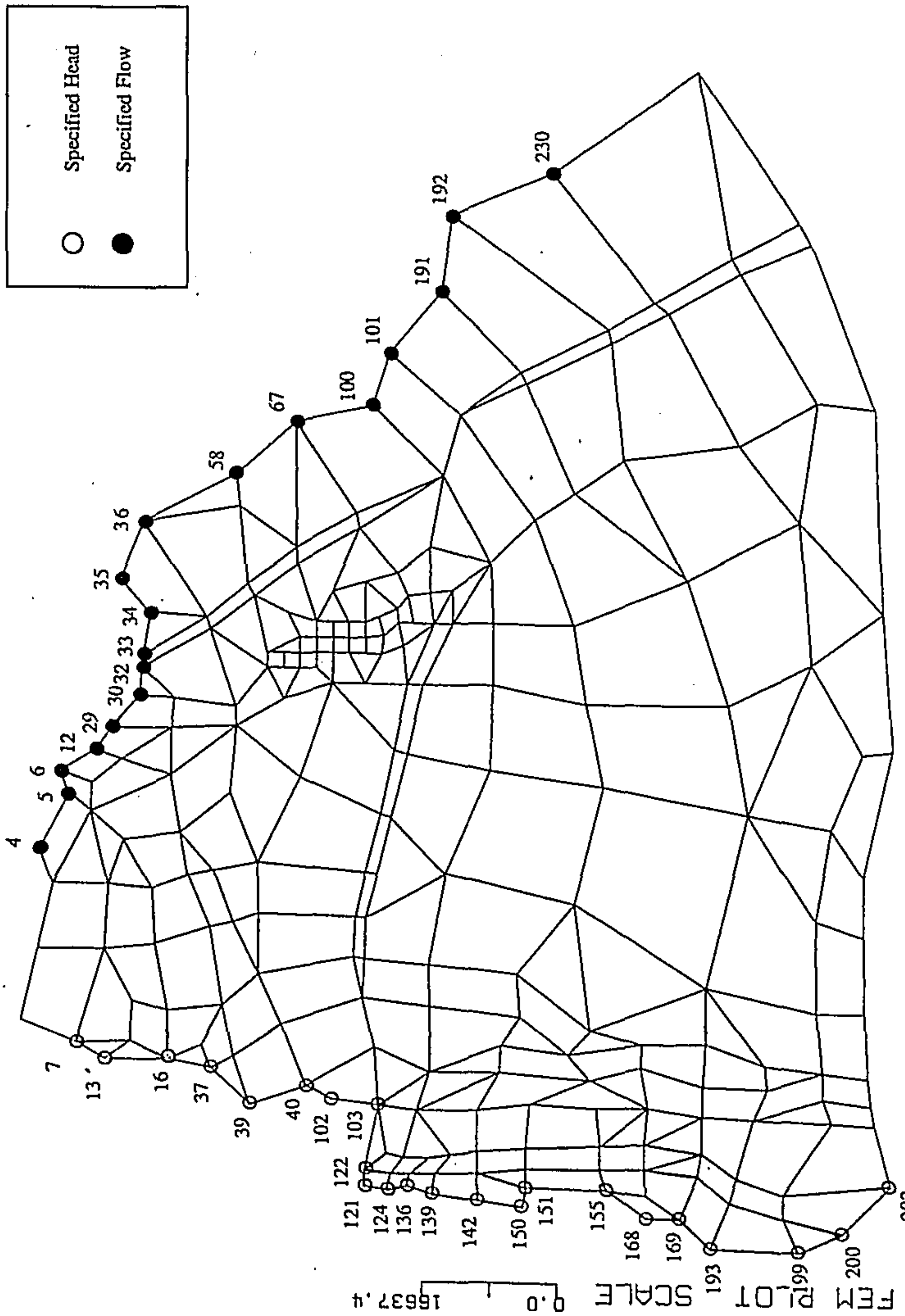


Fig. 15 Boundary Conditions

(2) **Aquifer Constants**

Aquifer constants of K and S with the symbol of layer ,which are shown on Table 3, are stored in the data file for FEM calculation. Each pair of K and S is specified for each node according to the symbol of layer which is also included in the data file 'FOR021.DAT'.

The data including above items are stored in the data file **'MODEL2.NEW'** shown below;

```
SETTING, CHEC,  3600,   0
TITLE
     WATER RESOURCES STUDY OF THE JAFR BASIN ( LOWER AJLUN )
1ST ,  231,  229,    8,  231,    3
2ND ,    3,    0,    0,    0,    0
3RD ,    0,    0,    0,    0,    0,    0
4TH ,    0,    0
*
*    --- MESH DATA ---
*
GENE
*
*
UNIT,  ME    ,  DAY , 25, 5.0E-01
CONT,  STEADY
*
*
*    --- BOUNDARY CONDITION ---
*
*        HF :  SPECIFIED HEAD
*        QF :  SPECIFIED FLOW
*
*       NODE          CONDITION
*
NCON,    7,    7,  1,  HF
NCON,   13,   13,  1,  HF
NCON,   16,   16,  1,  HF
NCON,   37,   37,  1,  HF
NCON,   39,   39,  1,  HF
NCON,   40,   40,  1,  HF
NCON,  102,  102,  1,  HF
NCON,  103,  103,  1,  HF
NCON,  121,  121,  1,  HF
NCON,  122,  122,  1,  HF
NCON,  124,  124,  1,  HF
NCON,  136,  136,  1,  HF
NCON,  139,  139,  1,  HF
NCON,  142,  142,  1,  HF
NCON,  150,  150,  1,  HF
NCON,  151,  151,  1,  HF
NCON,  155,  155,  1,  HF
NCON,  168,  168,  1,  HF
NCON,  169,  169,  1,  HF
NCON,  193,  193,  1,  HF
NCON,  199,  199,  1,  HF
NCON,  200,  200,  1,  HF
```

Mesh data are read from 'FOR021.DAT' by GENE command.

Western boundary (specified head)

```
NCON,  202, 202,  1,  HF
*
NCON,    4,   4,  1,  QF
NCON,    5,   5,  1,  QF
NCON,    6,   6,  1,  QF
NCON,   12,  12,  1,  QF
NCON,   29,  29,  1,  QF
NCON,   30,  30,  1,  QF
NCON,   32,  32,  1,  QF
NCON,   33,  33,  1,  QF
NCON,   34,  34,  1,  QF
NCON,   35,  35,  1,  QF
NCON,   36,  36,  1,  QF
NCON,   58,  58,  1,  QF
NCON,   67,  67,  1,  QF
NCON,  100, 100,  1,  QF
NCON,  101, 101,  1,  QF
NCON,  191, 191,  1,  QF
NCON,  192, 192,  1,  QF
NCON,  230, 230,  1,  QF
*
*
*    --- INITIAL CONDITION ---
*
*       NODE          HEAD
*
INIP,    7,   7,  1,   945.00
INIP,   13,  13,  1,   950.00
INIP,   37,  37,  1,  1030.00
INIP,   39,  39,  1,  1000.00
INIP,   40,  40,  1,   951.00
INIP,  102, 102,  1,   951.00
INIP,  103, 103,  1,   952.00
INIP,  121, 121,  1,   965.00
INIP,  122, 122,  1,   960.00
INIP,  124, 124,  1,   975.00
INIP,  136, 136,  1,   975.00
INIP,  139, 139,  1,  1027.30
INIP,  142, 142,  1,  1171.20
INIP,  150, 150,  1,  1202.50
INIP,  151, 151,  1,  1131.60
INIP,  155, 155,  1,  1052.50
INIP,  168, 168,  1,  1154.00
INIP,  169, 169,  1,  1072.00
INIP,  193, 193,  1,  1102.50
INIP,  199, 199,  1,  1272.50
INIP,  200, 200,  1,  1272.50
INIP,  202, 202,  1,  1302.50
*
INIQ,    4,   4,  1,  -600
INIQ,    5,   5,  1,  -600
INIQ,    6,   6,  1,  -600
INIQ,   12,  12,  1,  -600
INIQ,   29,  29,  1,  -600
INIQ,   30,  30,  1,  -600
INIQ,   32,  32,  1,  -400
INIQ,   33,  33,  1,  -400
INIQ,   34,  34,  1,  -600
INIQ,   35,  35,  1,  -600
INIQ,   36,  36,  1,  -600
INIQ,   58,  58,  1,  -600
INIQ,   67,  67,  1,  -600
```

Eastern boundary (specified flow)

Specified head along the western boundary

Specified head along the eastern bounday

```
INIQ,  100, 100,  1,  -2600
INIQ,  101, 101,  1,  -2600
INIQ,  191, 191,  1,  -880
INIQ,  192, 192,  1,  -880
INIQ,  230, 230,  1,  -550
*
*
*    --- AQUIFER CONSTANTS ---
*
*      K : COEFFICIENT OF INFILTRATION CAPACITY
*      S : COEFFICIENT OF STORAGE
*
*                  SYMBOL OF      K        S
*                  AQUIFER
*
LAYE,  35
                   GRSF,         0.00001,  0.00001
                   AQ01,        10.0,      0.20
                   AQ02,         8.0,      0.197
                   AQ03,         6.0,      0.193
                   AQ04,         4.0,      0.187
                   AQ05,         2.0,      0.178
                   AQ06,         1.5,      0.174
                   AQ07,         1.0,      0.168
                   AQ08,         0.80,     0.165
                   AQ09,         0.60,     0.161
                   AQ10,         0.40,     0.156
                   AQ11,         0.20,     0.146
                   AQ12,         0.10,     0.137
                   AQ13,         0.09,     0.135
                   AQ14,         0.08,     0.134
                   AQ15,         0.07,     0.132
                   AQ16,         0.06,     0.130
                   AQ17,         0.05,     0.127
                   AQ18,         0.04,     0.124
                   AQ19,         0.03,     0.120
                   AQ20,         0.02,     0.115
                   AQ21,         0.01,     0.105
                   AQ22,         0.009,    0.104
                   AQ23,         0.008,    0.102
                   AQ24,         0.007,    0.100
                   AQ25,         0.006,    0.098
                   AQ26,         0.005,    0.096
                   AQ27,         0.004,    0.092
                   AQ28,         0.003,    0.088
                   AQ29,         0.002,    0.083
                   AQ30,         0.001,    0.073
                   AQ31,         0.0005,   0.064
                   AQ32,         0.0001,   0.042
                   AQ33          0.00005,  0.032
                   AQ34,         0.00001,  0.010
*
*
*    --- GEOLOGICAL DATA ---
*
*
GENE
*
*
*
ENDD
```

Geological data are read from 'FOR21.DAT' by GENE command.

(3) **Initial Condition**

The initial condition of piezometric head is assumed at DH m above the elevation at bottom of the A1-6 as shown below.

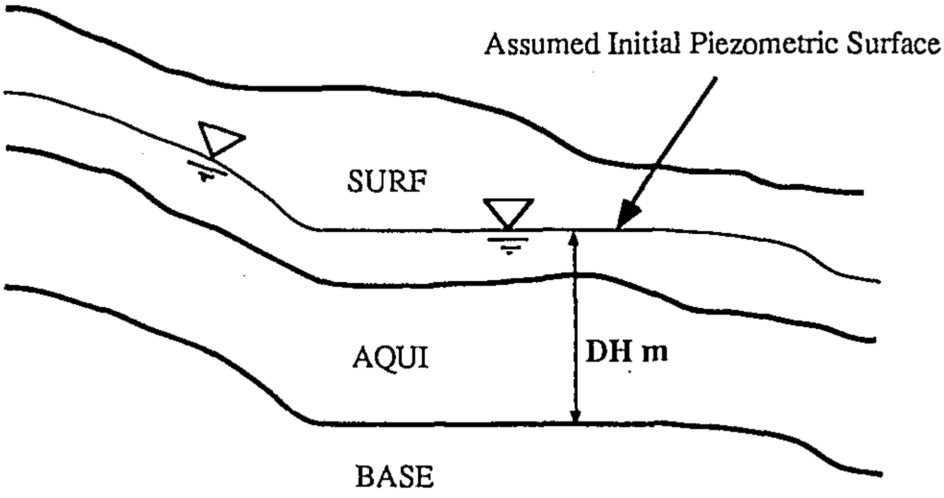


Fig. 16 Assumption of Initial Head

The data of initial condition for each node are prepared. The data file 'MODEL2.DAT', which ncludes all the data needed for FEM calculation, is created by the program **'INIP'**. The operation of 'INIP' is described below;

1) $ **INIP** [enter]

2) 1. New Date File
   2. Old Data File

   Please Select (1/2) ? **1**

3) Default File Name

   UNIT1 : FOR021.DAT (default only)
   UNIT2 : MODEL2.NEW
   UNIT3 : MODEL2.DAT

   Use Default ? (Y/N) **Y**

4) UNIT1: FOR021.DAT
   UNIT2: MODEL2.NEW
   UNIT3: MODEL2.DAT

   Press enter to continue [enter]

5) Setting Initial Head
   (Initial Head) = (top of BASE) + DH

   DH (m) ? = **55** — Initial head is assumed at 55 m above the top elevation of layer symbolized BASE

   .
   .
   .
   (processing)
   .
   .
   .
   FORTRAN STOP

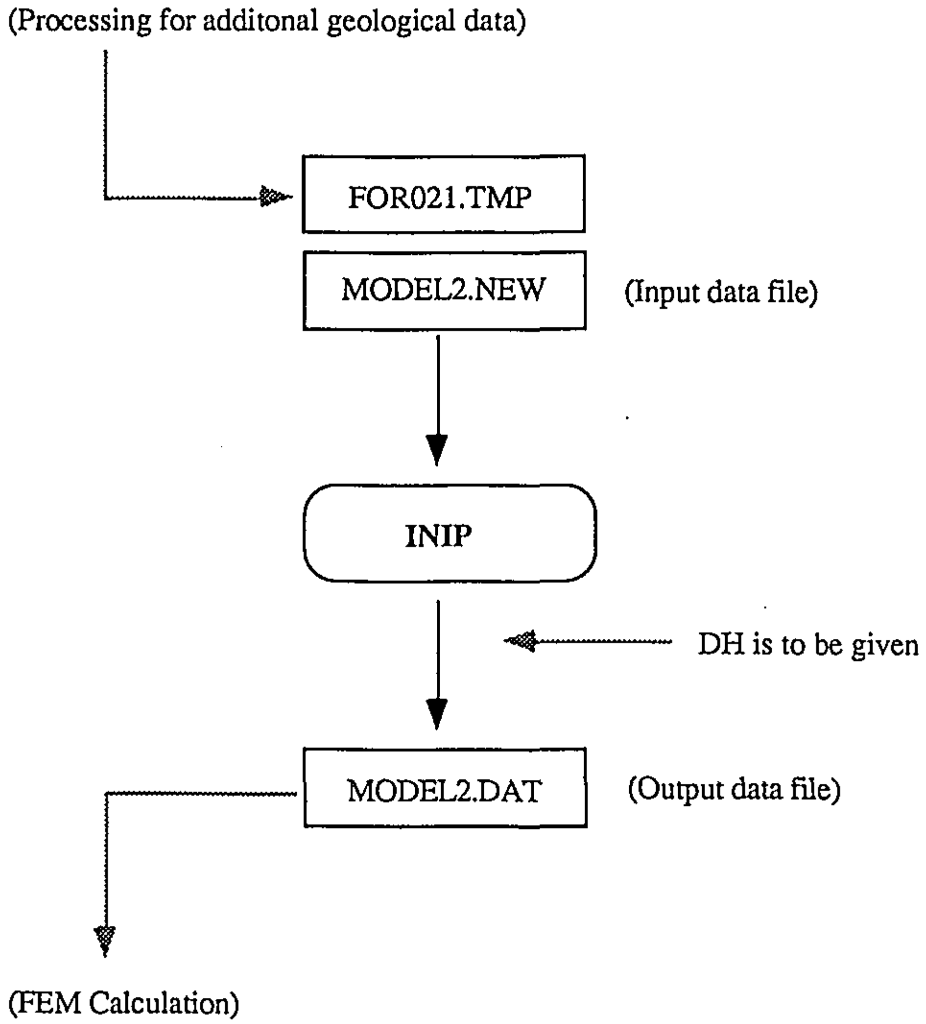


Fig. 17 Processing for Assumption of Initial Head

2. FEM Calculation by UNISSF2

(1) Data Check

1) $ **UNISSF** [enter]

2)
```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
END         < E >
```

PLEASE ENTER ----> **M** [enter] ('M' for **UNISSF2**)

3) RESTART ? (Y/N) **N** [enter]

4) FILE NAME(?.dat) **MODEL2** [enter]

.
.
.

(checking the data)

.
.
.

