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A Groundwater Model of Cache Valley, Utah

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ABSTRACT

This report describes the development, calibration and use of a quantitative, predictive management model for the groundwater in the Utah portion of the Cache Valley in northern Utah. The quasi-three-dimensional finite difference computer model was adapted from the U.S. Geological Survey's Trescott and Larson model and simulates the groundwater levels and flows in the groundwater basin. The variable spacing grid system is 23 nodes x 38 x 2 and represents the complex natural system by a simpler approximation with one unconfined and one confined aquifer and the appropriate boundary and initial conditions. River nodes, spring nodes, and constant head nodes were developed to simulate the real interactions of the aquifers with streams, springs, and reservoirs. Evapotranspiration from the land surface is also represented by the program. The program was calibrated by adjusting the model parameters such as transmissivity, storativity, leakance, river nodes, spring nodes, etc. until the predicted values of head and flow were nearly the same as the observed conditions. Calibration was done in two stages: first a steady-state comparison with 1969 conditions and then a transient-state comparison with the water level change maps of 1969 to 1972. The calibrated model was then exercised to predict the groundwater system response to various assumed scenarios of groundwater recharge and draft. Thus the model provides a tool to guide future groundwater development and management towards the best alternatives.

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TABLE OF CONTENTS

	Page
INTRODUCTION	1
GROUNDWATER CONDITIONS IN CACHE VALLEY IN UTAH	3
Geology	3
Hydrology and Climatology	5
Groundwater Budget Analysis	5
Groundwater Conditions by Areas	6
Smithfield-Hyrum-Wellsville area	7
Little Bear River area south of Hyrum	7
Wellsville to Newton area	8
Lower Little Bear-Benson-the Barrens area	8
Cub River subvalley area	8
Fairview-Lewiston-Trenton area	8
Weston Creek subvalley area	8
MODEL DESCRIPTION	11
Computer Program	11
Selection of Model Grid System	13
Parameters	15
Boundary conditions and recharges	15
Initial water levels for the confined aquifer	16
Initial water levels for the unconfined aquifer	19
Transmissivity of the confined aquifer	19
Hydraulic conductivity of the unconfined aquifer	21
Storage coefficient	21
Leakance	21
Bottom elevation of water table unit	25
River node leakage	25
Spring nodes leakage	26
Evapotranspiration	26
Pumpage	28
MODEL CALIBRATION	31
Steady-State Calibration	31
Transient-State Calibration	32

TABLE OF CONTENTS (Continued)

	Page
USE OF THE MODEL FOR MANAGEMENT PURPOSES	45
SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS	51
REFERENCES	55
APPENDICES	57
Appendix A: Computer Program Listing	57
Appendix B: Program Input Data Documentation . . .	75
Appendix C: Model Input Data of Transient-state Calibration of March 1969	87
Appendix D: Model Output of Transient-state Calibration of March 1969	99
Appendix E: Steady-state Drawdown Difference Map . .	113

LIST OF FIGURES

Figure		Page
1.	Location of Cache Valley, Utah and Idaho, and the Cache Valley drainage basin	4
2.	Relation of confined, unconfined, and perched groundwater in Cache Valley	6
3.	Map showing groundwater areas in the Cache Valley, Utah model	8
4.	Model grid system and boundaries	14
5.	Nodes of recharge wells (constant finite-flux boundaries) for layer 1 (confined aquifer) . . .	17
6.	The observed potentiometric surface contour map of the confined aquifer of March 1969 . . .	18
7.	The observed water level contour map of the water-table aquifer for March 1969	20
8.	Transmissivity of the confined aquifer resulting from calibration of the model	22
9.	Hydraulic conductivity of the unconfined aquifer resulting from calibration	23
10.	Storage coefficient value of the confined aquifer resulting from calibration	24
11.	Location of river nodes, spring nodes, and constant head nodes	27
12.	The linear relationship between the evapotranspiration and the depth below the land surface	28
13.	Total number of "small" wells within each grid cell	29
14.	Calculated steady-state water level contour map of confined aquifer	33
15.	Calculated steady-state water level contour map of unconfined aquifer	34

LIST OF FIGURES (Continued)