FORTRAN STOP

```
UNISSF2     < M >
UNISSF2/G   < G >
UNISSF2/P   < P >
DISPLAY     < D >
XYPLOT      < X >
END         < E >
```

PLEASE ENTER ----> **E** [enter] ('E' for end)

5) $ **ED MODEL2.PRN** [enter] (print output to be checked)

6) Press **PF4** function key (at the end of check)

7) Command : **QUIT** [enter]

(2) FEM Calculation

1) **$ ED MODEL2.DAT** [enter]

   1st line of the data to be changed

```
SETTING, CHEC,   100
    |
    v
SETTING, RUN ,   100
          ^
          |
   (RUN + one blank)
```

2) Press **PF4** key (at the end of edit)
3) Command : **EXIT** [enter] (save the data)

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >

   PLEASE ENTER ---> **M** [enter] ('M' for **UNISSF2**)

6) RESTART ? (Y/N) **N**

7) FILENAME (?.dat) **MODEL2**

   .
   .
   .
   (processing) It takes about 30 minutes by VAX 8200
   .
   .
   .
   FORTRAN STOP

8) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >

   PLEASE ENTER ---> **E** [enter]

9) **$ ED MODEL2.PRN** [enter]

10) Press **PF4** function key
11) Command: **QUIT** [enter]

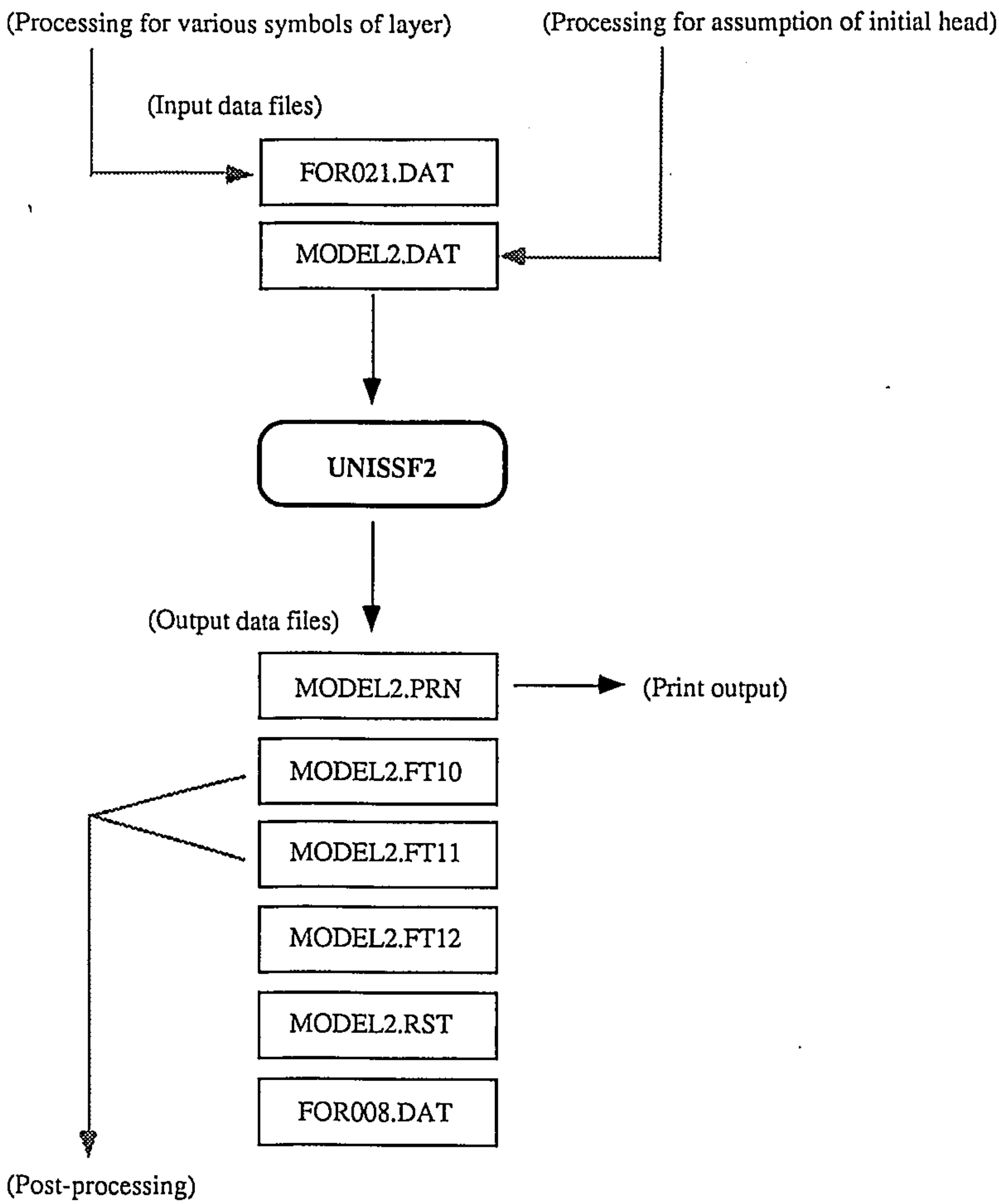


Fig. 18 FEM Calculation

3. Post-processing by UNISSF2/P

(1) Creation of the data file for plot control

1) **$ ED CONT.DAT**

2) Input Data

```
START,2,TP
SUBTITLE

NNUM, OFF
ENUM, OFF
DIVI, OFF
DOWN, OFF
MESH, OFF
FPRI, ON
SCAL, A4
CONT, MANU
 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950,
1000,1050,1100,1150,1200,1250,1300,1350,1400,1450,1500,1550,
1600,1650
VECT, 25
PLOT, ALL
END
```

4) Press **PF4** function key
5) Command : **EXIT** [enter]

(2) Post-processing

1) $ **UNISSF** [enter]

2) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **P** [enter] ('M' for **UNISSF2/P**)

3) FILENAME (?.dat) **CONT**

4) FILENAME (FT10) **MODEL2.FT10** [enter]

5) FILENAME (FT11) **MODEL2.FT11** [enter]

.
.
.
(processing)
.
.
.
FORTRAN STOP

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **E** [enter]

5) $ **ED CONT.PRN** [enter] (print output to be checked)

6) Press **PF4** function key (at the end of check)
7) Command: **QUIT** [enter]

4. Graphic and Plotting

(1) Graphic on TEXTRONIX Terminal

1) Press **SET UP** key
2) * **CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> **D** [enter] ('D' for **DISPLAY**)

6) FILE NAME : **FOR040.DAT** [enter]

7) press **CLEAR** key

   (graphic 1) (Press [enter] to show the next graphic)
   (graphic 2) (Press 'E' for end of graphic)
   .
   .
   .

8) At the end of graphic (no graphic on display), Press **CLEAR** key

9) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> **E** [enter] ('E' for end)

10) Press **SET UP** key
11) * **CODE ANSI** [enter]
12)) Press **SET UP** key, and [enter]

(2) Plotting

1) Plotter set up
2) Paper set
3) Press 'On-line' soft key

4) $ **UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **X** [enter] ('X' for **XYPLOT**)

6) FILE NAME : **FOR040.DAT** [enter]

.
.
.
(plotting)
.
.
.

7) If there are more than 2 drawings, the plotting is stopped and the message **'HALT RECIEVED...'** is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press **'On-line'** soft key.

8) At the end of plotting, the message **'PLOT COMPLETE'** is shown in the plotter window.

9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> **E** [enter]

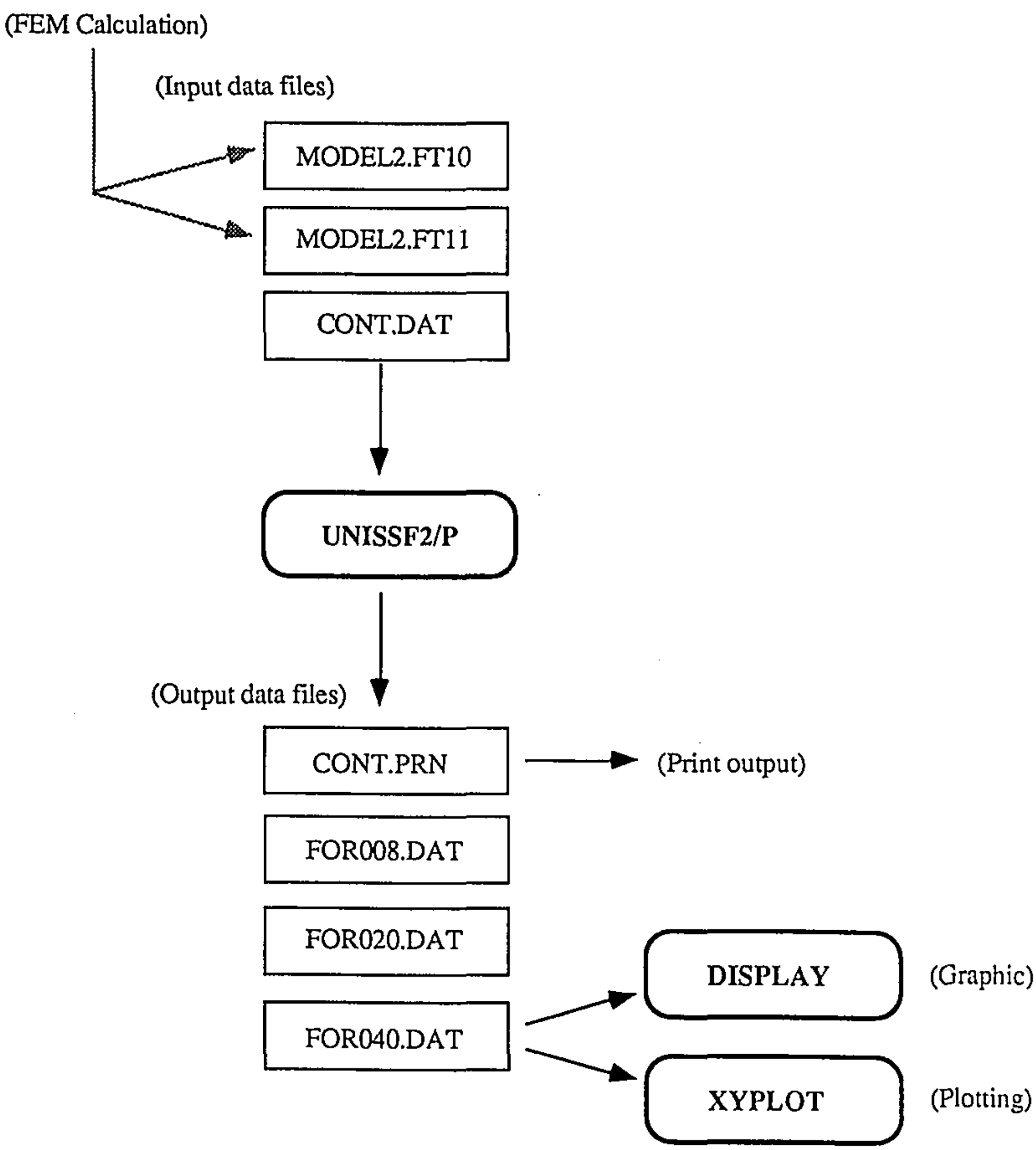


Fig. 19 Post-processing

CHAPTER V
STEADY STATE MODEL CALIBRATION

1. Calibration for A1-6 Aquifer

The model which includes the 'FOR021.DAT' and 'MODEL2.DAT' is needed to be calibrated by comparing the calculated results with the actual groundwater condition in the A1-6 aquifer. However, hydrogeological data for the A1-6 aquifer is very limited to simulate the model. The model calibration of A1-6 aquifer is considered as one of the examination level.

2. Items to be Calibrated

(1) Piezometric Level in the JT-3 Groundwater Monitoring Well

The calculated head is needed to be calibrated by comparing with the piezometric head in the groundwater monitoring well. The JT-3 monitoring well is specified at the node in the FEM mesh (Fig. 20). At this node (node 89), the calculated head is needed to be reasonably adjusted to the piezometric head (EL 870 m) in the monitoring well.

(2) Piezometric Surface

Prior to the groundwater model analysis, the piezometric surface was preliminary estimated by using the field data (Fig. 21). The contour diagram of piezometric surface which was drawn by the model simulation is approximately needed to coincide with the measured one.

(3) Groundwater Flow Path

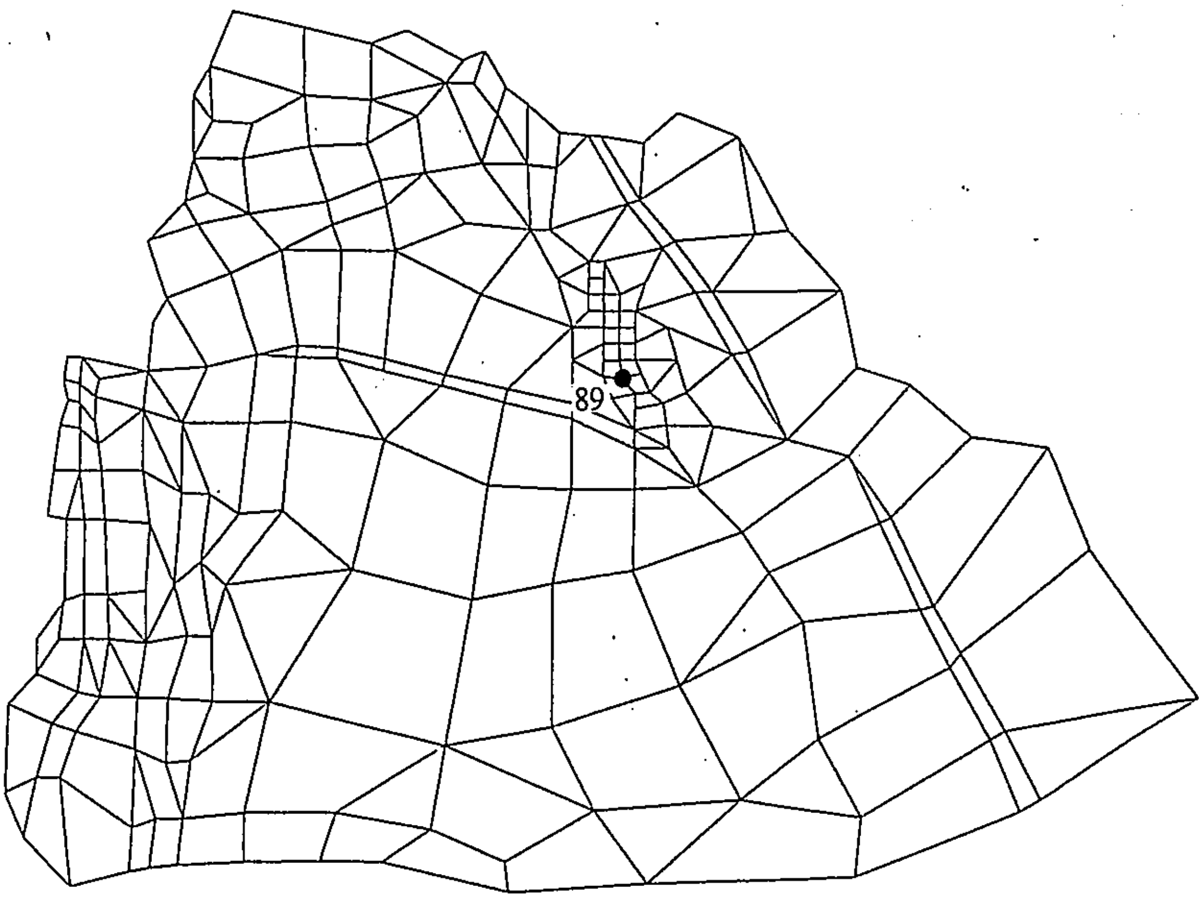
The direction of groundwater flow in the A1-6 aquifer was estimated as follows;

Tafila ——► East Hasa

(4) Water Balance

Water Balance through the boundaries in the A1-6 aquifer was preliminary estimated from +/- 4 to 6 MCM/y. The calculated result of total recharge (+) / discharge (-) is needed to match with the range above.

Fig. 20 Location of the JT-3 monitoring well



Monitoring well

Node	Well No.	Piezometric Level (EL m)
89	JT-3	870 m

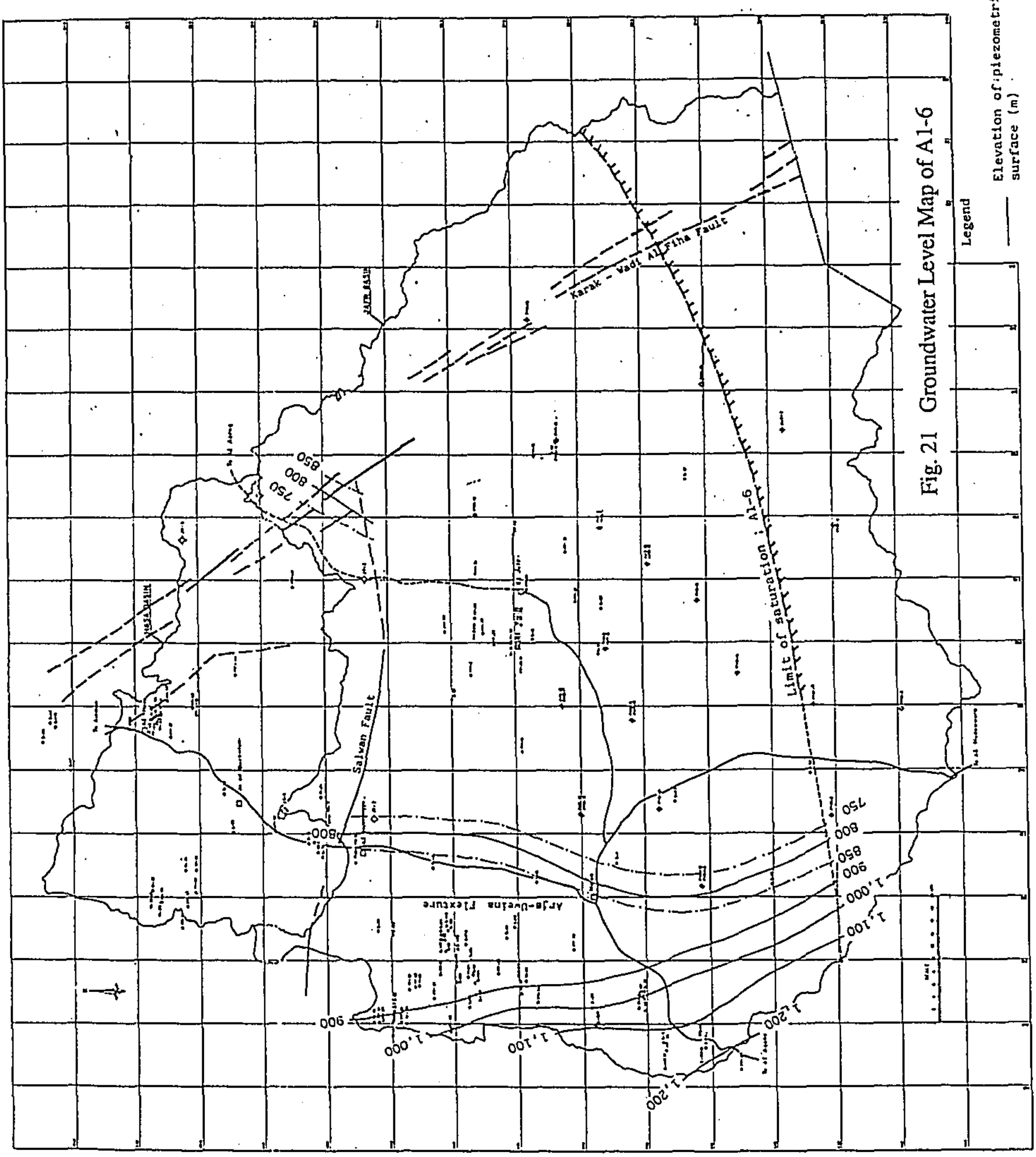


Fig. 21 Groundwater Level Map of A1-6

2. Convergence of Solution

Unknown piezometric head is calculated by numerical analysis. Solution of the dominant equation for groundwater flow condition is obtained by iterative calculation. The calculation of unknown head is started from the initial condition. The value of head is fluctuating during iterative calculation. After several times of the iteration, the fluctuation is gradually decreasing. Finally, the value of head is almost stable and the range of fluctuation is nearly equal to zero. It is the convergence of solution and the calculation is successfully finished at this case. But in some case, the fluctuation is not decreased by the iteration and the stable solutions is not obtained. The convergence of solution is depend on the model which is made up with the input data.

The data for calculation control such as the maximum times of iteration and the error, which is a criterion for the convergence, are prepared for numerical analysis. These data are incorporated in the data file 'MODEL2.DAT' in the case of UNISSF.

(1) Maximum Times of Iteration and Error

Given by 'UNIT' command in 'MODEL2.DAT'

UNIT, ME, DAY, 25, 5.0E-01

- Max. times of iteration : 25 times
- Error for the criterion of convergence : 0.5 m

(2) Output in the case of successful results

```
***** FIX HEAD TO BOTTOM   ITER- 17 NODE- 223 P-  6.3098E+02  TO PNEW-  6.9000E+02
***** FIX HEAD TO BOTTOM   ITER- 17 NODE- 225 P-  6.1859E+02  TO PNEW-  6.2621E+02
***** FIX HEAD TO BOTTOM   ITER- 17 NODE- 228 P-  6.0700E+02  TO PNEW-  6.2451E+02
TIME -       0.000      TIME STEP -   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  17  WAS  1.20096E+02  AT NODE    36
TIME -       0.000      TIME STEP -   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  18  WAS  1.14323E+02  AT NODE   101
TIME -       0.000      TIME STEP -   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  19  WAS  9.25379E+01  AT NODE   228
TIME -       0.000      TIME STEP -   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  20  WAS  7.08476E+01  AT NODE   226
TIME -       0.000      TIME STEP -   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  21  WAS  2.24683E+01  AT NODE   208
TIME -       0.000      TIME STEP -   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  22  WAS  4.22900E+00  AT NODE   209
TIME -       0.000      TIME STEP -   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  23  WAS  2.76511E+00  AT NODE   206
TIME -       0.000      TIME STEP -   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  24  WAS  9.50911E-01  AT NODE   208
TIME -       0.000      TIME STEP -   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  25  WAS  4.50933E-01  AT NODE   206

FLUX INFO     TIME -  0.0000E+00     INFLOW -  1.5869E+04  OUTFLOW - -1.5869E+04  FLUX -  1.0742E-01  TOTAL FLUX -  1.0742E-01
```

The last line " ... **MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION 25 WAS 4.50933E-01 AT NODE 206"** shows the maximum fluctuation of calculated head is less than the error which is given by 0.5 m so that the calculation is successfully finished at the 25th of iteration.