Figure		Page
16.	Calculated water level contour map of confined aquifer of March 1969	35
17.	Calculated water level contour map of unconfined aquifer of March 1969	36
18a.	Observed water level change map of confined aquifer from March 1969 to March 1970	37
18b.	Calculated water level change map of confined aquifer from March 1969 to March 1970	38
19a.	Observed water level change map of confined aquifer from March 1970 to March 1971	39
19b.	Calculated water level change map of confined aquifer from March 1970 to March 1971	40
20a.	Observed water level change map of confined aquifer from March 1971 to March 1972	41
20b.	Calculated water level change map of confined aquifer from March 1971 to March 1972	42
21a.	Comparison between computed and observed water level changes in selected wells	43
21b.	Comparison between computed and observed water level changes in selected wells	44
21c.	Comparison between computed and observed water level changes in selected wells	44
22.	Water level change map of confined aquifer of predictive simulation 1	47
23.	Water level change map of confined aquifer of predictive simulation 2	48
24.	Water level change map of confined aquifer of predictive simulation 3	49

LIST OF TABLES

Table Page

1. Groundwater budget analysis, Cache Valley, Utah 7

2. New well locations and pumping rates for three predictive simulations 45

INTRODUCTION

Groundwater is potentially a major source of water supply in Cache Valley, Utah and Idaho; but presently it is only lightly utilized. Mostly surface water has been used in the past, but as the demand for water is increased by a rapidly expanding population, more industries, and increased irrigation, the groundwater resource will be more fully developed. For planning and management during this development period, knowledge of the groundwater systems must be expanded.

Numerical modeling provides a quantitative tool for groundwater management applications. It helps structure our understanding of groundwater systems and can be used in studying groundwater problems. A model mathematically describes aquifer behavior and is used to simulate aquifer response to various well locations and pumping rates. The methods and tools presented in this study are applicable to similar groundwater problems in other locations of Utah and elsewhere.

This report describes application of a quasi-three-dimensional finite-difference computer model to simulate the groundwater levels and flows in the Utah portion of the Cache Valley, a major groundwater basin in Utah. Cache Valley was selected for the study because an operational groundwater model is needed during the developmental period to help state officials evaluate proposed withdrawals from the groundwater basin as well as possible recharge methods and other management schemes. From information obtained by modeling, development can be guided towards more complete and economic utilization of groundwater in conjunction with surface water resources.

The computer program used is the U.S. Geological Survey's Trescott and Larson Model (1975, 1976). Some modifications were made to this program in order to adapt the model to the groundwater conditions in Cache Valley.

Due to funding limitations and lack of participation by Idaho agencies, this model study includes only the Utah portion of Cache Valley. The northern boundary of the area modeled is at the Utah-Idaho state line, but boundary conditions were generated to represent the groundwater inflow from Idaho into Utah.

GROUNDWATER CONDITIONS IN CACHE VALLEY IN UTAH

Cache Valley is a north-south oriented structural valley in northeastern Utah and southeastern Idaho (Figure 1). Cache Valley is surrounded by mountains which consist of the Bear River Range on the east, the Bannock, Malad, and Wasatch Ranges on the west, the Portneuf Range on the north, and South Hills on the south. The valley floor, which ranges in altitude from about 4,400 to 5,400 feet above mean sea level, is approximately 60 miles long and mostly 8 to 16 miles wide. Of the approximately 660 square miles in the valley, about 365 are in Utah and 295 are in Idaho. The floor is a low flat plain bordered by gentle alluvial slopes, terraces, and deltas left by ancient Lake Bonneville, and alluvial fans (Bjorklund and McGreevy 1971). The Cache Valley drainage basin, a segment of the Bear River Basin, includes approximately 1,840 square miles, with about 1,180 in Utah and 660 in Idaho, mostly of mountainous terrain.

Geology

Cache Valley is bounded by north-striking, high angle normal faults and is composed of downthrown fault blocks covered by deposits of Cenozoic age. In parts of the valley, the maximum vertical displacement of the fault blocks probably exceeds 10,000 feet. A gravity survey of Cache Valley indicates a maximum thickness of Cenozoic rocks of about 8,000 feet. The bedrock of the Cache Valley watershed consists of Precambrian, Paleozoic, and Tertiary rocks of limestone and dolomite, shale, sandstone and conglomerate, quartzite and phyllite, and volcanic tuff (Bjorklund and McGreevy 1971 and Beer 1967).