(3) Output in the case of unsuccessful results

```
***** FIX HEAD TO BOTTOM   ITER= 19 NODE= 212 P=  7.2628E+02  TO PNEW=  7.5341E+02
***** FIX HEAD TO BOTTOM   ITER= 19 NODE= 214 P=  7.1242E+02  TO PNEW=  7.1727E+02
***** FIX HEAD TO BOTTOM   ITER= 19 NODE= 218 P=  6.7510E+02  TO PNEW=  6.8577E+02
TIME =       0.000      TIME STEP =   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  19  WAS  2.65589E+02  AT NODE      6
***** FIX HEAD TO BOTTOM   ITER= 20 NODE= 228 P=  6.2368E+02  TO PNEW=  6.2451E+02
TIME =       0.000      TIME STEP =   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  20  WAS  2.44762E+02  AT NODE     34
TIME =       0.000      TIME STEP =   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  21  WAS  2.17047E+02  AT NODE     35
***** FIX HEAD TO BOTTOM   ITER= 22 NODE= 218 P=  6.8531E+02  TO PNEW=  6.8577E+02
TIME =       0.000      TIME STEP =   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  22  WAS  7.19054E+01  AT NODE    100
TIME =       0.000      TIME STEP =   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  23  WAS  2.14295E+01  AT NODE    100
***** FIX HEAD TO BOTTOM   ITER= 24 NODE= 209 P=  8.5135E+02  TO PNEW=  8.5817E+02
***** FIX HEAD TO BOTTOM   ITER= 24 NODE= 218 P=  6.8440E+02  TO PNEW=  6.8577E+02
TIME =       0.000      TIME STEP =   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  24  WAS  1.19435E+01  AT NODE    208
TIME =       0.000      TIME STEP =   0      MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION  25  WAS  2.71655E+00  AT NODE    204

FLUX INFO     TIME =  0.0000E+00     INFLOW =  1.7109E+04  OUTFLOW = -1.7109E+04  FLUX =  3.3203E-02  TOTAL FLUX =  3.3203E-02
```

The last line " ... **MAXIMUM CHANGE IN PRESSURE HEAD DURING ITERATION 25 WAS 2.71655E+00 AT NODE 204**" shows the maximum fluctuation of calculated head is over the error which is given by 0.5 m so that the calculation is unsuccessfully finished in accordance with the maximum times of iteration.

For such case, the model constructed by the data is needed to be modified. Check items are described below;

- Maximum times of iteration is not enough
- Error of criterion for convergence is too small.
- Boundary condition is not appropriate.
- Initial condition is not appropriate.
- Model is too complicated.

3. Data Modification for Calibration

The model calibration is carried out by Trial and Error. After FEM calculation by 'UNISSF2' and post-processing by 'UNISSF2/P', the calculated results are delivered by print output and graphics and plotting. These outputs are compared with the estimated actual groundwater condition. If the calculated results do not coincide reasonably, the data in 'FOR021.DAT' and 'MODEL2.DAT' are needed to be modified and the next trial of calculation is to be performed. The data modification and the trial of calculation are to be repeated until the reasonable results are obtained. Procedures from modification of data for the next trial are described below.

(1) Mesh Data

Case : - Mesh data is incorrect.
- Add or delete the nodes

1) **$ ED MESH.DAT** [enter]

2) (Data modification)

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) Mesh Data Processing ⟶ Refer to Page 4
6) Geological Data Processing ⟶ Refer to Page 12
7) Additional Geological Data ⟶ Refer to Page 21
8) Aquifer Symbols ⟶ Refer to Page 26

9) Assumption of Initial Head

1- **$ RENAME MODEL2.DAT MODEL2.OLD** [enter]
2- **$ INIP** [enter]

3- 1. New Date File
2. Old Data File

Please Select (1/2) ? **2**

4- Default File Name

UNIT1 : FOR021.DAT (default only)
UNIT2 : MODEL2.OLD
UNIT3 : MODEL2.DAT

Use Default ? (Y/N) **Y**

5- UNIT1: FOR021.DAT
UNIT2: MODEL2.NEW
UNIT3: MODEL2.DAT

Press enter to continue [enter]

6- Setting Initial Head
(Initial Head) = (top of BASE) + DH

DH (m) ? = **(INPUT)**

.
.
.

(processing)

.
.
.

FORTRAN STOP

10) FEM Calculation → Refer to Page 41
11) Post-processing → Refer to Page 44
12) Graphic or Plotting → Refer to Page 45 or 46

(2) Geological Data

Case : - Geological data is incorrect.
- Geological contour diagram is not preferable.

1) **$ ED GEOL.DAT** [enter]

2) (Data modification)

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) Geological Data Processing → Refer to Page 12
6) Additional Geological Data → Refer to Page 21
7) Aquifer Symbols → Refer to Page 26

8) Assumption of Initial Head

1- **$ RENAME MODEL2.DAT MODEL2.OLD** [enter]
2- **$ INIP** [enter]

3- 1. New Date File
2. Old Data File

Please Select (1/2) ? **2**

4- Default File Name

UNIT1 : FOR021.DAT (default only)
UNIT2 : MODEL2.OLD
UNIT3 : MODEL2.DAT

Use Default ? (Y/N) **Y**

5- UNIT1: FOR021.DAT
UNIT2: MODEL2.NEW
UNIT3: MODEL2.DAT

Press enter to continue [enter]

6- Setting Initial Head
(Initial Head) = (top of BASE) + DH

DH (m) ? = **(INPUT)**

.
.
.
(processing)
.

.
.
FORTRAN STOP

9) FEM Calculation → Refer to Page 41
10) Post-processing → Refer to Page 44
11) Graphic or Plotting → Refer to Page 45 or 46

(3) Additional Geological Data

Case : - Nodes needed to give the additional data are changed due to the modification of the geological data for key points and regions.

1) **$ ED GEOL.ADD** [enter]

2) (Data modification)

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) Additional Geological Data → Refer to Page 21
6) Aquifer Symbols → Refer to Page 26

7) Assumption of Initial Head

1- **$ RENAME MODEL2.DAT MODEL2.OLD** [enter]
2- **$ INIP** [enter]

3- 1. New Date File
2. Old Data File

Please Select (1/2) ? **2**

4- Default File Name

UNIT1 : FOR021.DAT (default only)
UNIT2 : MODEL2.OLD
UNIT3 : MODEL2.DAT

Use Default ? (Y/N) **Y**

5- UNIT1: FOR021.DAT
UNIT2: MODEL2.NEW
UNIT3: MODEL2.DAT

Press enter to continue [enter]

6- Setting Initial Head
(Initial Head) = (top of BASE) + DH

DH (m) ? = **(INPUT)**
.
.

(processing)

.

.

.

FORTRAN STOP

8)	FEM Calculation	→	Refer to Page 41
9)	Post-processing	→	Refer to Page 44
10)	Graphic or Plotting	→	Refer to Page 45 or 46

(4) Symbol of Layer (Aquifer Constants)

Case: - Calculated contour diagram of groundwater piezometric head is not preferable.

Aquifer constants K and S are changed in accordance with the modification of symbol of layer.

Example:

1- Modification of Symbols in 'NMAT.DAT'

Node	Symbol		Modified Symbol
1	AQ01	→	AQ04
2	AQ02	→	AQ05
3	AQ03	→	AQ06

2- Modification of Symbols in 'FOR021.DAT'

After modifying the 'NMAT.DAT', the program 'NMAT' is processed and the data stored in 'FOR021.DAT' are modified in accordance with the modified data in the 'NMAT.DAT'

(Previous)

```
GEOL,      1,      1,      1,      2
           BASE,          AQ01,           GRSF
           (H11)          (H12)           (H13)
GEOL,      2,      2,      1,      2
           BASE,          AQ02,           GRSF
           (H21)          (H22)           (H23)
GEOL,      3,      3,      1,      2
           BASE,          AQ03,           GRSF
           (H31)          (H32)           (H33)
```

(Modified)

```
GEOL,      1,    1,    1,    2
       BASE,     AQ04,       GRSF
       (H11)     (H12)       (H13)
GEOL,      2,    2,    1,    2
       BASE,     AQ05,       GRSF
       (H21)     (H22)       (H23)
GEOL,      3,    3,    1,    2
       BASE,     AQ06,       GRSF
       (H31)     (H32)       (H33)
```

3- Modification of K and S

K and S are automatically selected from the table of symbols, K and S in 'MODEL2.DAT'.

(Table of Symbols, K and S in 'MODEL2.DAT')

Symbol	K	S
GRSF	K_1	S_1
AQ01	K'_1	S'_1
AQ02	K'_2	S'_2
AQ03	K'_3	S'_3
AQ04	K'_4	S'_4
AQ05	K'_5	S'_5
AQ06	K'_6	S'_6
.		
.		
.		

(Modified 'FOR021.DAT')

```
GEOL,      1,    1,    1,    2
       BASE,     AQ04,       GRSF
       (H11)     (H12)       (H13)
GEOL,      2,    2,    1,    2
       BASE,     AQ05,       GRSF
       (H21)     (H22)       (H23)
GEOL,      3,    3,    1,    2
       BASE,     AQ06,       GRSF
       (H31)     (H32)       (H33)
```

(K and S selected during FEM calculation)

Node 1	Upper layer	$K = K_1$,	$S = S_1$
	Aquifer	$K = K'_4$,	$S = S'_4$
Node 2	Upper layer	$K = K_1$,	$S = S_1$
	Aquifer	$K = K'_5$,	$S = S'_5$

Node 3	Upper layer	$K = K_1$,	$S = S_1$
	Aquifer	$K = K'_6$,	$S = S'_6$

1) **$ ED NMAT.DAT** [enter]

2) (Data modification)

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) Aquifer Symbols (Modification of symbols in 'FOR021.DAT') ——► Refer to Page 26

6) FEM Calculation ——► Refer to Page 41
7) Post-processing ——► Refer to Page 44
8) Graphic or Plotting ——► Refer to Page 45 or 46

(5) Boundary Conditions

Case:
- Calculated contour diagram of groundwater piezometric head is not preferable.
- Calculated water balance in the study area is not reasonable.
- Solution is not converged.

1) **$ ED MODEL2.DAT** [enter]

2) (Data modification)

3) Press **PF4** function key (at the end of modification)
4) Command : **EXIT**

5) FEM Calculation ——► Refer to Page 41
6) Post-processing ——► Refer to Page 44
7) Graphic or Plotting ——► Refer to Page 45 or 46

(6) Initial Condition

Case:
- Calculated contour diagram of groundwater piezometric head is not preferable.
- Solution is not converged.

1) Assumption of Initial Head

   1- **$ RENAME MODEL2.DAT MODEL2.OLD** [enter]

2- **$ INIP** [enter]

3- 1. New Date File
2. Old Data File

Please Select (1/2) ? **2**

4- Default File Name

UNIT1 : FOR021.DAT (default only)
UNIT2 : MODEL2.OLD
UNIT3 : MODEL2.DAT

Use Default ? (Y/N) **Y**

5- UNIT1: FOR021.DAT
UNIT2: MODEL2.NEW
UNIT3: MODEL2.DAT

Press enter to continue [enter]

6- Setting Initial Head
(Initial Head) = (top of BASE) + DH

DH (m) ? = **(INPUT)** (another DH to examine)

.
.
.

(processing)

.
.
.

FORTRAN STOP

2) FEM Calculation → Refer to Page 41
3) Post-processing → Refer to Page 44
4) Graphic or Plotting → Refer to Page 45 or 46

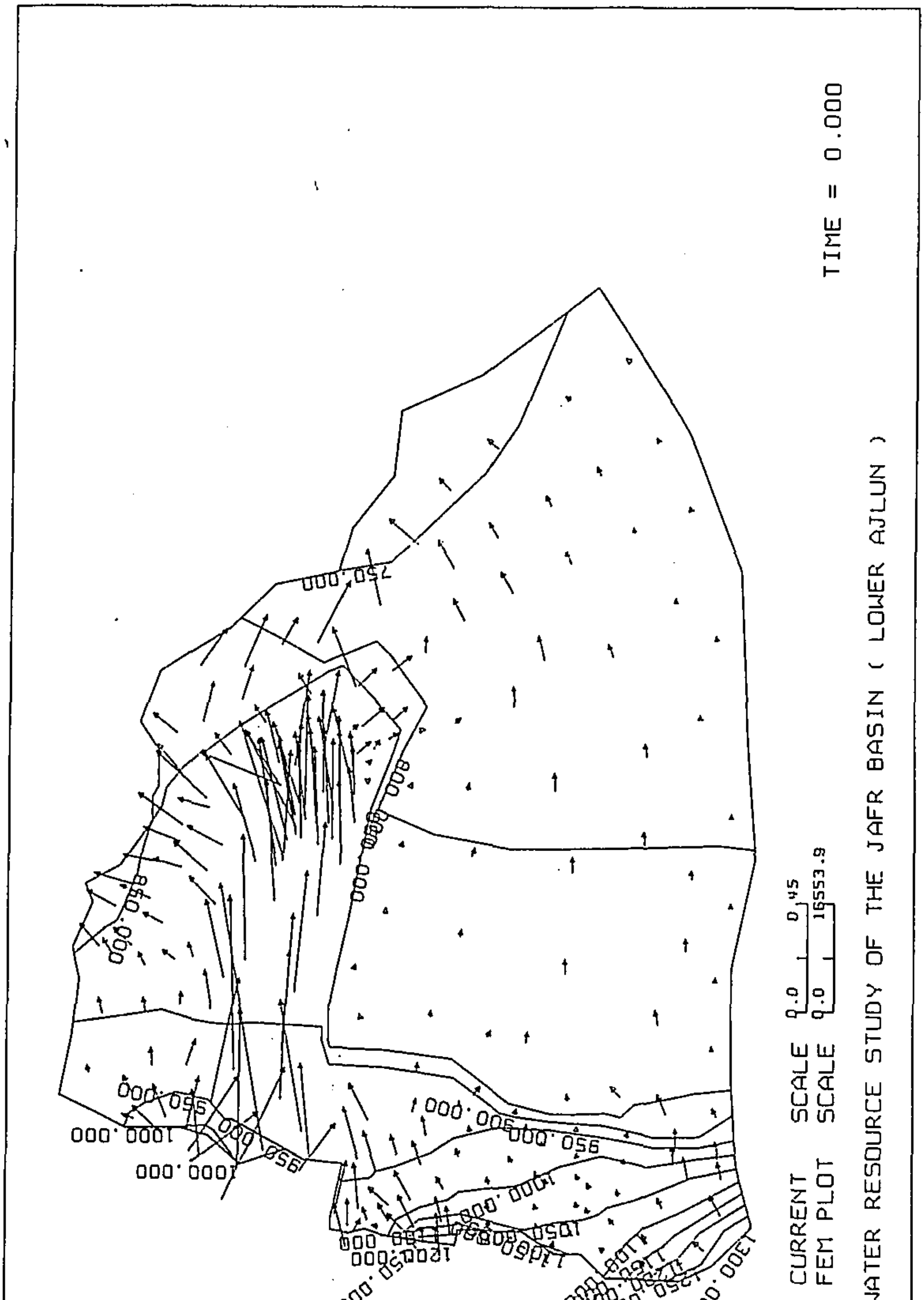


Fig. 22 Calibrated Piezometric Surface and Reginal Flow Vector

CHAPTER VI
MODEL SIMULATION

1. Model Simulation in A1-6 Aquifer

Coefficient of storage (S) in the A1-6 aquifer is not calibrated by non-steady analysis because there are no monitoring records such as the record of the monitoring well of S-121 in B2/A7 aquifer. For this, coefficiet of storage in the A1-6 aquifer is simply assmued. The model of the A1-6 is considered as an examination level. The simulation model of A1-6 aquifer is desired to be improved after the adding hydrogeological data in the A1-6 aquifer.

2. Experimental Wellfield

The simulation model predicts the influences of future groundwater exploitation such as 'East Hasa' on the regional groundwater flows. This expermental wellfield assumes prodution wells of 10 in number with a unit pumping rate at 1.0 MCM/y which are located at a distance from each other of 2 km.

3. Data Input

Production wells of 10 in number are located in the East Hasa wellfield, assuming a unit pumping rate of 1.0 MCM/y. The calibrated model is composed of 'FOR021.DAT' and 'MODEL2.DAT'. In addtion to the data in 'MODEL2.DAT', the following data are given to the model.