Cache Valley was a bay of ancient Lake Bonneville during a part of Pleistocene time. The name "Lake Bonneville" is given to the lake that occupied the basin during the last major glacial state, the Wisconsin, which began about 75,000 years ago (Bjorklund and McGreevy 1971). The valley fill deposits include unconsolidated quaternary, clastic sediments of gravel, sand, silt, and clay, which were derived from the surrounding watershed, and precipitates accumulated in former Lake Bonneville. The pre-Lake Bonneville, Lake Bonneville, and post-Lake Bonneville group of sediments of the Quaternary age form the Cache Valley fill. (See the geologic map and section on Plate 4 of Bjorklund and McGreevy 1971.) The alluvial fan gravels of the pre-Lake Bonneville deposits are exposed along the foothills on both east and west sides of the valley, particularly at the mouth of Blacksmith Fork and Logan Canyons. The Lake Bonneville group is divided into the Alpine, Bonneville, and Provo formations. Each represents deposits of Lake Bonneville at different stages, consisting of lacustrine gravel, sand, silt and clay, that are exposed extensively throughout the valley floor. The Provo formation includes an older gravel and sand member, and a younger silt and clay member. The gravel and sand member forms many deltas, bars, and spits. These deltas form important groundwater recharge zones in Cache Valley. The post-Lake Bonneville deposits consist of slope wash and flood-plain alluvium, and high-level alluvial fan gravels deposited along the mountain fronts, and overlie the silt and clay member of the Provo formation. The sandy flood-plain alluvium is exposed along the major streams of the valley, particularly the

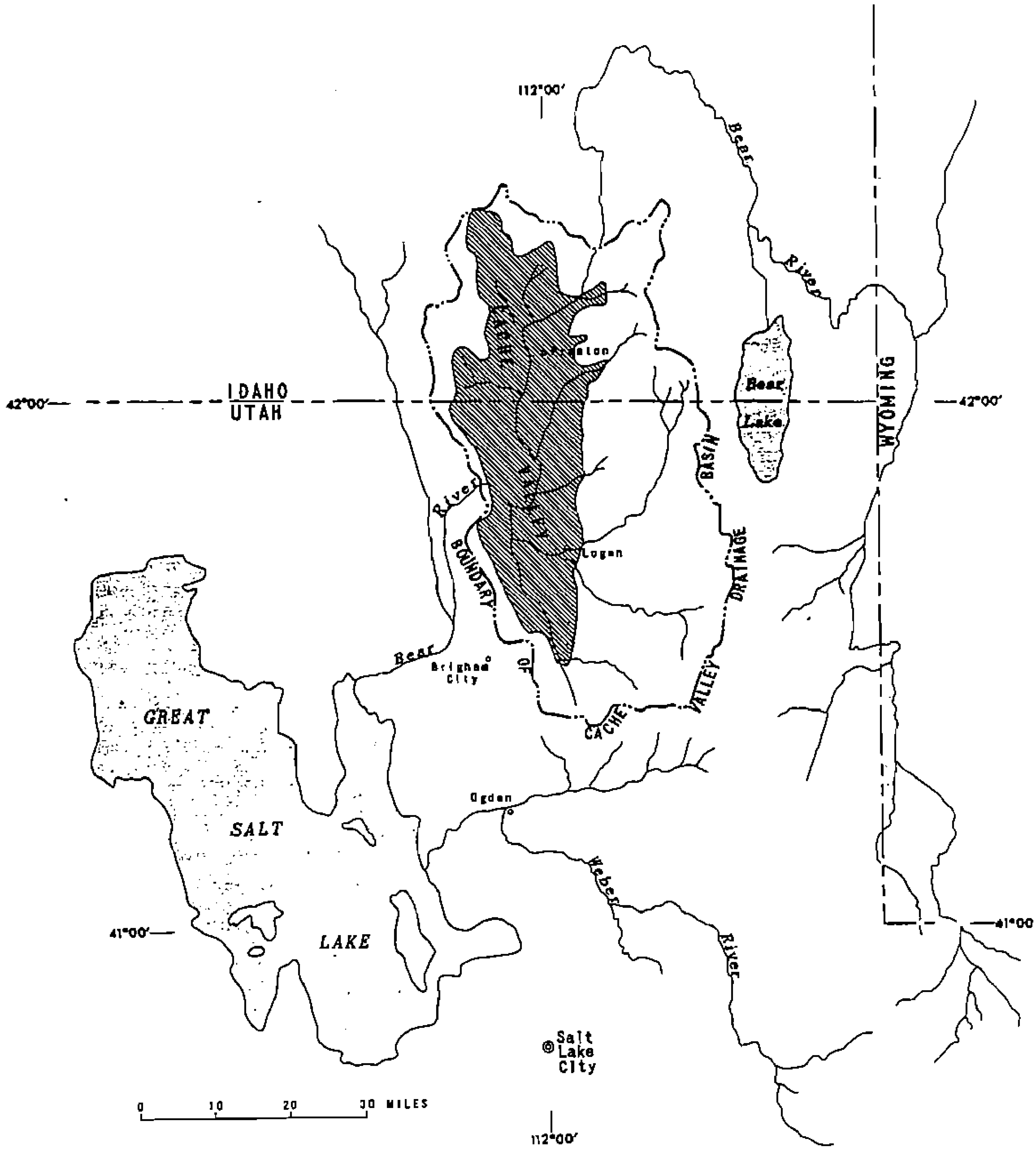

Figure 1. Location of Cache Valley, Utah and Idaho, and the Cache Valley drainage basin (from Bjorklund and McGreevy 1971).