- **Time stage and step after 60 years**
- **Pumping rate for each production well in East Hasa wellfield**

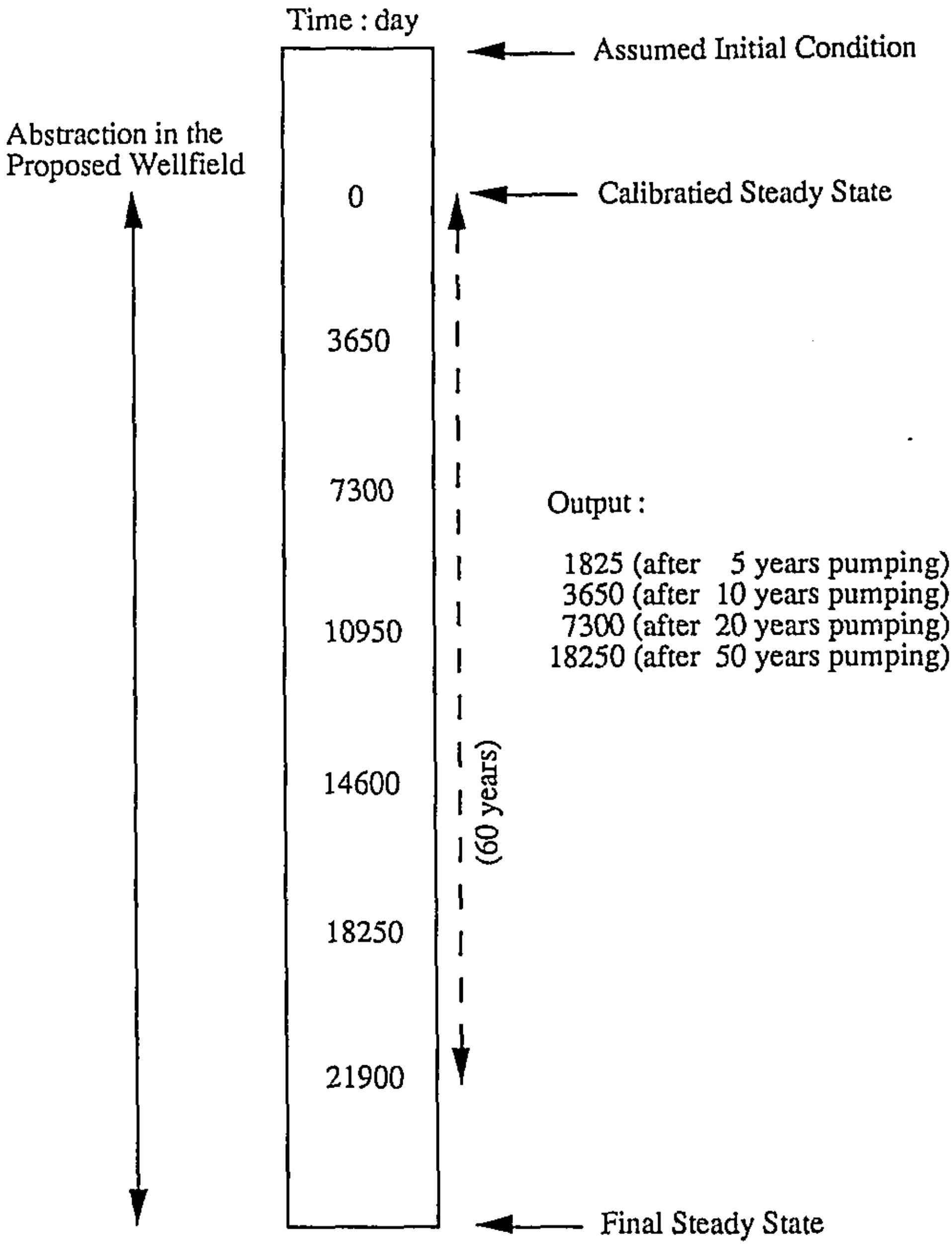


Fig. 22 Procedure of Calculation in Model Simlation

1) COPY MODEL2.DAT MODEL4.DAT [enter]
2) ED MODEL4.DAT [enter]

```
SETTING, RUN ,   3600,    0
TITLE
     WATER RESOURCES STUDY OF THE JAFR BASIN ( LOWER AJLUN )
1ST ,  231,  229,    8,  231,    3
2ND ,    3,    0,    0,    0,    0
3RD ,    0,    0,    0,    0,    0,    0
4TH ,    0,    0
*
*    --- MESH DATA ---
*
GENE
*
TIME,  8
STEP,  1,   9.125,   365
STEP,  2,  18.25 ,   730
STEP,  3,  36.5  ,  1095
STEP,  4,  73.0  ,  1460
STEP,  5,  91.25 ,  1825
STEP,  6, 182.5  ,  5475
STEP,  7, 365.0  , 10950
STEP,  8, 730.0  , 21900
*
UNIT,  ME    ,  DAY , 25, 5.0E-01
CONT,  STUN
*
*
*    --- BOUNDARY CONDITION ---
*
*        HF :  SPECIFIED HEAD
*        QF :  SPECIFIED FLOW
*
*       NODE          CONDITION
*
NCON,    7,    7,   1,   HF
NCON,   13,   13,   1,   HF
NCON,   16,   16,   1,   HF
NCON,   37,   37,   1,   HF
NCON,   39,   39,   1,   HF
NCON,   40,   40,   1,   HF
NCON,  102,  102,   1,   HF
NCON,  103,  103,   1,   HF
NCON,  121,  121,   1,   HF
NCON,  122,  122,   1,   HF
NCON,  124,  124,   1,   HF
NCON,  136,  136,   1,   HF
NCON,  139,  139,   1,   HF
NCON,  142,  142,   1,   HF
NCON,  150,  150,   1,   HF
NCON,  151,  151,   1,   HF
NCON,  155,  155,   1,   HF
NCON,  168,  168,   1,   HF
NCON,  169,  169,   1,   HF
NCON,  193,  193,   1,   HF
NCON,  199,  199,   1,   HF
NCON,  200,  200,   1,   HF
NCON,  202,  202,   1,   HF
*
```

Mesh data are read from 'FOR021.DAT' by GENE command

Time stage and step (Non-steady)

Western boundary (specified head)

Eastern boundary (specified flow)

```
NCON,    4,    4,  1,  QF
NCON,    5,    5,  1,  QF
NCON,    6,    6,  1,  QF
NCON,   12,   12,  1,  QF
NCON,   29,   29,  1,  QF
NCON,   30,   30,  1,  QF
NCON,   32,   32,  1,  QF
NCON,   33,   33,  1,  QF
NCON,   34,   34,  1,  QF
NCON,   35,   35,  1,  QF
NCON,   36,   36,  1,  QF
NCON,   58,   58,  1,  QF
NCON,   67,   67,  1,  QF
NCON,  100,  100,  1,  QF
NCON,  101,  101,  1,  QF
NCON,  191,  191,  1,  QF
NCON,  192,  192,  1,  QF
NCON,  230,  230,  1,  QF
*
*
*    --- INITIAL CONDITION ---
*
*         NODE                     HEAD
*
INIP,       1,       1,       1, 505.00
INIP,       2,       2,       1, 505.00
INIP,       3,       3,       1, 504.55
INIP,       4,       4,       1, 505.00
INIP,       5,       5,       1, 517.83
INIP,       6,       6,       1, 525.00
INIP,       7,       7,       1, 555.00
INIP,       8,       8,       1, 537.06
INIP,       9,       9,       1, 502.74
INIP,      10,      10,       1, 511.65

        .
        .
        .

INIP,     223,     223,       1, 745.00
INIP,     224,     224,       1, 597.91
INIP,     225,     225,       1, 681.21
INIP,     226,     226,       1, 745.00
INIP,     227,     227,       1, 589.20
INIP,     228,     228,       1, 679.51
INIP,     229,     229,       1, 745.00
INIP,     230,     230,       1, 555.00
INIP,     231,     231,       1, 735.00
*
INIP,    7,    7,  1,    945.00
INIP,   13,   13,  1,    950.00
INIP,   16,   16,  1,   1000.00
INIP,   37,   37,  1,   1030.00
INIP,   39,   39,  1,   1000.00
INIP,   40,   40,  1,    951.00
INIP,  102,  102,  1,    951.00
INIP,  103,  103,  1,    952.00
INIP,  121,  121,  1,    965.00
INIP,  122,  122,  1,    960.00
INIP,  124,  124,  1,    975.00
INIP,  136,  136,  1,    975.00
INIP,  139,  139,  1,   1027.30
INIP,  142,  142,  1,   1171.20
```

Specified head along the western boundary

```
INIP,  150, 150,  1,  1202.50
INIP,  151, 151,  1,  1131.60
INIP,  155, 155,  1,  1052.50
INIP,  168, 168,  1,  1154.00
INIP,  169, 169,  1,  1072.00
INIP,  193, 193,  1,  1102.50
INIP,  199, 199,  1,  1272.50
INIP,  200, 200,  1,  1272.50
INIP,  202, 202,  1,  1302.50
*
INIQ,    4,   4,  1,  -600
INIQ,    5,   5,  1,  -600
INIQ,    6,   6,  1,  -600
INIQ,   12,  12,  1,  -600
INIQ,   29,  29,  1,  -600
INIQ,   30,  30,  1,  -600
INIQ,   32,  32,  1,  -400
INIQ,   33,  33,  1,  -400
INIQ,   34,  34,  1,  -600
INIQ,   35,  35,  1,  -600
INIQ,   36,  36,  1,  -600
INIQ,   58,  58,  1,  -600
INIQ,   67,  67,  1,  -600
INIQ,  100, 100,  1,  -2600
INIQ,  101, 101,  1,  -2600
INIQ,  191, 191,  1,  -880
INIQ,  192, 192,  1,  -880
INIQ,  230, 230,  1,  -550
*
*
*    --- AQUIFER CONSTANTS ---
*
*        K : COEFFICIENT OF INFILTRATION CAPACITY
*        S : COEFFICIENT OF STORAGE
*
*                  SYMBOL OF       K        S
*                  AQUIFER
*
LAYE,  35
                   GRSF,         0.00001,  0.00001
                   AQ01,        10.0,      0.20
                   AQ02,         8.0,      0.197
                   AQ03,         6.0,      0.193
                   AQ04,         4.0,      0.187
                   AQ05,         2.0,      0.178
                   AQ06,         1.5,      0.174
                   AQ07,         1.0,      0.168
                   AQ08,         0.80,     0.165
                   AQ09,         0.60,     0.161
                   AQ10,         0.40,     0.156
                   AQ11,         0.20,     0.146
                   AQ12,         0.10,     0.137
                   AQ13,         0.09,     0.135
                   AQ14,         0.08,     0.134
                   AQ15,         0.07,     0.132
                   AQ16,         0.06,     0.130
                   AQ17,         0.05,     0.127
                   AQ18,         0.04,     0.124
                   AQ19,         0.03,     0.120
                   AQ20,         0.02,     0.115
                   AQ21,         0.01,     0.105
                   AQ22,         0.009,    0.104
                   AQ23,         0.008,    0.102
```

Specified flow along the eastern booundary

```
                  AQ24,          0.007,      0.100
                  AQ25,          0.006,      0.098
                  AQ26,          0.005,      0.096
                  AQ27,          0.004,      0.092
                  AQ28,          0.003,      0.088
                  AQ29,          0.002,      0.083
                  AQ30,          0.001,      0.073
                  AQ31,          0.0005,     0.064
                  AQ32,          0.0001,     0.042
                  AQ33           0.00005,    0.032
                  AQ34,          0.00001,    0.010
*
*
*    --- GEOLOGICAL DATA ---
*
GENE
*
PRTIME,  1825, 3650, 7300, 18250, 21900
PLTIME,  1825, 3650, 7300, 18250  21900
*
NBTIME,  0.0
*
*
*
ENDD
NEWB, 10, 0.0
76, QF, 0, SS, 0, CG, -2740
79, QF, 0, SS, 0, CG, -2740
80, QF, 0, SS, 0, CG, -2740
81, QF, 0, SS, 0, CG, -2740
82, QF, 0, SS, 0, CG, -2740
83, QF, 0, SS, 0, CG, -2740
84, QF, 0, SS, 0, CG, -2740
88, QF, 0, SS, 0, CG, -2740
89, QF, 0, SS, 0, CG, -2740
90, QF, 0, SS, 0, CG, -2740
```

Geological data are read from 'FOR021.DAT' By GENE command.

Outputs are to be obtained at specified times.

Boundary conditions are to be changed at specified times.

Boundary conditions are to be changed at time = 0 day

East Hasa :
Node 76, 79, 80, 81, 82, 83, 84, 88, 89, 90

3) Press **PF4** function key (at the end of edit)
4) Command : **EXIT** (save the data)

4. Operation

(1) Data Check

1) **$ ED 10MCM.DAT** [enter]

   1st line of the data to be changed

   ```
   SETTING, RUN ,   100
           ↓
   SETTING, CHEC,   100
   ```

2) **$ UNISSF** [enter]

3) UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> **M** [enter] ('M' for **UNISSF2**)

4) RESTART ? (Y/N) **N** [enter]

5) FILE NAME(?.dat) **MODEL4** [enter]

   .
   .
   .
   (checking the data)
   .
   .
   .

   FORTRAN STOP

   UNISSF2 < M >
   UNISSF2/G < G >
   UNISSF2/P < P >
   DISPLAY < D >
   XYPLOT < X >
   END < E >

   PLEASE ENTER ----> E [enter] ('E' for end)

6) **$ ED MODEL4.PRN** [enter] (print output to be checked)

7) Press **PF4** function key (at the end of check)
8) Command : **QUIT** [enter]

(2) FEM Calculation

1) **$ ED MODEL4.DAT** [enter]

1st line of the data to be changed

```
SETTING, CHEC,  100
       |
       v
SETTING, RUN ,  100
           ^
           |
   (RUN + one blank)
```

2) Press **PF4** function key (at the end of edit)
3) Command : **EXIT** [enter] (save the data)

4) **$ UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **M** [enter] ('M' for **UNISSF2**)

6) RESTART ? (Y/N) **N**

7) FILENAME (?.dat) **MODEL4**

.
.
.
(processing) It takes about 8 hours by VAX 8200
.
.
.
FORTRAN STOP

8) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **E** [enter]

9) **$ ED MODEL4.PRN** [enter]

10) Press **PF4** key
11) Command: **QUIT** [enter]

(3) Post-processing to deliver the contour diagram

1) **$ ED CONT.DAT** [enter]

2) Input data

```
START,2,TP
PLTIME,  7300, 18250
SUBTITLE

NNUM, OFF
ENUM, OFF
DIVI, OFF
DOWN, OFF
MESH, OFF
FPRI, ON
SCAL, A1
CONT, MANU
 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950,
1000,1050,1100,1150,1200,1250,1300,1350,1400,1450,1500,1550,
1600,1650
VECT, 25
PLOT, ALL
END
```

Contour diagrams after 20 years and 50 years are to be shown

3) **$ UNISSF** [enter]

4) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **P** [enter] ('M' for UNISSF2/P)

5) FILENAME (?.dat) **CONT**

6) FILENAME (FT10) **MODEL4.FT10** [enter]

7) FILENAME (FT11) **MODEL4.FT11** [enter]

.
.
.
(processing)
.
.
.
FORTRAN STOP

8) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **E** [enter]

9) **$ ED CONT.PRN** [enter] (print output to be checked)

10) Press **PF4** function key (at the end of check)

11) Command: **QUIT** [enter]

(5) Post-processing to deliver the drawdown contour diagram

1) **$ ED DOWN.DAT** [enter]

2) Input data

```
START,2,TP
PLTIME, 0, 7300, 18250
SUBTITLE

NNUM, OFF
ENUM, OFF
DIVI, OFF
DOWN, OFF
MESH, OFF
FPRI, ON
SCAL, A1
CONT, MANU
 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950,
1000,1050,1100,1150,1200,1250,1300,1350,1400,1450,1500,1550,
1600,1650
VECT, 25
PLOT, ALL
END
```

Drawdown contour diagrams after 20 years and 50 years are to be shown. /1

3) **$ UNISSF** [enter]

4) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **P** [enter] ('M' for **UNISSF2/P**)

5) FILENAME (?.dat) **CONT**

6) FILENAME (FT10) **MODEL4.FT10** [enter]

7) FILENAME (FT11) **MODEL4.FT11** [enter]

.
.
.
(processing)
.
.
.
FORTRAN STOP

8) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> **E** [enter]

9) **$ ED CONT.PRN** [enter] (print output to be checked)

10) Press **PF4** function key (at the end of check)
11) Command: **QUIT** [enter]

Note : Drawdown is calculated as follows;

(Drawdown at time = 7300)

= (Piezometric level at time = 7300) - (Piezometric level at time = 0)

(6) Graphic on TEXTRONIX Terminal

1) Press **SET UP** key
2) *** CODE TEK** [enter]
3) Press **SET UP** key, and [enter]

4) **$ UNISSF** [enter]

5) UNISSF2 <M>
   UNISSF2/G <G>
   UNISSF2/P <P>
   DISPLAY <D>
   XYPLOT <X>
   END <E>

   PLEASE ENTER ----> **D** [enter] ('D' for **DISPLAY**)

6) FILE NAME : **FOR040.DAT** [enter]

7) press **CLEAR** key

   (graphic 1) (Press [enter] to show the next graphic)
   (graphic 2) (Press 'E' for end of graphic)
   .
   .
   .

8) At the end of graphic (no graphic on display), Press **CLEAR** key

9) UNISSF2 <M>
   UNISSF2/G <G>
   UNISSF2/P <P>
   DISPLAY <D>
   XYPLOT <X>
   END <E>

   PLEASE ENTER ----> **E** [enter] ('E' for end)

10) Press **SET UP** key
11) *** CODE ANSI** [enter]
12)) Press **SET UP** key, and [enter]

(5) Plotting

1) Plotter set up
2) Paper set
3) Press **'On-line'** soft key

4) $ **UNISSF** [enter]

5) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> X [enter] ('X' for **XYPLOT**)

6) FILE NAME : **FOR040.DAT** [enter]

.
.
.

(plotting)

.
.
.

7) If there are more than 2 drawings, the plotteing is stopped and the message **'HALT RECIEVED...'** is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press **'On-line'** soft key.

8) At the end of plotting, the message **'PLOT COMPLETE'** is shown in the plotter window.