Bear, Cub, Little Bear, and Logan Rivers. The slope wash is exposed on the west side of the valley near Trenton, and along the south flank of the valley near Wellsville and consists of silts and sands (Beer 1967). Two referenced reports by Williams (1958, 1962) give more geologic details about Cache Valley.

In Cache Valley, deposits related to Lake Bonneville and earlier lakes play an important role in the occurrence of groundwater and the many related topographic features affect the occurrence and movement of groundwater.

Hydrology and Climatology

The best sources of groundwater in Cache Valley are from the unconsolidated deposits. Some locations have a water table and others artesian conditions. The general relation of confined, unconfined, and perched groundwater in Cache Valley is illustrated in Figure 2. The diagram directly represents conditions near Logan, Utah, and generally applies to the entire valley (Bjorklund and McGreevy 1971).

Confined groundwater underlies more than 200 square miles in Cache Valley and occurs in those locations where permeable water-bearing aquifers of sand and gravel are overlain by relatively impermeable beds of lake-bottom clay and silt. Within about 130 square miles of the area, the artesian pressure is great enough to force water above the land surface, causing wells to flow. Only a few square miles of this area are in Idaho, most are located in Utah (Bjorkland and McGreevy 1971, plate 3). The confining beds retard upward movement of the water and maintain it under artesian pressure caused by the higher elevations of the recharge areas along the sides of the valley. The confining beds are partially permeable, however, and the groundwater must be modeled as occurring under leaky-aquifer conditions.

Along the mountain fronts near the margins of Cache Valley, the groundwater is unconfined along a narrow strip where the confining beds that overlie the principal aquifers are discontinuous or absent. The boundary of the confining layer is generally gradational rather than abrupt.

In most of the area of flowing wells, a water table in an aquifer above the confining layer is near the land surface. The shape and the slope of the water table is generally about the same as that of the land surface. Local perched groundwater bodies are also common in many parts of Cache Valley. They develop above the main water table where beds of clay or other materials of low permeability intercept water percolating downward (see Figure 2). Some of the perched groundwater bodies are seasonal and poorly defined. Their water is generally not tapped by wells, but perched water is often encountered when drilling wells on the alluvial slopes and fans and in excavations for construction (Bjorklund and McGreevy 1971).

The well-defined seasons (warm and wet springs, warm and dry summers, cool and wet autumns, cold and damp winters), large daily temperature changes, and moderate precipitation are characteristics of the climate of the Cache Valley. The growing season ordinarily lasts about 150 days from May through September. Snow usually covers the valley floor during December, January, and February. The valley normally receives 10 to 20 inches of precipitation annually, and 20 to 50 inches fall in the mountainous area surrounding the valley. The runoff usually has its maximum volume during May or June and results mostly from melting snow which accumulated during the winter on the surrounding mountains (Bjorklund and McGreevy 1971 and Beer 1967).

Groundwater Budget Analysis

Over any finite period of time, the quantity of water entering Cache

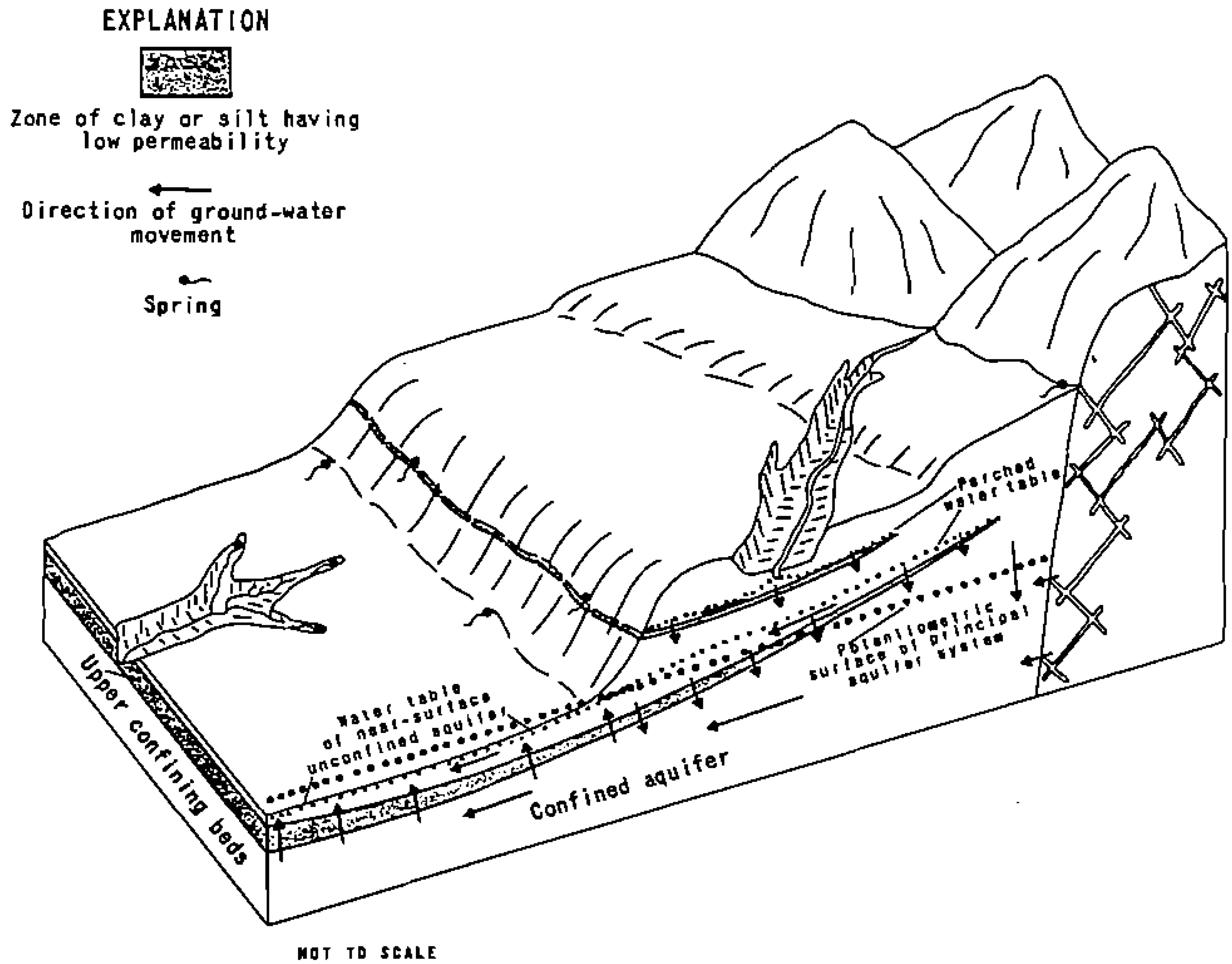

Figure 2. Relation of confined, unconfined, and perched groundwater in Cache Valley (from Bjorklund and McGreevy 1971).

Valley is equal to the quantity leaving the valley plus or minus the change in storage within the valley. Since much of the groundwater reservoir in Cache Valley is overflowing, and the change in groundwater storage over the years has been small or negligible, the total recharge in Cache Valley is about equal to the total discharge and is estimated to be about 280,000 acre-feet per year (Bjorklund and McGreevy 1971). The Utah portion, estimated from the model calibration of this project, is about 170,000 acre-feet annually. Items of inflow and outflow of groundwater are given in Table 1. Deep subsurface outflow from Cache Valley is negligible.

Groundwater Conditions by Areas

Bjorklund and McGreevy (1971) used land use data (see their plate 4) along with geologic and hydrologic conditions to subdivide Cache Valley into 11 principal areas of generally similar groundwater conditions as shown in their Figure 13. Seven of those areas are within the model region as shown in Figure 3. The boundaries are not sharply distinct, and the areas blend into each other. The dotted lines which delimit the areas are not lines of separation but approximations of where general conditions change. Outside of these areas, groundwater occurs locally

Table 1. Groundwater budget analysis, Cache Valley, Utah.

	Utah & Idaho (USGS) (acre-feet)	Utah (acre-feet)
<u>Recharge</u>		
Seepage from Irrigation System	100,000*	72,000
Subsurface Inflow	32,000*	18,000
Seepage from Streams and Infiltration of Rainfall	148,000	80,000
Total	280,000*	170,000
<u>Discharge</u>		
Pumpage (from Wells)	29,000*	24,000
Evapotranspiration	108,000*	63,000*
Accretion of Groundwater to Streams Rivers and Springs	143,000	83,000
Total	280,000*	170,000

*From Bjorklund and McGreevy (1971); other amounts are estimated from the groundwater modeling in this study.

in slope wash and alluvium, in sandstone and conglomerate of the Salt Lake formation, and in fracture and solution openings in older rocks.