9) UNISSF2 < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >
END < E >

PLEASE ENTER ----> E [enter]

PART 5 DATA FILES FOR THE CALIBRATED MODELS

PART 5 DATE FILES FOR THE CALIBRATED MODELS

CONTENTS

PAGE

1. 'MESH.DAT' FOR THE B2/A7 AQUIFER

```
TITLE
     AMMAN / WADI SIR ( B2/A7 )
SUBT
     FEM MESH
*
*         NODE NO.         X          Y
*
NODE,           1,    215798,   1028537
NODE,           2,    218141,   1031942
NODE,           3,    221729,   1031887
NODE,           4,    225838,   1033736
NODE,           5,    232518,   1034191
NODE,           6,    236925,   1037498
NODE,           7,    244448,   1034359
NODE,           8,    249940,   1032510
NODE,           9,    252792,   1033484
NODE,          10,    218544,   1025026
NODE,          11,    219625,   1025396
NODE,          12,    224408,   1022225
NODE,          13,    230376,   1028196
NODE,          14,    236336,   1028050
NODE,          15,    241780,   1026883
NODE,          16,    248242,   1027162
NODE,          17,    248796,   1028752
NODE,          18,    251150,   1029630
NODE,          19,    249309,   1027191
NODE,          20,    248319,   1026118
NODE,          21,    249315,   1026172
NODE,          22,    249964,   1026706
NODE,          23,    252383,   1028591
NODE,          24,    253114,   1027290
NODE,          25,    254260,   1026018
NODE,          26,    255510,   1029100
NODE,          27,    215771,   1020673
NODE,          28,    218839,   1021821
NODE,          29,    220934,   1020188
NODE,          30,    224325,   1020278
NODE,          31,    229648,   1020168
NODE,          32,    236343,   1021390
NODE,          33,    214500,   1015194
NODE,          34,    217641,   1016470
NODE,          35,    221953,   1015906
NODE,          36,    225872,   1015822
NODE,          37,    230400,   1016777
NODE,          38,    236190,   1016327
NODE,          39,    241952,   1018865
NODE,          40,    246132,   1022258
NODE,          41,    248972,   1022055
NODE,          42,    249936,   1021647
NODE,          43,    250882,   1020825
NODE,          44,    251287,   1025095
NODE,          45,    255418,   1023540
NODE,          46,    262710,   1023853
NODE,          47,    266157,   1023140
NODE,          48,    267915,   1023048
NODE,          49,    272966,   1022258
NODE,          50,    276528,   1022688
NODE,          51,    277345,   1025991
NODE,          52,    285217,   1024463
NODE,          53,    210125,   1010410
NODE,          54,    216139,   1012518
NODE,          55,    219221,   1013158
NODE,          56,    222851,   1014012
NODE,          57,    228354,   1014701
NODE,          58,    233208,   1015367
```

```
NODE,    59,  212527,  1003658
NODE,    60,  216346,  1005205
NODE,    61,  220267,  1006490
NODE,    62,  224305,  1008388
NODE,    63,  230004,  1010703
NODE,    64,  233743,  1012369
NODE,    65,  236294,  1014306
NODE,    66,  238265,  1014246
NODE,    67,  240201,  1014198
NODE,    68,  242173,  1014209
NODE,    69,  244240,  1014206
NODE,    70,  244893,  1017583
NODE,    71,  248950,  1020100
NODE,    72,  252528,  1020062
NODE,    73,  254873,  1020220
NODE,    74,  250140,  1016564
NODE,    75,  254078,  1018109
NODE,    76,  236198,  1012300
NODE,    77,  238229,  1012321
NODE,    78,  240189,  1012285
NODE,    79,  242150,  1012320
NODE,    80,  244216,  1012281
NODE,    81,  248196,  1012337
NODE,    82,  252233,  1012215
NODE,    83,  260117,  1010097
NODE,    84,  271139,  1014805
NODE,    85,  272792,  1014786
NODE,    86,  279901,  1016083
NODE,    87,  283562,  1010347
NODE,    88,  287485,  1011113
NODE,    89,  291414,  1011607
NODE,    90,  215987,  1002378
NODE,    91,  220350,  1000809
NODE,    92,  223469,  1000881
NODE,    93,  226218,  1000735
NODE,    94,  227972,  1002356
NODE,    95,  228437,  1005146
NODE,    96,  230338,  1008311
NODE,    97,  232429,  1010280
NODE,    98,  234366,  1010279
NODE,    99,  236278,  1010244
NODE,   100,  238226,  1010208
NODE,   101,  240164,  1010290
NODE,   102,  242182,  1010229
NODE,   103,  244120,  1010287
NODE,   104,  210894,   999650
NODE,   105,  216479,   998365
NODE,   106,  219829,   996874
NODE,   107,  224202,   996439
NODE,   108,  228996,   997708
NODE,   109,  229139,   999040
NODE,   110,  228693,  1001103
NODE,   111,  229171,  1002051
NODE,   112,  231768,  1003939
NODE,   113,  234901,  1000279
NODE,   114,  233851,  1006699
NODE,   115,  236219,  1008356
NODE,   116,  242251,  1006295
NODE,   117,  246519,  1005295
NODE,   118,  252212,  1002202
NODE,   119,  269109,  1000826
NODE,   120,  279795,  1003981
NODE,   121,  281780,  1004063
NODE,   122,  234525,   997240
NODE,   123,  240060,   995791
NODE,   124,  246171,   994201
NODE,   125,  252055,   993089
NODE,   126,  257982,   991762
NODE,   127,  263868,   990578
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NODE,	128,	270257,	993318
NODE,	129,	284531,	996407
NODE,	130,	286501,	996925
NODE,	131,	292948,	1000715
NODE,	132,	298208,	1004171
NODE,	133,	271882,	987383
NODE,	134,	276169,	984848
NODE,	135,	282459,	980811
NODE,	136,	290392,	984490
NODE,	137,	291613,	986026
NODE,	138,	296751,	991162
NODE,	139,	300266,	994793
NODE,	140,	228947,	996351
NODE,	141,	234228,	995852
NODE,	142,	240022,	994363
NODE,	143,	246089,	992939
NODE,	144,	252063,	991577
NODE,	145,	257917,	990181
NODE,	146,	263889,	988713
NODE,	147,	271803,	985023
NODE,	148,	279589,	980155
NODE,	149,	199973,	996617
NODE,	150,	202097,	996530
NODE,	151,	199634,	992950
NODE,	152,	200820,	992586
NODE,	153,	204024,	993436
NODE,	154,	207133,	994276
NODE,	155,	209973,	994566
NODE,	156,	214745,	992103
NODE,	157,	219477,	993173
NODE,	158,	224204,	994030
NODE,	159,	228216,	993212
NODE,	160,	232546,	992387
NODE,	161,	200024,	991077
NODE,	162,	201542,	991415
NODE,	163,	203532,	991756
NODE,	164,	204027,	990153
NODE,	165,	208314,	990440
NODE,	166,	210629,	990479
NODE,	167,	214453,	989712
NODE,	168,	219113,	989495
NODE,	169,	224246,	989282
NODE,	170,	228209,	988394
NODE,	171,	233241,	987214
NODE,	172,	199203,	988164
NODE,	173,	200794,	988619
NODE,	174,	202433,	988518
NODE,	175,	203789,	987784
NODE,	176,	206286,	985506
NODE,	177,	209898,	986088
NODE,	178,	212691,	987052
NODE,	179,	198257,	981734
NODE,	180,	200352,	982640
NODE,	181,	202653,	982562
NODE,	182,	204109,	983362
NODE,	183,	206368,	980993
NODE,	184,	209440,	981751
NODE,	185,	211832,	982120
NODE,	186,	214107,	981901
NODE,	187,	218156,	982463
NODE,	188,	224513,	983278
NODE,	189,	228866,	982407
NODE,	190,	233637,	982436
NODE,	191,	197604,	977082
NODE,	192,	199933,	976602
NODE,	193,	202579,	976624
NODE,	194,	204462,	976602
NODE,	195,	206321,	975302
NODE,	196,	207222,	977423

NODE,	197,	210221,	977391
NODE,	198,	213421,	977391
NODE,	199,	216715,	977342
NODE,	200,	221662,	977309
NODE,	201,	226900,	977672
NODE,	202,	232887,	977679
NODE,	203,	245817,	980156
NODE,	204,	251925,	982251
NODE,	205,	257820,	984267
NODE,	206,	262528,	980897
NODE,	207,	255003,	976289
NODE,	208,	199728,	970642
NODE,	209,	203315,	967293
NODE,	210,	205042,	970650
NODE,	211,	206193,	971573
NODE,	212,	207031,	973483
NODE,	213,	208613,	973465
NODE,	214,	206232,	969872
NODE,	215,	207673,	971156
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ELEM          386     357     360     361     361
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SAVE
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PLOT
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SCAL, A4
NNUM, OFF
ENUM, OFF
MESH, ON
MPLO
PEND
/END
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2. 'GEOL.DAT' FOR THE B2/A7 AQUIFER

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TITL
          GENERATION OF GEOLOGICAL DATA
SUBT

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          800,      950
GPOI,            6
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          780,      880,      1000
GPOI,            9
          BASE,     AQUI,     SURF
          670,      770,      900
GPOI,           27
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          1090,     1290
GPOI,           37
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GPOI,           40
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          650,      750       880
GPOI,           84
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GPOI,           26
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          560,      770,      1000
GPOI,           83
          BASE,     AQUI,     SURF
          640,      740,      880
GPOI,           87
          BASE,     AQUI,     SURF
          630,      800,      1000
GPOI,          117
          BASE,     AQUI,     SURF
          640,      740,      890
GPOI,           48
          BASE,     AQUI,     SURF
          610,      760,      880
GPOI,           52
          BASE,     AQUI,     SURF
          660,      910,      1000
GPOI,          149
          BASE,     AQUI
          1350,     1620
GPOI,          154
          BASE,     AQUI
          900,      1350
GPOI,          157
          BASE,     AQUI,     SURF
```

```
          380,     580,     1200
GPOI,          160
          BASE,    AQUI,    SURF
          400,     600,     1080
GPOI,          144
          BASE,    AQUI,    SURF
          560,     660,     970
GPOI,          128
          BASE,    AQUI,    SURF
          680,     800,     910
GPOI,           89
          BASE,    AQUI,    SURF
          600,     700      1050
GPOI,          139
          BASE,    AQUI,    SURF
          640      740      910
GPOI,          191
          BASE,    AQUI
          1420,    1670
GPOI,          197
          BASE,    AQUI
          1100,    1300
GPOI,          201
          BASE,    AQUI,    SURF
          440,     600,     1100
GPOI,          203
          BASE,    AQUI,    SURF
          500,     600,     930
GPOI,          206
          BASE,    AQUI,    SURF
          610,     660,     870
GPOI,          135
          BASE,    AQUI,    SURF
          670,     720,     870
GPOI,          208
          BASE,    AQUI
          1380,    1600
GPOI,          226
          BASE,    AQUI
          1000,    1200
GPOI,          229
          BASE,    AQUI,    SURF
          730,     900,     1180
GPOI,          233
          BASE,    AQUI,    SURF
          460,     560,     900
GPOI,          260
          BASE,    AQUI,    SURF
          490,     560,     870
GPOI,          340
          BASE,    AQUI,    SURF
          670,     720,     870
GPOI,          358
          BASE,    AQUI,    SURF
          680,     730,     920
GPOI,          301
          BASE,    AQUI
          1430,    1600
GPOI,          282
          BASE,    AQUI
          1000,    1200
GPOI,          286
          BASE,    AQUI,    SURF
          640,     720,     1120
GPOI,          291
          BASE,    AQUI,    SURF
          610,     690,     900
GPOI,          334
          BASE,    AQUI,    SURF
```

```
          580        660,       870
GPOI,           338
          BASE,      AQUI,      SURF
          630,       680,       870
GPOI,           360
          BASE,      SURF
          670,       860
GPOI,           361
          BASE,      SURF
          670        920
GPOI,           313
          BASE,      AQUI
          1450,      1600
GPOI,           328
          BASE,      AQUI
          1000       1150
GPOI,           331
          BASE,      AQUI,      SURF
          750        850,       1050
GPOI,           324
          BASE,      AQUI
          1470,      1600
GPOI,           325
          BASE,      AQUI
          1230,      1500
GPOI,           344
          BASE,      AQUI,      SURF
          730,       880,       950
GPOI,           349
          BASE,      AQUI,      SURF
          730,       880,       900
GPOI,           351
          BASE,      AQUI,      SURF
          710,       760,       870
GREG,  1, 27, 37,  4
GREG,  4, 37, 40,  6
GREG,  6, 40, 26,  9
GREG, 59,114, 37, 27
GREG, 37,114,117, 40
GREG, 26, 83, 84, 48
GREG, 40,117, 83, 26
GREG, 48, 84, 87, 51
GREG, 51, 87, 89, 52
GREG, 59,154,157,114
GREG,157,160,117,114
GREG,117,160,203,144
GREG,117,144,128, 83
GREG, 83,128, 87, 84
GREG, 89, 87,128,139
GREG,149,191,197,154
GREG,154,197,201,157
GREG,157,201,203,160
GREG,144,203,206,128
GREG,128,206,135,139
GREG,191,208,226,197
GREG,197,226,229,201
GREG,201,229,233,203
GREG,203,233,260,206
GREG,206,260,340,135
GREG,135,340,358,139
GREG,208,301,282,226
GREG,226,282,286,229
GREG,229,286,291,233
GREG,233,291,334,260
GREG,260,334,338,340
GREG,301,313,328,282
GREG,282,328,331,286
GREG,286,331,344,291
GREG,291,344,349,334
```

```
GREG,313,324,325,328
GREG,334,349,351,338
GREG,338,351,360,340
GREG,340,360,361,358
*
PLOT
STAR, 0, ME
FPRI, ON
CONT, MANU
400,450,500,550,600,650,700,750,800,850,900,950,1000,
1050,1100,1150,1200,1250,1300,1350,1400,1450,1500,1550,1600
SCAL, A3
GPLO, BASE
GPLO, AQUI
GPLO, SURF
PEND
/END
```

3. 'GEOL.ADD' FOR THE B2/A7 AQUIFER

```
GEOL ,      2 ,      2 ,      1 ,      1
  BASE    AQUI
 900.00,1100.00
GEOL ,      3 ,      3 ,      1 ,      1
  BASE    AQUI
 800.00,1050.00
GEOL ,     33 ,     33 ,      1 ,      1
  BASE    AQUI
1080.00,1300.00
GEOL ,     53 ,     53 ,      1 ,      1
  BASE    AQUI
1080.00,1300.00
GEOL ,    132 ,    132 ,      1 ,      2
  BASE    AQUI    SURF
 650.00, 700.00,1000.00
GEOL ,    150 ,    150 ,      1 ,      1
  BASE    AQUI
1350.00,1520.00
GEOL ,    300 ,    300 ,      1 ,      2
  BASE    AQUI    SURF
 620.00, 740.00, 920.00
GEOL ,    275 ,    275 ,      1 ,      1
  BASE    AQUI
1430.00,1650.00
GEOL ,    307 ,    307 ,      1 ,      1
  BASE    AQUI
1450.00,1670.00
GEOL ,    323 ,    323 ,      1 ,      1
  BASE    AQUI
1450.00,1650.00
GEOL ,    329 ,    329 ,      1 ,      2
  BASE    AQUI,   SURF
 860.00, 960.00,1200.00
GEOL ,    330 ,    330 ,      1 ,      2
  BASE    SURF
 810.00, 910.00 1100.00
GEOL ,    350 ,    350 ,      1 ,      2
  BASE    AQUI,   SURF
 730.00, 780.00, 880.00
GEOL ,    359 ,    359 ,      1 ,      1
  BASE    SURF
 680.00, 880.00
ADDEND
```

4. 'NMAT.DAT' FOR THE B2/A7 AQUIFER

1	AQ14
2	NOAQ
3	NOAQ
4	NOAQ
5	NOAQ
6	NOAQ
7	AQ14
8	AQ14
9	AQ14
10	AQ14
11	AQ14
12	AQ14
13	AQ14
14	AQ09
15	AQ09
16	AQ09
17	AQ09
18	AQ09
19	AQ09
20	AQ09
21	AQ09
22	AQ09
23	AQ09
24	AQ09
25	AQ09
26	AQ09
27	AQ14
28	AQ14
29	AQ14
30	AQ14
31	AQ14
32	AQ14
33	AQ14
34	AQ14
35	AQ14
36	AQ14
37	AQ14
38	AQ14
39	AQ13
40	AQ08
41	AQ08
42	AQ08
43	AQ08
44	AQ08
45	AQ10
46	AQ10
47	AQ12
48	AQ12
49	AQ10
50	AQ10
51	AQ10
52	AQ10
53	AQ13
54	AQ13
55	AQ13
56	AQ13
57	AQ13
58	AQ13
59	AQ13
60	AQ12
61	AQ12
62	AQ10
63	AQ10
64	AQ09
65	AQ09

66	AQ09
67	AQ09
68	AQ09
69	AQ09
70	AQ09
71	AQ09
72	AQ09
73	AQ09
74	AQ10
75	AQ10
76	AQ09
77	AQ09
78	AQ09
79	AQ09
80	AQ09
81	AQ09
82	AQ09
83	AQ10
84	AQ12
85	AQ12
86	AQ09
87	AQ09
88	AQ09
89	AQ09
90	AQ09
91	AQ09
92	AQ13
93	AQ13
94	AQ13
95	AQ16
96	AQ10
97	AQ10
98	AQ09
99	AQ09
100	AQ09
101	AQ09
102	AQ09
103	AQ09
104	AQ12
105	AQ12
106	AQ12
107	AQ19
108	AQ19
109	AQ16
110	AQ16
111	AQ16
112	AQ14
113	AQ10
114	AQ09
115	AQ09
116	AQ09
117	AQ09
118	AQ08
119	AQ08
120	AQ09
121	AQ09
122	AQ16
123	AQ16
124	AQ16
125	AQ16
126	AQ16
127	AQ16
128	AQ09
129	AQ14
130	AQ14
131	AQ10
132	AQ10
133	AQ19
134	AQ19

135	AQ06
136	AQ06
137	AQ06
138	AQ06
139	AQ06
140	AQ19
141	AQ19
142	AQ19
143	AQ19
144	AQ19
145	AQ19
146	AQ19
147	AQ19
148	AQ06
149	AQ14
150	AQ14
151	AQ14
152	AQ13
153	AQ14
154	AQ13
155	AQ13
156	AQ13
157	AQ19
158	AQ19
159	AQ19
160	AQ09
161	AQ13
162	AQ09
163	AQ12
164	AQ12
165	AQ12
166	AQ13
167	AQ15
168	AQ17
169	AQ17
170	AQ17
171	AQ09
172	AQ16
173	AQ15
174	AQ15
175	AQ15
176	AQ15
177	AQ17
178	AQ17
179	AQ16
180	AQ15
181	AQ15
182	AQ15
183	AQ15
184	AQ15
185	AQ15
186	AQ14
187	AQ14
188	AQ15
189	AQ15
190	AQ09
191	AQ16
192	AQ15
193	AQ15
194	AQ15
195	AQ13
196	AQ13
197	AQ14
198	AQ13
199	AQ13
200	AQ13
201	AQ14
202	AQ10
203	AQ10

204	AQ10
205	AQ10
206	AQ09
207	AQ09
208	AQ16
209	AQ13
210	AQ15
211	AQ15
212	AQ15
213	AQ15
214	AQ14
215	AQ14
216	AQ14
217	AQ13
218	AQ13
219	AQ13
220	AQ13
221	AQ14
222	AQ16
223	AQ14
224	AQ13
225	AQ13
226	AQ13
227	AQ13
228	AQ13
229	AQ16
230	AQ05
231	AQ05
232	AQ05
233	AQ05
234	AQ05
235	AQ05
236	AQ13
237	AQ13
238	AQ12
239	AQ09
240	AQ12
241	AQ13
242	AQ16
243	AQ16
244	AQ16
245	AQ15
246	AQ15
247	AQ15
248	AQ15
249	AQ13
250	AQ13
251	AQ13
252	AQ13
253	AQ11
254	AQ05
255	AQ05
256	AQ05
257	AQ05
258	AQ05
259	AQ05
260	AQ05
261	AQ05
262	AQ13
263	AQ11
264	AQ05
265	AQ05
266	AQ05
267	AQ05
268	AQ05
269	AQ13
270	AQ13
271	AQ11
272	AQ05

273	AQ05
274	AQ05
275	AQ15
276	AQ15
277	AQ15
278	AQ15
279	AQ15
280	AQ14
281	AQ14
282	AQ14
283	AQ14
284	AQ14
285	AQ14
286	AQ13
287	AQ11
288	AQ05
289	AQ05
290	AQ05
291	AQ05
292	AQ05
293	AQ05
294	AQ05
295	AQ05
296	AQ05
297	AQ05
298	AQ05
299	AQ05
300	AQ05
301	AQ16
302	AQ15
303	AQ15
304	AQ15
305	AQ14
306	AQ14
307	AQ15
308	AQ15
309	AQ12
310	AQ14
311	AQ14
312	AQ14
313	AQ15
314	AQ14
315	AQ14
316	AQ14
317	AQ12
318	AQ12
319	AQ12
320	AQ12
321	AQ10
322	AQ10
323	AQ18
324	AQ18
325	NOAQ
326	NOAQ
327	NOAQ
328	NOAQ
329	NOAQ
330	NOAQ
331	NOAQ
332	AQ05
333	AQ05
334	AQ05
335	AQ05
336	AQ05
337	AQ05
338	AQ05
339	AQ05
340	AQ05
341	AQ05

```
 342     AQ05
 343     AQ05
 344     NOAQ
 345     AQ06
 346     AQ06
 347     AQ06
 348     AQ06
 349     NOAQ
 350     NOAQ
 351     NOAQ
 352     NOAQ
 353     NOAQ
 354     AQ06
 355     AQ06
 356     AQ06
 357     AQ06
 358     AQ06
 359     NOAQ
 360     NOAQ
 361     NOAQ
AQEND
```

5. 'MODEL2.DAT' FOR THE B2/A7 AQUIFER

```
SETTING,  RUN ,  3600,   0
TITLE
    WATER RESOURCES STUDY OF THE JAFR BASIN  ( B2 / A7 )
1ST ,  361,  386,    8,  361,    3
2ND ,    2,    0,    0,    0,    0
3RD ,    0,    0,    0,    0,    0,    0
4TH ,    0,    0
*
*    --- MESH  ---
*
GENE
*
*
UNIT,  ME     ,  DAY , 25,   1.0E-01
CONT,  STEADY,  SURF
*
*
*
*    --- BOUNDARY CONDITION ---
*
*        HF :  CONSTANT HEAD
*        QF :  CONSTANT FLOW
*
*     NODE             CONDITION
*
NCON,    1,    1,  1,  HF
NCON,   27,   27,  1,  HF
NCON,   33,   33,  1,  HF
NCON,   53,   53,  1,  HF
NCON,   59,   59,  1,  HF
NCON,  104,  104,  1,  HF
NCON,  149,  149,  1,  HF
NCON,  150,  150,  1,  HF
NCON,  151,  151,  1,  HF
NCON,  154,  154,  1,  HF
NCON,  161,  161,  1,  HF
NCON,  172,  172,  1,  HF
NCON,  179,  179,  1,  HF
NCON,  191,  191,  1,  HF
NCON,  192,  192,  1,  HF
NCON,  208,  208,  1,  HF
NCON,  242,  242,  1,  HF
NCON,  275,  275,  1,  HF
NCON,  276,  276,  1,  HF
NCON,  301,  301,  1,  HF
NCON,  307,  307,  1,  HF
NCON,  313,  313,  1,  HF
NCON,  323,  323,  1,  HF
NCON,  324,  324,  1,  HF
*
NCON,    7,    7,  1,  QF
NCON,    8,    8,  1,  QF
NCON,    9,    9,  1,  QF
NCON,   26,   26,  1,  QF
NCON,   46,   46,  1,  QF
NCON,   47,   47,  1,  QF
NCON,   48,   48,  1,  QF
NCON,   51,   51,  1,  QF
NCON,   52,   52,  1,  QF
NCON,   89,   89,  1,  QF
NCON,  132,  132,  1,  QF
NCON,  139,  139,  1,  QF
NCON,  300,  300,  1,  QF
NCON,  343,  343,  1,  QF
NCON,  358,  358,  1,  QF
```

```
*
*
NCON,  162, 162,  1,  QF
NCON,  163, 163,  1,  QF
NCON,  164, 164,  1,  QF
NCON,  173, 173,  1,  QF
NCON,  174, 174,  1,  QF
NCON,  180, 180,  1,  QF
NCON,  181, 181,  1,  QF
NCON,  182, 182,  1,  QF
NCON,  193, 193,  1,  QF
NCON,  194, 194,  1,  QF
NCON,  195, 195,  1,  QF
NCON,  196, 196,  1,  QF
NCON,  209, 209,  1,  QF
NCON,  210, 210,  1,  QF
NCON,  211, 211,  1,  QF
NCON,  212, 212,  1,  QF
NCON,  215, 215,  1,  QF
NCON,  216, 216,  1,  QF
NCON,  217, 217,  1,  QF
NCON,  218, 218,  1,  QF
NCON,  236, 236,  1,  QF
NCON,  237, 237,  1,  QF
NCON,  243, 243,  1,  QF
NCON,  244, 244,  1,  QF
NCON,  245, 245,  1,  QF
NCON,  277, 277,  1,  QF
NCON,  278, 278,  1,  QF
NCON,  279, 279,  1,  QF
NCON,  302, 302,  1,  QF
NCON,  303, 303,  1,  QF
NCON,  304, 304,  1,  QF
NCON,  305, 305,  1,  QF
NCON,  308, 308,  1,  QF
NCON,  309, 309,  1,  QF
NCON,  310, 310,  1,  QF
NCON,  311, 311,  1,  QF
NCON,  312, 312,  1,  QF
NCON,  314, 314,  1,  QF
*
*
*    --- INITIAL CONDITION ---
*
*         NODE                    HEAD(EL M)
*
INIP,       1,        1,       1,1250.00
INIP,       2,        2,       1,1050.00
INIP,       3,        3,       1, 950.00
INIP,       4,        4,       1, 950.00
INIP,       5,        5,       1, 926.76
INIP,       6,        6,       1, 930.00
INIP,       7,        7,       1, 872.21
INIP,       8,        8,       1, 831.12
INIP,       9,        9,       1, 820.00
INIP,      10,       10,       1,1176.98
INIP,      11,       11,       1,1149.67
INIP,      12,       12,       1,1043.17
INIP,      13,       13,       1, 923.43
INIP,      14,       14,       1, 873.96
INIP,      15,       15,       1, 845.53
INIP,      16,       16,       1, 812.74
INIP,      17,       17,       1, 817.84
INIP,      18,       18,       1, 808.63
INIP,      19,       19,       1, 806.51
INIP,      20,       20,       1, 806.78
INIP,      21,       21,       1, 801.06
INIP,      22,       22,       1, 799.99
INIP,      23,       23,       1, 795.71
```

INIP,	24,	24,	1, 785.16
INIP,	25,	25,	1, 784.59
INIP,	26,	26,	1, 780.00
INIP,	27,	27,	1,1240.00
INIP,	28,	28,	1,1171.69
INIP,	29,	29,	1,1127.30
INIP,	30,	30,	1,1053.34
INIP,	31,	31,	1, 948.60
INIP,	32,	32,	1, 887.37
INIP,	33,	33,	1,1230.00
INIP,	34,	34,	1,1166.69
INIP,	35,	35,	1,1084.70
INIP,	36,	36,	1,1014.39
INIP,	37,	37,	1, 950.00
INIP,	38,	38,	1, 885.75
INIP,	39,	39,	1, 852.31
INIP,	40,	40,	1, 800.00
INIP,	41,	41,	1, 795.96
INIP,	42,	42,	1, 794.89
INIP,	43,	43,	1, 794.21
INIP,	44,	44,	1, 789.83
INIP,	45,	45,	1, 785.07
INIP,	46,	46,	1, 777.54
INIP,	47,	47,	1, 766.87
INIP,	48,	48,	1, 760.00
INIP,	49,	49,	1, 785.27
INIP,	50,	50,	1, 801.69
INIP,	51,	51,	1, 810.00
INIP,	52,	52,	1, 810.00
INIP,	53,	53,	1,1230.00
INIP,	54,	54,	1,1153.74
INIP,	55,	55,	1,1101.88
INIP,	56,	56,	1,1044.38
INIP,	57,	57,	1, 953.24
INIP,	58,	58,	1, 892.22
INIP,	59,	59,	1,1150.00
INIP,	60,	60,	1,1076.85
INIP,	61,	61,	1,1003.79
INIP,	62,	62,	1, 941.11
INIP,	63,	63,	1, 858.61
INIP,	64,	64,	1, 826.31
INIP,	65,	65,	1, 851.34
INIP,	66,	66,	1, 839.00
INIP,	67,	67,	1, 827.38
INIP,	68,	68,	1, 816.28
INIP,	69,	69,	1, 804.50
INIP,	70,	70,	1, 810.09
INIP,	71,	71,	1, 797.73
INIP,	72,	72,	1, 792.44
INIP,	73,	73,	1, 788.82
INIP,	74,	74,	1, 795.84
INIP,	75,	75,	1, 791.87
INIP,	76,	76,	1, 818.41
INIP,	77,	77,	1, 813.38
INIP,	78,	78,	1, 807.72
INIP,	79,	79,	1, 802.84
INIP,	80,	80,	1, 797.25
INIP,	81,	81,	1, 793.77
INIP,	82,	82,	1, 792.87
INIP,	83,	83,	1, 790.00
INIP,	84,	84,	1, 790.00
INIP,	85,	85,	1, 791.31
INIP,	86,	86,	1, 800.25
INIP,	87,	87,	1, 780.00
INIP,	88,	88,	1, 764.67
INIP,	89,	89,	1, 750.00
INIP,	90,	90,	1,1004.50
INIP,	91,	91,	1, 809.47
INIP,	92,	92,	1, 714.17

```
INIP,    93,    93,    1, 620.64
INIP,    94,    94,    1, 644.94
INIP,    95,    95,    1, 769.81
INIP,    96,    96,    1, 812.90
INIP,    97,    97,    1, 802.84
INIP,    98,    98,    1, 783.56
INIP,    99,    99,    1, 784.09
INIP,   100,   100,    1, 784.91
INIP,   101,   101,    1, 787.16
INIP,   102,   102,    1, 787.91
INIP,   103,   103,    1, 789.44
INIP,   104,   104,    1,1072.06
INIP,   105,   105,    1, 841.23
INIP,   106,   106,    1, 666.20
INIP,   107,   107,    1, 562.18
INIP,   108,   108,    1, 590.72
INIP,   109,   109,    1, 603.20
INIP,   110,   110,    1, 619.07
INIP,   111,   111,    1, 630.26
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INIP,   113,   113,    1, 644.84
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INIQ,  312, 312,  1,     137
INIQ,  314, 314,  1,     685
*
*    --- AQUIFER CONSTANTS ---
*
*      K : COEFFICIENT OF INFILTRATION CAPACITY
*      S : COEFFICIENT OF STORAGE
*
*                 SYMBOL OF       K        S
*                 AQUIFER
*
LAYE, 40
                 GS00,        1.0E-08,  1.00E-07
                 GS01,        1.0E-08,  1.00E-03
                 GS02,        1.0E-08,  9.09E-04
                 GS03,        1.0E-08,  8.03E-04
                 GS04,        1.0E-08,  6.75E-04
                 GS05,        1.0E-08,  5.02E-04
                 GS06,        1.0E-08,  3.73E-04
                 GS07,        1.0E-08,  3.30E-04
                 GS08,        1.0E-08,  2.77E-04
                 GS09,        1.0E-08,  2.06E-04
                 GS10,        1.0E-08,  1.39E-04
                 GS11,        1.0E-08,  1.23E-04
                 GS12,        1.0E-08,  1.03E-04
                 GS13,        1.0E-08,  7.67E-05
                 GS14,        1.0E-08,  5.18E-05
                 GS15,        1.0E-08,  3.85E-05
                 GS16,        1.0E-08,  1.93E-05
                 GS17,        1.0E-08,  7.20E-06
                 GS18,        1.0E-08,  2.68E-06
                 GS19,        1.0E-08,  1.00E-06
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                 AQ03,       60.0,      0.2258
                 AQ04,       40.0,      0.2082
                 AQ05,       20.0,      0.1813
                 AQ06,       10.0,      0.1578
                 AQ07,        7.5,      0.1490
                 AQ08,        5.0,      0.1374
                 AQ09,        2.5,      0.1197
                 AQ10,        1.0,      0.0997
                 AQ11,        0.75,     0.0941
                 AQ12,        0.50,     0.0868
                 AQ13,        0.25      0.0756
                 AQ14,        0.10,     0.0629
                 AQ15,        0.05,     0.0548
                 AQ16,        0.01,     0.0397
                 AQ17,        0.001,    0.0251
                 AQ18,        0.0001,   0.0158
                 AQ19,        0.00001,  0.0100
*
*
*    ---  GEOLOGICAL DATA  ---
*
GENE
*
*
*
ENDD
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6. 'MESH.DAT' FOR THE A1-6 AQUIFER

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TITLE
     LOWER AJLUN ( A1-6 )
SUBT
     FEM MESH
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*          NODE NO.        X          Y
*
NODE              1     220289    1039499
NODE              2     229599    1037482
NODE              3     238302    1035662
NODE              4     242963    1037206
NODE              5     249898    1033584
NODE              6     252635    1034788
NODE              7     217487    1032678
NODE              8     229751    1029144
NODE              9     238333    1028667
NODE             10     247759    1030851
NODE             11     251233    1030801
NODE             12     255365    1030425
NODE             13     215427    1029185
NODE             14     217849    1025901
NODE             15     222969    1025545
NODE             16     215407    1021309
NODE             17     221773    1021203
NODE             18     230406    1022845
NODE             19     237851    1023202
NODE             20     244193    1026736
NODE             21     217423    1017069
NODE             22     222599    1014442
NODE             23     232779    1016062
NODE             24     239558    1018804
NODE             25     245165    1019703
NODE             26     252315    1020949
NODE             27     254314    1027131
NODE             28     258312    1020900
NODE             29     258240    1028370
NODE             30     262390    1024900
NODE             31     262004    1020471
NODE             32     266057    1024567
NODE             33     267676    1024452
NODE             34     273157    1023636
NODE             35     277535    1027354
NODE             36     285217    1024463
NODE             37     214341    1015897
NODE             38     216033    1013118
NODE             39     209795    1011071
NODE             40     212229    1004075
NODE             41     220278    1007115
NODE             42     226723    1009996
NODE             43     233497    1013154
NODE             44     234741    1010061
NODE             45     240362    1015624
NODE             46     241594    1010020
NODE             47     250280    1013577
NODE             48     258770    1012862
NODE             49     261161    1012825
NODE             50     271123    1016168
NODE             51     272749    1016565
NODE             52     262218    1006827
NODE             53     266373    1008973
NODE             54     268277    1009003
NODE             55     275577    1010655
NODE             56     277187    1011516
NODE             57     287517    1012483
NODE             58     291926    1012918
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NODE	59	266345	1006962
NODE	60	268308	1006945
NODE	61	266341	1004963
NODE	62	268196	1005005
NODE	63	270338	1004966
NODE	64	273489	1006436
NODE	65	279912	1005272
NODE	66	282101	1005340
NODE	67	298718	1005631
NODE	68	266348	1002964
NODE	69	268335	1002888
NODE	70	270250	1002942
NODE	71	272297	1002950
NODE	72	252314	1004912
NODE	73	264298	1000886
NODE	74	268295	1000842
NODE	75	270259	1000849
NODE	76	272245	1000939
NODE	77	276289	1001014
NODE	78	264265	996865
NODE	79	268327	998855
NODE	80	270253	998981
NODE	81	272335	998977
NODE	82	268275	996820
NODE	83	270332	996888
NODE	84	272283	996906
NODE	85	277589	996945
NODE	86	284733	997632
NODE	87	286846	998057
NODE	88	268257	994893
NODE	89	270652	994559
NODE	90	273131	995296
NODE	91	272370	992814
NODE	92	274225	992975
NODE	93	278876	992960
NODE	94	269437	992204
NODE	95	272317	990922
NODE	96	275903	991635
NODE	97	276274	988890
NODE	98	282378	988818
NODE	99	292054	987233
NODE	100	300796	996157
NODE	101	307608	994152
NODE	102	210500	1001000
NODE	103	209901	995035
NODE	104	217474	995619
NODE	105	223777	997083
NODE	106	229072	998276
NODE	107	234345	998006
NODE	108	240305	996778
NODE	109	247889	994900
NODE	110	255900	993251
NODE	111	264291	991654
NODE	112	272258	988388
NODE	113	276682	986110
NODE	114	228883	996847
NODE	115	234213	996791
NODE	116	240165	995290
NODE	117	247474	993599
NODE	118	255487	991629
NODE	119	264274	989715
NODE	120	272352	985997
NODE	121	199818	996889
NODE	122	201817	996813
NODE	123	203855	994049
NODE	124	199417	994054
NODE	125	201445	993502
NODE	126	203411	991939
NODE	127	209363	990342

NODE	128	214268	988724
NODE	129	222858	988687
NODE	130	228257	988905
NODE	131	240353	986773
NODE	132	253433	981330
NODE	133	264275	980935
NODE	134	272388	980989
NODE	135	280391	981351
NODE	136	199977	991525
NODE	137	201455	991170
NODE	138	203441	988774
NODE	139	198983	988422
NODE	140	201510	987935
NODE	141	203789	986018
NODE	142	198169	982799
NODE	143	201536	982772
NODE	144	204236	982786
NODE	145	209364	982811
NODE	146	214233	980050
NODE	147	217838	979966
NODE	148	221561	977539
NODE	149	227149	978009
NODE	150	197509	977213
NODE	151	199939	976796
NODE	152	202200	976806
NODE	153	204699	976770
NODE	154	210283	976300
NODE	155	199690	966824
NODE	156	202276	967658
NODE	157	205072	967637
NODE	158	209850	968075
NODE	159	213424	968824
NODE	160	216728	971687
NODE	161	219920	968826
NODE	162	236401	970864
NODE	163	251557	967262
NODE	164	261982	969432
NODE	165	272282	970994
NODE	166	286321	975852
NODE	167	299877	985238
NODE	168	196357	962045
NODE	169	196279	957797
NODE	170	199059	961976
NODE	171	202246	962102
NODE	172	201559	955528
NODE	173	204289	954935
NODE	174	205291	962107
NODE	175	208871	954872
NODE	176	209911	961687
NODE	177	212738	954814
NODE	178	215114	962570
NODE	179	218297	954487
NODE	180	218197	962445
NODE	181	225614	954450
NODE	182	248304	949230
NODE	183	262057	951682
NODE	184	278342	956919
NODE	185	289842	970972
NODE	186	294349	964972
NODE	187	303906	977056
NODE	188	309159	966482
NODE	189	305291	977736
NODE	190	310903	967011
NODE	191	315486	987732
NODE	192	325254	986481
NODE	193	192735	953956
NODE	194	198302	951570
NODE	195	201297	950647
NODE	196	208586	948528

NODE	197	212481	946876		
NODE	198	215607	947132		
NODE	199	192412	943007		
NODE	200	194771	937724		
NODE	201	196415	944902		
NODE	202	200706	931642		
NODE	203	199401	944954		
NODE	204	207945	933591		
NODE	205	208227	938876		
NODE	206	210427	934067		
NODE	207	211190	940011		
NODE	208	213968	934470		
NODE	209	214676	940021		
NODE	210	222423	934860		
NODE	211	222450	940750		
NODE	212	232368	934956		
NODE	213	234500	940925		
NODE	214	240411	934902		
NODE	215	246546	938994		
NODE	216	256494	931356		
NODE	217	256030	935112		
NODE	218	274387	932646		
NODE	219	267557	941420		
NODE	220	286340	942945		
NODE	221	296344	950524		
NODE	222	301897	940941		
NODE	223	301216	933760		
NODE	224	312973	959476		
NODE	225	318151	950591		
NODE	226	321911	941835		
NODE	227	314265	961285		
NODE	228	320008	951715		
NODE	229	324692	943349		
NODE	230	330942	973972		
NODE	231	344641	955973		
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ELEM	2	2	8	9	3
ELEM	3	3	9	10	10
ELEM	4	4	3	10	5
ELEM	5	5	10	11	6
ELEM	6	7	13	14	14
ELEM	7	7	14	15	8
ELEM	8	15	17	18	8
ELEM	9	8	18	19	9
ELEM	10	9	19	20	20
ELEM	11	9	20	10	10
ELEM	12	10	20	25	26
ELEM	13	11	10	26	27
ELEM	14	6	11	27	12
ELEM	15	12	27	28	29
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ELEM	19	16	21	22	17
ELEM	20	17	22	23	18
ELEM	21	18	23	24	19
ELEM	22	19	24	25	20
ELEM	23	37	39	38	38
ELEM	24	21	37	38	22
ELEM	25	22	42	43	23
ELEM	26	23	43	45	24
ELEM	27	24	45	25	25
ELEM	28	25	45	46	47
ELEM	29	25	47	48	26
ELEM	30	27	26	28	28
ELEM	31	26	48	28	28
ELEM	32	29	28	31	30
ELEM	33	28	48	49	31
ELEM	34	30	31	32	32

ELEM	35	32	31	49	50
ELEM	36	33	32	50	51
ELEM	37	33	51	34	34
ELEM	38	35	34	51	36
ELEM	39	36	51	56	57
ELEM	40	36	57	58	58
ELEM	41	38	39	40	41
ELEM	42	38	41	42	22
ELEM	43	43	42	44	44
ELEM	44	43	44	46	45
ELEM	45	47	46	72	48
ELEM	46	48	52	53	49
ELEM	47	49	53	50	50
ELEM	48	50	53	54	55
ELEM	49	51	50	55	56
ELEM	50	53	52	61	59
ELEM	51	53	59	60	54
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ELEM	55	61	68	69	62
ELEM	56	62	69	70	63
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ELEM	71	73	78	79	74
ELEM	72	74	79	80	75
ELEM	73	75	80	81	76
ELEM	74	81	84	85	77
ELEM	75	93	86	77	85
ELEM	76	79	78	88	82
ELEM	77	79	82	83	80
ELEM	78	80	83	84	81
ELEM	79	82	88	89	83
ELEM	80	83	89	90	84
ELEM	81	78	111	94	88
ELEM	82	88	94	91	89
ELEM	83	89	91	92	90
ELEM	84	92	85	84	90
ELEM	85	92	96	93	85
ELEM	86	111	112	94	94
ELEM	87	91	94	112	95
ELEM	88	91	95	96	92
ELEM	89	95	112	97	96
ELEM	90	97	112	113	113
ELEM	91	96	97	98	93
ELEM	92	93	98	99	86
ELEM	93	86	99	87	87
ELEM	94	87	99	100	67
ELEM	95	97	113	135	98
ELEM	96	98	135	99	99
ELEM	97	99	167	101	100
ELEM	98	40	102	103	104
ELEM	99	40	104	105	41
ELEM	100	41	105	106	42
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ELEM	102	44	107	108	46
ELEM	103	46	108	109	72

ELEM	104	72	109	110	73
ELEM	105	73	110	111	78
ELEM	106	105	114	106	106
ELEM	107	106	114	115	107
ELEM	108	107	115	116	108
ELEM	109	108	116	117	109
ELEM	110	109	117	118	110
ELEM	111	110	118	119	111
ELEM	112	111	119	120	112
ELEM	113	112	120	113	113
ELEM	114	120	135	113	113
ELEM	115	135	166	167	99
ELEM	116	167	189	191	101
ELEM	117	121	124	125	122
ELEM	118	122	125	126	123
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ELEM	129	119	133	134	120
ELEM	130	120	134	135	135
ELEM	131	124	136	137	125
ELEM	132	125	137	138	126
ELEM	133	136	139	140	137
ELEM	134	137	140	141	138
ELEM	135	126	138	141	127
ELEM	136	139	142	143	140
ELEM	137	140	143	144	141
ELEM	138	141	144	145	127
ELEM	139	127	145	146	146
ELEM	140	127	146	128	128
ELEM	141	128	146	147	147
ELEM	142	128	147	148	129
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ELEM	148	134	165	166	135
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ELEM	152	144	153	154	145
ELEM	153	145	154	159	146
ELEM	154	146	159	160	147
ELEM	155	147	160	148	148
ELEM	156	148	160	161	149
ELEM	157	149	161	162	162
ELEM	158	151	155	156	152
ELEM	159	152	156	157	153
ELEM	160	153	157	158	154
ELEM	161	176	159	154	158
ELEM	162	155	168	169	170
ELEM	163	155	170	171	156
ELEM	164	156	171	174	157
ELEM	165	157	174	176	176
ELEM	166	158	157	176	176
ELEM	167	159	176	178	178
ELEM	168	159	178	180	160
ELEM	169	160	180	161	161
ELEM	170	161	180	179	181
ELEM	171	161	181	162	162
ELEM	172	162	181	182	163

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ELEM        173     163     182     183     164
ELEM        174     164     183     184     165
ELEM        175     165     184     185     166
ELEM        176     166     185     187     167
ELEM        177     167     187     189     189
ELEM        178     170     169     172     171
ELEM        179     171     172     173     173
ELEM        180     174     171     173     173
ELEM        181     174     173     175     175
ELEM        182     176     174     175     175
ELEM        183     176     175     177     178
ELEM        184     178     177     179     180
ELEM        185     169     193     194     172
ELEM        186     172     194     195     173
ELEM        187     173     195     196     175
ELEM        188     175     196     197     177
ELEM        189     177     197     198     179
ELEM        190     179     198     181     181
ELEM        191     198     209     211     181
ELEM        192     181     211     213     182
ELEM        193     182     213     215     215
ELEM        194     182     215     217     219
ELEM        195     182     219     183     183
ELEM        196     183     219     220     184
ELEM        197     185     184     186     186
ELEM        198     185     186     188     187
ELEM        199     187     188     190     189
ELEM        200     189     190     192     191
ELEM        201     184     220     221     186
ELEM        202     186     221     224     188
ELEM        203     188     224     227     190
ELEM        204     190     227     230     192
ELEM        205     193     199     201     194
ELEM        206     194     201     203     195
ELEM        207     195     203     205     196
ELEM        208     196     205     207     207
ELEM        209     197     196     207     209
ELEM        210     198     197     209     209
ELEM        211     199     200     201     201
ELEM        212     201     200     202     203
ELEM        213     203     202     204     205
ELEM        214     205     204     206     207
ELEM        215     207     206     208     209
ELEM        216     209     208     210     211
ELEM        217     211     210     212     213
ELEM        218     213     212     214     215
ELEM        219     215     214     216     217
ELEM        220     217     216     218     219
ELEM        221     219     218     220     220
ELEM        222     220     218     223     222
ELEM        223     221     220     222     222
ELEM        224     221     222     225     224
ELEM        225     224     225     228     227
ELEM        226     227     228     231     230
ELEM        227     222     223     226     225
ELEM        228     225     226     229     228
ELEM        229     228     229     231     231
*
SAVE
NOWR
PLOT
STAR,  0,ME
SCAL,  A4
NNUM,  OFF
ENUM,  OFF
MESH,  ON
MPLO
PEND
/END
```