The above information on areas of similar groundwater conditions was helpful at an early stage of the study in setting up the simulation model and estimating some parameters, especially for the values of transmissivity and hydraulic conductivity of different aquifer systems. Brief descriptions of the areas of similar groundwater conditions in Cache Valley in Utah are excerpted from Bjorklund and McGreevy (1971) and given below.

<u>Smithfield-Hyrum-Wellsville area</u>

Coarse fan and delta deposits of Summit Creek, Logan River, Blacksmith Fork, and Little Bear River coalesce to form this complex aquifer system in the Smithfield-Hyrum-Wellsville area in Utah (area 1, Figure 3). This aquifer system is the largest and most productive in Cache Valley and is an overflowing groundwater basin where the shallow water table is so high that groundwater flows from many seeps and springs into the surface water streams. The system is very permeable, and the transmissivity ranges from 10,000 to 330,000 ft^2 per day. Both confined and unconfined aquifers are present.

<u>Little Bear River area south of Hyrum</u>

This unconfined aquifer system extends southward from Hyrum along the flood-plain and terraces of the Little Bear River (area 2, Figure 3). The groundwater recharge is mostly by seepage from streams and canals and from irrigation. The thin aquifer is very permeable and the estimated transmissivities are up to about 15,000 ft^2 per day.