7. 'GEOL.DAT' FOR THE A1-6 AQUIFER

```
TITL
     LOWER AJLUN ( A1/6 )
SUBT
     GENERATION OF GEOLOGICAL DATA
RESU
*
GPOI, 2
BASE,      AQUI,      SURF
450.0,     550.0      1000.0
GPOI, 4
BASE,      AQUI,      SURF
450.0,     600.0      1000.0
GPOI, 6
BASE,      AQUI,      SURF
470.0,     620.0      950.0
GPOI, 7
BASE,      AQUI,      SURF
500.0,     600.0      1000.0
GPOI, 37
BASE,      AQUI,      SURF
1000.0     1100.0,    1200.0
GPOI, 23
BASE,      AQUI,      SURF
440.0,     540.0,     1000.0
GPOI, 25
BASE,      AQUI,      SURF
450.0,     550.0,     880.0
GPOI, 30
BASE,      AQUI,      SURF
450.0,     650.0,     880.0
GPOI, 36
BASE,      AQUI,      SURF
450.0,     670.0,     1000.0
GPOI, 121
BASE,      AQUI,      SURF
850.0,   1000.0     1450.0
GPOI, 102
BASE,      AQUI,      SURF
300.0,     500.0,     1200.0
GPOI, 103
BASE,      AQUI,      SURF
300.0,     500.0,     1200.0
GPOI, 105
BASE,      AQUI,      SURF
160.0,     480.0,     1100.0
GPOI, 89
BASE,      AQUI,      SURF
420.0,     680.0,     910.0
GPOI, 100
BASE,      AQUI,      SURF
450.0      670.0      920.0
GPOI, 150
BASE,      AQUI,      SURF
1150.0,    1250.0,    1650.0
GPOI, 149
BASE,      AQUI,      SURF
330.0,     500.0,     1100.0
GPOI, 132
BASE,      AQUI,      SURF
160.0,     480.0,     910.0
GPOI, 155
BASE,      AQUI,      SURF
1000.0,    1100.0,    1650.0
GPOI, 161
BASE,      AQUI,      SURF
```

```
500.0,     630.0,     1100.0
GPOI, 163
BASE,      AQUI,      SURF
280.0,     480.0,     880.0
GPOI, 185
BASE,      AQUI,      SURF
420.0,     600.0,     880.0
GPOI, 192
BASE,      AQUI,      SURF
450.0,     670.0      920.0
GPOI, 193
BASE,      AQUI,      SURF
1050.0,    1250.0,    1700.0
GPOI, 179
BASE,      AQUI,      SURF
600.0,     750.0,     1100.0
GPOI, 182
BASE,      AQUI,      SURF
500.0,     650.0,     900.0
GPOI, 221
BASE,      AQUI,      SURF
550.0,     700.0,     880.0
GPOI, 230
BASE,      AQUI,      SURF
500.0,     670.0,     930.0
GPOI, 202
BASE,      AQUI,      SURF
1200.0,    1350.0,    1650.0
GPOI, 210
BASE,      AQUI,      SURF
800.0,     900.0,     1100.0
GPOI, 216
BASE,      AQUI,      SURF
690.0,     800.0,     890.0
GPOI, 223
BASE,      AQUI,      SURF
690.0,     800.0,     890.0
GPOI, 231
BASE,      AQUI,      SURF
680.0,     750.0      920.0
GREG,  7, 37, 23,  2
GREG,  2, 23, 25,  4
GREG, 25,109, 89, 30
GREG,  4, 25, 30,  6
GREG, 37,102,105, 23
GREG, 23,105,132, 25
GREG, 25,132, 89, 30
GREG, 30, 89,100, 36
GREG,102,121,103,105
GREG,121,150,149,103
GREG,103,149,132,105
GREG,150,155,161,149
GREG,149,161,163,132
GREG,132,163,185, 89
GREG, 89,185,192,100
GREG,155,193,179,161
GREG,161,179,182,163
GREG,163,182,221,185
GREG,185,221,230,192
GREG,193,202,210,179
GREG,179,210,216,182
GREG,182,216,223,221
GREG,221,223,231,230
*
PLOT
STAR, 0, ME
FPRI, ON
CONT, MANU
200,250,300,350,
```

```
400,450,500,550,600,650,700,750,800,850,900,950,1000,
1050,1100,1150,1200,1250,1300,1350,1400,1450,1500,1550,1600
SCAL, A3
GPLO, BASE
GPLO, AQUI
GPLO, SURF
PEND
/END
```

8. 'GEOL.ADD' FOR THE A1-6 AQUIFER

```
GEOL ,      1 ,      1 ,      1 ,      2
  BASE     AQUI     SURF
 450.00, 550.00,1000.00
GEOL ,     13 ,     13 ,      1 ,      2
  BASE     AQUI     SURF
 650.00, 750.00,1200.00
GEOL ,     35 ,     35 ,      1 ,      2
  BASE     AQUI     SURF
 450.00, 670.00,1000.00
GEOL ,     39 ,     39 ,      1 ,      2
  BASE     AQUI,    SURF
1000.00,1100.00,1200.00
GEOL ,     58 ,     58 ,      1 ,      2
  BASE     AQUI     SURF
 450.00, 650.00, 950.00
GEOL ,     67 ,     67 ,      1 ,      2
  BASE     AQUI     SURF
 450.00, 650.00, 950.00
GEOL ,    101 ,    101 ,      1 ,      2
  BASE     AQUI     SURF
 450.00, 650.00,1200.00
GEOL ,    124 ,    124 ,      1 ,      2
  BASE     AQUI     SURF
 900.00,1050.00,1450.00
GEOL ,    168 ,    168 ,      1 ,      2
  BASE     AQUI     SURF
1050.00,1200.00,1680.00
GEOL ,    199 ,    199 ,      1 ,      2
  BASE     AQUI     SURF
1220.00,1300.00,1680.00
GEOL ,    200 ,    200 ,      1 ,      2
  BASE     AQUI     SURF
1220.00,1350.00,1680.00
GEOL ,    226 ,    226 ,      1 ,      2
  BASE     AQUI     SURF
 690.00, 800.00, 900.00
GEOL ,    229 ,    229 ,      1 ,      2
  BASE     AQUI     SURF
 690.00, 800.00, 900.00
ADDEND
```

9. 'NMAT.DAT' FOR THE A1-6 AQUIFER

1	AQ12
2	AQ12
3	AQ12
4	AQ11
5	AQ11
6	AQ11
7	AQ11
8	AQ11
9	AQ11
10	AQ11
11	AQ11
12	AQ11
13	AQ11
14	AQ11
15	AQ11
16	AQ11
17	AQ11
18	AQ11
19	AQ11
20	AQ11
21	AQ11
22	AQ10
23	AQ10
24	AQ10
25	AQ10
26	AQ12
27	AQ10
28	AQ12
29	AQ10
30	AQ10
31	AQ12
32	AQ10
33	AQ10
34	AQ10
35	AQ10
36	AQ10
37	AQ10
38	AQ10
39	AQ10
40	AQ10
41	AQ06
42	AQ06
43	AQ07
44	AQ05
45	AQ07
46	AQ05
47	AQ07
48	AQ07
49	AQ10
50	AQ17
51	AQ17
52	AQ05
53	AQ05
54	AQ05
55	AQ22
56	AQ22
57	AQ08
58	AQ08
59	AQ05
60	AQ05
61	AQ05
62	AQ05
63	AQ05
64	AQ05
65	AQ20

66	AQ20
67	AQ08
68	AQ05
69	AQ05
70	AQ05
71	AQ05
72	AQ05
73	AQ05
74	AQ05
75	AQ05
76	AQ05
77	AQ05
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124	AQ12
125	AQ10
126	AQ10
127	AQ08
128	AQ08
129	AQ34
130	AQ34
131	AQ17
132	AQ17
133	AQ17
134	AQ17

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204    AQ22
205    AQ12
206    AQ22
207    AQ12
208    AQ22
209    AQ12
210    AQ18
211    AQ12
212    AQ12
213    AQ10
214    AQ12
215    AQ10
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222    AQ10
223    AQ11
224    AQ11
225    AQ11
226    AQ11
227    AQ10
228    AQ10
229    AQ10
230    AQ10
231    AQ10
AQEND
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135	AQ34
136	AQ12
137	AQ11
138	AQ11
139	AQ12
140	AQ12
141	AQ12
142	AQ12
143	AQ12
144	AQ12
145	AQ12
146	AQ12
147	AQ15
148	AQ17
149	AQ30
150	AQ18
151	AQ18
152	AQ18
153	AQ15
154	AQ15
155	AQ22
156	AQ22
157	AQ18
158	AQ18
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161	AQ30
162	AQ10
163	AQ10
164	AQ10
165	AQ10
166	AQ10
167	AQ10
168	AQ22
169	AQ21
170	AQ21
171	AQ18
172	AQ15
173	AQ18
174	AQ18
175	AQ18
176	AQ18
177	AQ30
178	AQ30
179	AQ30
180	AQ30
181	AQ10
182	AQ09
183	AQ08
184	AQ07
185	AQ07
186	AQ07
187	AQ11
188	AQ11
189	AQ11
190	AQ11
191	AQ10
192	AQ10
193	AQ22
194	AQ18
195	AQ18
196	AQ20
197	AQ20
198	AQ20
199	AQ18
200	AQ18
201	AQ18
202	AQ17
203	AQ15

```
NCON,  230, 230,  1,  QF
*
*
*     --- INITIAL CONDITION ---
*
*          NODE                    HEAD (EL M)
*
INIP,       1,        1,        1, 505.00
INIP,       2,        2,        1, 505.00
INIP,       3,        3,        1, 504.55
INIP,       4,        4,        1, 505.00
INIP,       5,        5,        1, 517.83
INIP,       6,        6,        1, 525.00
INIP,       7,        7,        1, 555.00
INIP,       8,        8,        1, 537.06
INIP,       9,        9,        1, 502.74
INIP,      10,       10,        1, 511.65
INIP,      11,       11,        1, 515.68
INIP,      12,       12,        1, 519.57
INIP,      13,       13,        1, 705.00
INIP,      14,       14,        1, 713.31
INIP,      15,       15,        1, 648.06
INIP,      16,       16,        1, 873.44
INIP,      17,       17,        1, 739.03
INIP,      18,       18,        1, 548.38
INIP,      19,       19,        1, 501.07
INIP,      20,       20,        1, 504.62
INIP,      21,       21,        1, 932.94
INIP,      22,       22,        1, 757.22
INIP,      23,       23,        1, 495.00
INIP,      24,       24,        1, 501.05
INIP,      25,       25,        1, 505.00
INIP,      26,       26,        1, 504.17
INIP,      27,       27,        1, 510.89
INIP,      28,       28,        1, 502.47
INIP,      29,       29,        1, 516.27
INIP,      30,       30,        1, 505.00
INIP,      31,       31,        1, 501.06
INIP,      32,       32,        1, 504.66
INIP,      33,       33,        1, 504.57
INIP,      34,       34,        1, 503.96
INIP,      35,       35,        1, 505.00
INIP,      36,       36,        1, 505.00
INIP,      37,       37,        1,1055.00
INIP,      38,       38,        1, 880.41
INIP,      39,       39,        1,1055.00
INIP,      40,       40,        1, 510.16
INIP,      41,       41,        1, 557.13
INIP,      42,       42,        1, 537.63
INIP,      43,       43,        1, 456.37
INIP,      44,       44,        1, 416.56
INIP,      45,       45,        1, 475.55
INIP,      46,       46,        1, 414.99
INIP,      47,       47,        1, 488.96
INIP,      48,       48,        1, 495.00
INIP,      49,       49,        1, 494.31
INIP,      50,       50,        1, 496.56
INIP,      51,       51,        1, 497.41
INIP,      52,       52,        1, 488.53
INIP,      53,       53,        1, 489.35
INIP,      54,       54,        1, 488.07
INIP,      55,       55,        1, 493.29
INIP,      56,       56,        1, 494.72
INIP,      57,       57,        1, 499.73
INIP,      58,       58,        1, 505.00
INIP,      59,       59,        1, 487.52
INIP,      60,       60,        1, 485.89
INIP,      61,       61,        1, 485.69
INIP,      62,       62,        1, 483.75
```