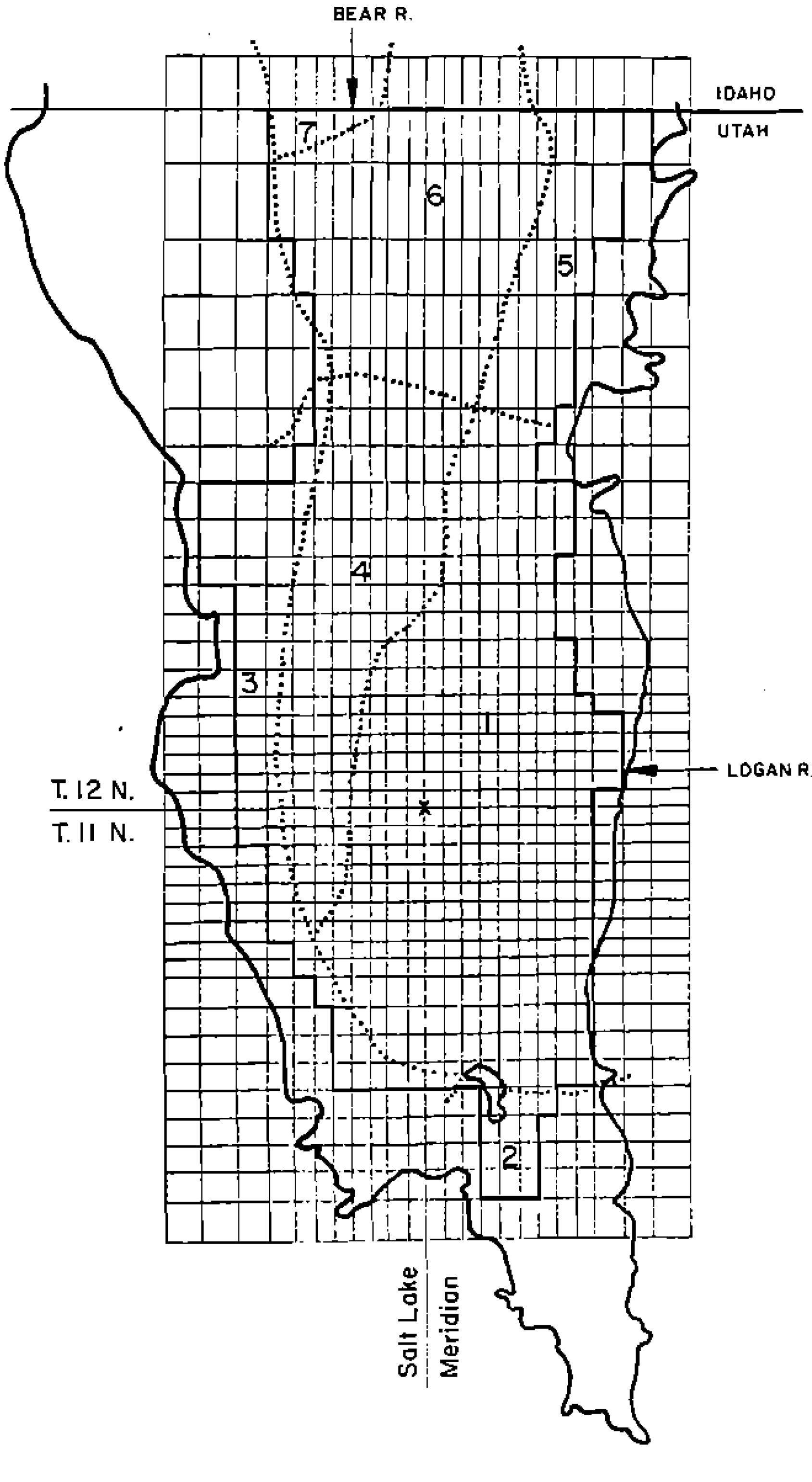

Figure 3. Map showing groundwater areas in the Cache Valley, Utah model.

Wellsville to Newton area

Groundwater conditions are poorly known in this area which lies along the west side of Cache Valley from southeast of Wellsville to near Newton (area 3, Figure 3). Groundwater is both confined and unconfined. The fill is predominantly low permeability and fine grained, but it includes some permeable sands and gravels.

Lower Little Bear River-Benson-the Barrens area

This area is in the central part of Cache Valley along the lower part of the Little Bear river and near Benson and the Barrens (area 4, Figure 3). The Quaternary deposits are predominantly clay and silt but have thin beds of sand and fine gravel that contain confined groundwater. In most of this area, artesian pressures are high, and heads as much as 62 feet above the land surface have been measured. The hydraulic connection between the water-producing beds is poor.

Cub River subvalley area

This aquifer system extends along the Cub River from near Franklin to a few miles south of Richmond (area 5, Figure 3). The groundwater is mostly confined and some wells flow. Transmissivities probably range from about 1,000 to 4,000 ft^2 per day in most of the area. The gravel deposits of the Cherry Creek and High Creek alluvial fans are thicker, and their transmissivities are higher.

Fairview-Lewiston-Trenton area

The reworked sand and silt deposited from near Fairview to Cutler Reservoir, as the Bear River eroded into its delta near Preston, formed this principal water-bearing material in the area from near Fairview and Lewiston to near Trenton (area 6, Figure 3). Groundwater is unconfined and is near the land surface. The transmissivity is probably less than 1,000 ft^2 per day. Potentially productive aquifers may lie beneath the delta deposits in the older deposits, but they have not been explored east of the present Bear River channel.

Weston Creek subvalley area

This is one of the major aquifer systems in the Idaho part of Cache Valley (area 7, Figure 3), and a small portion extends into Utah. The groundwater is both confined and unconfined. The transmissivity is estimated to be about 30,000 ft^2 per day in the area southeast of Weston. The proportion of permeable water-bearing materials decreases southward and eastward from near Weston.

MODEL DESCRIPTION

A groundwater model represents the heads, flows, and hydraulic losses in a geologic environment with equations containing hydrologic and hydraulic parameters. Computer solution is used to simulate the response of the groundwater system to natural conditions and human development.

Flow in a porous saturated medium in three dimensions may be expressed by the partial differential equation

$$\frac{\partial}{\partial x}\left(K_{xx}\frac{\partial h}{\partial x}\right) + \frac{\partial}{\partial y}\left(K_{yy}\frac{\partial h}{\partial y}\right) + \frac{\partial}{\partial z}\left(K_{zz}\frac{\partial h}{\partial z}\right) = S_s\frac{\partial h}{\partial t} + w(x,y,z,t) \qquad (1)$$

where h is the hydraulic head [L] at time, t, K_{xx}, K_{yy}, K_{zz} are the principal components of the hydraulic conductivity tensor aligned with the coordinate axes [L/t], S_s is the specific storage [1/L], x, y, z are the coordinate directions [L], and w(x,y,z,t) is a source term for inflow or withdrawal per unit volume of an aquifer. In most cases, analytical solution is not possible for Equation 1. However, a variety of numerical techniques have been developed for use with high-speed digital computers to approximate solutions of partial differential equations. These methods have greatly enhanced capabilities for modeling groundwater flow. The computer program applied in this study uses finite-difference approximations to solve Equation 1.

Computer Program

The finite-difference and finite-element methods are the two major numerical techniques used to obtain approximate solutions. Most of the available groundwater model computer codes are based on one of these two methods.