10. 'MODEL2.DAT' FOR THE A1-6 AQUIFER

```
SETTING, RUN ,  3600,    0
TITLE
     WATER RESOURCES STUDY OF THE JAFR BASIN ( LOWER AJLUN )
1ST ,  231,  229,    8,  231,    3
2ND ,    3,    0,    0,    0,    0
3RD ,    0,    0,    0,    0,    0,    0
4TH ,    0,    0
*
*    --- MESH DATA  ---
*
GENE
*
*
UNIT,  ME    ,  DAY , 25, 5.0E-01
CONT,  STEADY
*
*
*    --- BOUNDARY CONDITION ---
*
*        HF :  CONSTANT HEAD
*        QF :  CONSTANT FLOW
*
*      NODE           CONDITION
*
NCON,    7,    7,  1,  HF
NCON,   13,   13,  1,  HF
NCON,   16,   16,  1,  HF
NCON,   37,   37,  1,  HF
NCON,   39,   39,  1,  HF
NCON,   40,   40,  1,  HF
NCON,  102, 102,  1,  HF
NCON,  103, 103,  1,  HF
NCON,  121, 121,  1,  HF
NCON,  122, 122,  1,  HF
NCON,  124, 124,  1,  HF
NCON,  136, 136,  1,  HF
NCON,  139, 139,  1,  HF
NCON,  142, 142,  1,  HF
NCON,  150, 150,  1,  HF
NCON,  151, 151,  1,  HF
NCON,  155, 155,  1,  HF
NCON,  168, 168,  1,  HF
NCON,  169, 169,  1,  HF
NCON,  193, 193,  1,  HF
NCON,  199, 199,  1,  HF
NCON,  200, 200,  1,  HF
NCON,  202, 202,  1,  HF
*
NCON,    4,    4,  1,  QF
NCON,    5,    5,  1,  QF
NCON,    6,    6,  1,  QF
NCON,   12,   12,  1,  QF
NCON,   29,   29,  1,  QF
NCON,   30,   30,  1,  QF
NCON,   32,   32,  1,  QF
NCON,   33,   33,  1,  QF
NCON,   34,   34,  1,  QF
NCON,   35,   35,  1,  QF
NCON,   36,   36,  1,  QF
NCON,   58,   58,  1,  QF
NCON,   67,   67,  1,  QF
NCON,  100, 100,  1,  QF
NCON,  101, 101,  1,  QF
NCON,  191, 191,  1,  QF
NCON,  192, 192,  1,  QF
```

```
INIP,   132,   132,   1, 215.00
INIP,   133,   133,   1, 312.75
INIP,   134,   134,   1, 388.55
INIP,   135,   135,   1, 465.64
INIP,   136,   136,   1, 965.22
INIP,   137,   137,   1, 929.09
INIP,   138,   138,   1, 903.63
INIP,   139,   139,   1,1029.76
INIP,   140,   140,   1, 966.53
INIP,   141,   141,   1, 927.29
INIP,   142,   142,   1,1119.71
INIP,   143,   143,   1,1027.97
INIP,   144,   144,   1, 953.98
INIP,   145,   145,   1, 813.47
INIP,   146,   146,   1, 713.58
INIP,   147,   147,   1, 616.02
INIP,   148,   148,   1, 539.55
INIP,   149,   149,   1, 385.00
INIP,   150,   150,   1,1205.00
INIP,   151,   151,   1,1134.10
INIP,   152,   152,   1,1071.77
INIP,   153,   153,   1,1002.52
INIP,   154,   154,   1, 845.65
INIP,   155,   155,   1,1055.00
INIP,   156,   156,   1, 996.85
INIP,   157,   157,   1, 926.03
INIP,   158,   158,   1, 807.96
INIP,   159,   159,   1, 721.09
INIP,   160,   160,   1, 648.84
INIP,   161,   161,   1, 555.00
INIP,   162,   162,   1, 411.77
INIP,   163,   163,   1, 335.00
INIP,   164,   164,   1, 362.53
INIP,   165,   165,   1, 395.04
INIP,   166,   166,   1, 478.75
INIP,   167,   167,   1, 490.31
INIP,   168,   168,   1,1105.00
INIP,   169,   169,   1,1071.20
INIP,   170,   170,   1,1041.64
INIP,   171,   171,   1, 973.02
INIP,   172,   172,   1, 957.68
INIP,   173,   173,   1, 905.72
INIP,   174,   174,   1, 906.77
INIP,   175,   175,   1, 823.07
INIP,   176,   176,   1, 806.09
INIP,   177,   177,   1, 753.55
INIP,   178,   178,   1, 691.81
INIP,   179,   179,   1, 655.00
INIP,   180,   180,   1, 624.47
INIP,   181,   181,   1, 616.93
INIP,   182,   182,   1, 555.00
INIP,   183,   183,   1, 545.03
INIP,   184,   184,   1, 529.67
INIP,   185,   185,   1, 475.00
INIP,   186,   186,   1, 519.80
INIP,   187,   187,   1, 474.64
INIP,   188,   188,   1, 535.90
INIP,   189,   189,   1, 475.10
INIP,   190,   190,   1, 536.58
INIP,   191,   191,   1, 502.51
INIP,   192,   192,   1, 505.00
INIP,   193,   193,   1,1105.00
INIP,   194,   194,   1,1039.13
INIP,   195,   195,   1, 999.50
INIP,   196,   196,   1, 902.35
INIP,   197,   197,   1, 857.94
INIP,   198,   198,   1, 801.28
INIP,   199,   199,   1,1275.00
INIP,   200,   200,   1,1275.00
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INIP,     64,     64,     1, 488.50
INIP,     65,     65,     1, 491.61
INIP,     66,     66,     1, 493.07
INIP,     67,     67,     1, 505.00
INIP,     68,     68,     1, 483.87
INIP,     69,     69,     1, 481.58
INIP,     70,     70,     1, 483.02
INIP,     71,     71,     1, 484.51
INIP,     72,     72,     1, 424.81
INIP,     73,     73,     1, 482.53
INIP,     74,     74,     1, 481.39
INIP,     75,     75,     1, 480.93
INIP,     76,     76,     1, 482.58
INIP,     77,     77,     1, 485.83
INIP,     78,     78,     1, 445.46
INIP,     79,     79,     1, 479.57
INIP,     80,     80,     1, 479.05
INIP,     81,     81,     1, 480.81
INIP,     82,     82,     1, 477.02
INIP,     83,     83,     1, 477.02
INIP,     84,     84,     1, 478.83
INIP,     85,     85,     1, 483.73
INIP,     86,     86,     1, 490.65
INIP,     87,     87,     1, 492.74
INIP,     88,     88,     1, 459.00
INIP,     89,     89,     1, 475.00
INIP,     90,     90,     1, 478.14
INIP,     91,     91,     1, 476.82
INIP,     92,     92,     1, 478.37
INIP,     93,     93,     1, 482.30
INIP,     94,     94,     1, 445.91
INIP,     95,     95,     1, 462.98
INIP,     96,     96,     1, 479.72
INIP,     97,     97,     1, 479.83
INIP,     98,     98,     1, 483.70
INIP,     99,     99,     1, 488.48
INIP,    100,    100,     1, 505.00
INIP,    101,    101,     1, 505.00
INIP,    102,    102,     1, 355.00
INIP,    103,    103,     1, 355.00
INIP,    104,    104,     1, 286.53
INIP,    105,    105,     1, 215.00
INIP,    106,    106,     1, 251.26
INIP,    107,    107,     1, 265.34
INIP,    108,    108,     1, 272.34
INIP,    109,    109,     1, 284.80
INIP,    110,    110,     1, 345.24
INIP,    111,    111,     1, 397.34
INIP,    112,    112,     1, 443.27
INIP,    113,    113,     1, 467.16
INIP,    114,    114,     1, 230.38
INIP,    115,    115,     1, 249.60
INIP,    116,    116,     1, 255.70
INIP,    117,    117,     1, 271.72
INIP,    118,    118,     1, 326.90
INIP,    119,    119,     1, 379.12
INIP,    120,    120,     1, 426.07
INIP,    121,    121,     1, 905.00
INIP,    122,    122,     1, 797.53
INIP,    123,    123,     1, 828.81
INIP,    124,    124,     1, 955.00
INIP,    125,    125,     1, 901.29
INIP,    126,    126,     1, 866.35
INIP,    127,    127,     1, 720.13
INIP,    128,    128,     1, 502.76
INIP,    129,    129,     1, 330.05
INIP,    130,    130,     1, 298.55
INIP,    131,    131,     1, 237.37
```

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INIQ,  100, 100,  1,  -2600
INIQ,  101, 101,  1,  -2600
INIQ,  191, 191,  1,  -880
INIQ,  192, 192,  1,  -880
INIQ,  230, 230,  1,  -550
*
*
*    ---  AQUIFER CONSTANTS  ---
*
*      K : COEFFICIENT OF INFILTRATION CAPACITY
*      S : COEFFICIENT OF STORAGE
*
*                SYMBOL OF      K        S
*                AQUIFER
*
LAYE,  35
                 GRSF,          0.00001,  0.00001
                 AQ01,         10.0,      0.20
                 AQ02,          8.0,      0.197
                 AQ03,          6.0,      0.193
                 AQ04,          4.0,      0.187
                 AQ05,          2.0,      0.178
                 AQ06,          1.5,      0.174
                 AQ07,          1.0,      0.168
                 AQ08,          0.80,     0.165
                 AQ09,          0.60,     0.161
                 AQ10,          0.40,     0.156
                 AQ11,          0.20,     0.146
                 AQ12,          0.10,     0.137
                 AQ13,          0.09,     0.135
                 AQ14,          0.08,     0.134
                 AQ15,          0.07,     0.132
                 AQ16,          0.06,     0.130
                 AQ17,          0.05,     0.127
                 AQ18,          0.04,     0.124
                 AQ19,          0.03,     0.120
                 AQ20,          0.02,     0.115
                 AQ21,          0.01,     0.105
                 AQ22,          0.009,    0.104
                 AQ23,          0.008,    0.102
                 AQ24,          0.007,    0.100
                 AQ25,          0.006,    0.098
                 AQ26,          0.005,    0.096
                 AQ27,          0.004,    0.092
                 AQ28,          0.003,    0.088
                 AQ29,          0.002,    0.083
                 AQ30,          0.001,    0.073
                 AQ31,          0.0005,   0.064
                 AQ32,          0.0001,   0.042
                 AQ33           0.00005,  0.032
                 AQ34,          0.00001,  0.010
*
*
*    ----  GEOLOGICAL DATA ---
*
*
GENE
*
*
*
ENDD
```

```
INIP,     201,      201,        1,1156.49
INIP,     202,      202,        1,1255.00
INIP,     203,      203,        1,1105.25
INIP,     204,      204,        1,1110.75
INIP,     205,      205,        1,1036.18
INIP,     206,      206,        1,1063.57
INIP,     207,      207,        1, 971.61
INIP,     208,      208,        1, 999.81
INIP,     209,      209,        1, 913.17
INIP,     210,      210,        1, 855.00
INIP,     211,      211,        1, 787.98
INIP,     212,      212,        1, 808.41
INIP,     213,      213,        1, 727.28
INIP,     214,      214,        1, 772.27
INIP,     215,      215,        1, 692.83
INIP,     216,      216,        1, 745.00
INIP,     217,      217,        1, 706.96
INIP,     218,      218,        1, 740.77
INIP,     219,      219,        1, 653.76
INIP,     220,      220,        1, 657.41
INIP,     221,      221,        1, 605.00
INIP,     222,      222,        1, 694.76
INIP,     223,      223,        1, 745.00
INIP,     224,      224,        1, 597.91
INIP,     225,      225,        1, 681.21
INIP,     226,      226,        1, 745.00
INIP,     227,      227,        1, 589.20
INIP,     228,      228,        1, 679.51
INIP,     229,      229,        1, 745.00
INIP,     230,      230,        1, 555.00
INIP,     231,      231,        1, 735.00
*
INIP,    7,    7,  1,   945.00
INIP,   13,   13,  1,   950.00
INIP,   16,   16,  1,  1000.00
INIP,   37,   37,  1,  1030.00
INIP,   39,   39,  1,  1000.00
INIP,   40,   40,  1,   951.00
INIP,  102,  102,  1,   951.00
INIP,  103,  103,  1,   952.00
INIP,  121,  121,  1,   965.00
INIP,  122,  122,  1,   960.00
INIP,  124,  124,  1,   975.00
INIP,  136,  136,  1,   975.00
INIP,  139,  139,  1,  1027.30
INIP,  142,  142,  1,  1171.20
INIP,  150,  150,  1,  1202.50
INIP,  151,  151,  1,  1131.60
INIP,  155,  155,  1,  1052.50
INIP,  168,  168,  1,  1154.00
INIP,  169,  169,  1,  1072.00
INIP,  193,  193,  1,  1102.50
INIP,  199,  199,  1,  1272.50
INIP,  200,  200,  1,  1272.50
INIP,  202,  202,  1,  1302.50
*
INIQ,    4,    4,  1,  -600
INIQ,    5,    5,  1,  -600
INIQ,    6,    6,  1,  -600
INIQ,   12,   12,  1,  -600
INIQ,   29,   29,  1,  -600
INIQ,   30,   30,  1,  -600
INIQ,   32,   32,  1,  -400
INIQ,   33,   33,  1,  -400
INIQ,   34,   34,  1,  -600
INIQ,   35,   35,  1,  -600
INIQ,   36,   36,  1,  -600
INIQ,   58,   58,  1,  -600
INIQ,   67,   67,  1,  -600
```

PART 6 PLOTTER OPERATION GUIDANCE

PART 5 PLOTTER OPERATION GUIDANCE

CONTENTS

PAGE

1. CONFIDENCE PLOT

Procedure

(1) Insert the pens into the pen turret
(2) Load the pen turret
(3) Power on
(4) Raise the plotter cover
(5) Pinch roller up
(6) Set the paper
(7) Pinch roller down
(8) Lower the plotter cover

(9) Press the " Manual " soft key

.

.

(Sizing media)

.

.

(10) Press " NEXT " key
(11) Press " NEXT " key
(12) Press " Test " soft key
(13) Press " Conf Plot " soft key

.

.

(Plotting)

.

.

(Plot finished)

(14) Raise the cover
(15) Pinch roller up
(16) Remove the paper
(17) Pinch roller down
(18) Lower the cover

2. PLOT THE DRAWING (UNISSF2)

Procedure

(1) Insert the pens into the pen turret

(2) Load the pen turret

(3) Power on

(4) Raise the plotter cover

(5) Pinch roller up

(6) Set the paper

(7) Pinch roller down

(8) Lower the plotter cover

(9) Press the " Manual " soft key

.

.

(Sizing media)

.

.

.

(Sizing finished)

*** Plot origin can be moved by using arrow key at this step

(10) Press " Online " soft key

*** If the message " Plot Complete " is shown in the display of the plotter, go to step (11) of 4)

(11) Send the plot data from the VAX

*** Check the drawing size to be fit to the paper size

1) $ UNISSF [enter]

2) UNISSF < M >
UNISSF2/G < G >
UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> X [enter]

3) FILENAME : FOR040.DAT

.
.
.

(Plotting)

.
.
.

*** If there are more than 2 drawings, the plotting is stopped and the message '**HALT RECIEVED...**' is shown in the plotter window when each drawing is finished. Replace the paper. After sizing paper, press '**On-line**' soft key.

[Repeat the procedure (4) to (10)]

.
.
.

(Sizing media and plot restarted)

.
.
.

4) UNISSF < M >
UNISSF2/G < G >

UNISSF2/P < P >
DISPLAY < D >
XYPLOT < X >

PLEASE ENTER ---> E [enter]

(11) Raise the cover
(12) Pinch roller up
(13) Remove the paper

(14) Pinch roller down
(15) Lower the cover

3. PLOTTER SETTING (CONNECTING WITH VAX 8200)

(1) Plotter Side

Format	PCI
Baud Rate	9600
Byte Length	8 bit
Stop Bits	1
Parity	None
Handshake	Ack/Nak
Sync Character	2
No. of Sync Character	1
End Message Character	3
Checksum	disabled
Plot Manager	disabled

Note : The Setting above is already fixed in the data set of " User 1 ".

(2) VAX Side (Connection though DEC server)

A. DEC Server Port Setting

Note : The port setting is already fixed for the DEC Server placed in the 7th floor of WAJ.

1) Port setting

Local > set priv
Password > system

(Server Name : WATER7)

Local > define port 2 access remote
Local > define port 2 autobaud disable break disable
Local > define port 2 speed 9600
Local > define port 2 name port_2
Local > define port 2 type soft
Local > define port 2 autoconnect disable
Local > define port 2 autoprompt disable
Local > define port 2 broadcast disable

Local > set port 2 access remote
Local > set port 2 autobaud disable break disable
Local > set port 2 speed 9600
Local > set port 2 name port_2
Local > set port 2 type soft
Local > set port 2 autoconnect disable
Local > set port 2 autoprompt disable
Local > set port 2 broadcast disable
Local > logout port 2

2) DEC server power off

3) DEC server power on and confirm the setting

Local > show port 2

Port 2 : (Remote)

Character Size :	8	Input Speed :	9600
Flow Control :	XON	Output Speed :	9600
Parity :	None		
Access :	Remote	Local Switch :	None
Backwards Switch :	None	Name :	Port_2
Break :	Disabled	Session Limit:	2
Forwards Switch :	None	Type :	Soft

Preferred Service : None

Authorized Groups : 0
(Current Groups) : 0

Enable Characteristics :

Input Flow Control, Loss Notification, Message Codes,
Output Flow Control, Verification

B. Device Setting (LTA5:)

Note : If VAX 8200 is stopped and restarted again, the command procedure of " CALCOMP7F.COM " is also to be executed again.

File " CALCOMP7F.COM " is already prepared in the following directory.

. DUA0:[JICA]

1) Create command procedure " CALCOMP7F.COM "

FILE : CALCOMP7F.COM

```
$ run sys$system:latcp
create port LTA5: /nolog
set port LTA5: /application /node=WATER7 /port=PORT_2
exit
$ set terminal/perm/speed=9600/width=128/page=24/interactive-
/nohostsync/wrap/eightbit/fulldup/nohangup/noecho-
/ttsync/scope/nobroadcast/nomodem/nobrdcstmbx/noansi-
/noedit/typeahead/lowercase/noreadsync/nolocal_echo-
/nodma/noregis/nodec_crt/noescape/notab/noholdscreen-
/noform/noautobaud/noblock_mode/device_type=unknown-
LTA5:
$ set protect=w:rwlp/dev LTA5:
```

2) Execute the command procedure " CALCOMP7F.COM " by System Manager

```
$ SET DEF [JICA]
$ @CALCOMP7F
```

3) Confirm the setting of LTA5:

```
$ show term  LTA5:
```

```
Terminal : _LTA5:        Device_Type : Unknown   Owner : No Owner

Input : 9600             LFfill : 0     Width : 128          Parity : None
Output: 9600             CRfill : 0     Page  :  24
```

Terminal Characteristics :

Interactive	No Echo	Type_ahead	No Escape
No Hostsync	TTsync	Lowercase	No Tab
Wrap	Scope	No Remote	Eightbit
No Broadcast	No Readsync	No Form	Fulldup
No Modem	No Local_echo	No Autobaud	No Hangup
No Brdstmbx	No Dma	No Altypeahead	Set_speed
No Line Editing	Overstrike Editing	No Fallback	No Dialup
No Secure Server	No Disconnect	No Pasthru	No Syspassword
No SIXEL Graphics	No Soft Characters	No Printer Port	Numeric Keyboard
No ANSI_CRT	No Regis	No Block_mode	No Advanced_video
No Edit_mode	No DEC_CRT	No DEC_CRT2	No DEC_CRT3

4. Cable Connection

Plotter Side		Cable (pin to pin)				VAX Side (DEC Server)
25 pin female	<---	25 pin male	-------	25 pin female	---->	25 pin male