Because numerous groundwater computer programs are available today, the first question in beginning a study is, "Which one should be used?" Considerable effort was spent to find a general program which could be easily adapted to portray the Cache Valley groundwater systems. Because of the complex geologic situation in Cache Valley, a three-dimensional model is preferred. Two tested three-dimensional models were available when the study began; one from USGS using the finite-difference method (Trescott 1975 and Trescott and Larson 1976), and the other from the University of California, Davis, using the finite-element method (Gupta et al. 1975).

The finite-element method reproduces the complex geometry of groundwater aquifers more conveniently and more accurately. Often it requires fewer nodal points to represent the discretized aquifer to the same level of accuracy, thus cutting down on storage, execution and input/output costs (Townley and Wilson 1980). However, when this project began, the finite-element computer codes were in somewhat early stages of development. Further work on accuracy, numerical stability and convergence properties, and its consistency with the physical system was needed. On the other hand, the finite-difference program from the USGS was well-documented and easily available to the user. Most important, this code has been widely used and continuously improved to accommodate various computer systems. After comparing the two, it was decided to use the codes from USGS which are based on the finite-difference method.

The USGS computer program as documented by Trescott (1975) and Trescott and Larson (1976) permits the use of variable grid spacing and uses the strongly implicit procedure (SIP) to solve simultaneously the set of equations which results from the finite difference equation at each grid point in the context of the appropriate boundary and initial conditions over the region of interest. The porous medium in which the flow is to be simulated may be heterogeneous and anisotropic and have irregular boundaries. One or more layers of nodes can be used to simulate each hydrogeologic unit. The uppermost hydrologic unit may have a free surface. Stress on the system may be in the form of well discharge (or recharge) and recharge from precipitation. Changes were made in the program to adapt it for use in the Cache Valley model. For example, river nodes and spring nodes were developed to represent the actual rivers and springs and evapotranspiration simulation was programmed for use in appropriate areas of the model.

Later on the 1983 version of the three-dimensional finite-difference groundwater simulation program was obtained from the USGS. In this improved version the programming has been modified to give increased capability and to be easier to understand. Because of the very large amount of input data needed for groundwater simulation, the USGS streamlined the method to handle the input data. Input to the program is specified in independent files, one basic package with 12 major options. For example: recharge, rivers, drains, and evapotranspiration are major options handled by separate packages (McDonald 1982). Each option has its own input file. A given file is needed only if the corresponding major option is going to be used and is specified by the user.

The Drain package and River package of the 1983 USGS model perform the same function as the spring nodes and river nodes adapted by the project for use in the Cache Valley model. The evapotranspiration package of the USGS model defines a linear relationship between the evapotranspiration rate and the depth below the land surface just as is used in the Cache Valley model (see Figure 12). Two additional solution packages for Equation 1 are included besides the SIP package of the earlier versions. The SSOR package uses the sliced-successive overrelaxation method. The DE4 package, uses a direct solution method, but can only be used for two-dimensional models (one aquifer layer). Thus, the new version of the program has improvements that make it easier and faster to use and make its basic capabilities much the same as used in the Cache Valley model.

The large number of arithmetic calculations and the excessive computer storage required for numerical solution of the three-dimensional groundwater flow equations of multiple aquifer systems usually precludes solving the equations in three dimensions. To adequately represent transient flow in multiple layers, each layer must be represented by a number of nodes. This greatly increases the number of nodes used to represent the system as well as the computer time required for solution. When the hydrologic system can be represented by aquifers in which flow is assumed to be only horizontal between confining layers in which flow is assumed to be only vertical, the fully three-dimensional problem is reduced to a quasi three-dimensional problem by eliminating the layers of nodes representing the confining beds. One can then solve the two-dimensional equations for each aquifer with the aquifers being coupled through their vertical leakage (Bredehoeft and Pinder 1970). In the Cache Valley model, each hydrologic unit is represented by one layer of nodes. For this approach, Equation 1 is multiplied by b, the thickness of the unit, becomes

$$\frac{\partial}{\partial x}(T_{xx}\frac{\partial h}{\partial x}) + \frac{\partial}{\partial y}(T_{yy}\frac{\partial h}{\partial y} + b\frac{\partial}{\partial z}(K_{zz}\frac{\partial h}{\partial z})$$

$$= s\frac{\partial h}{\partial t} + bw(x,y,z,t) \qquad (2)$$

where

T_{xx}, T_{yy} are transmissivity tensor $[L^2/T]$

s is the storage coefficient [dimensionless]

For a quasi three-dimensional model, the third term in Equation 2 is replaced by the flow through the confining layer into or out of the adjacent aquifer and is given by

$$q = -\frac{K}{L}(h_{(i,j,k+1)} - h_{(i,j,k)}) \qquad (3)$$

where

K is the hydraulic conductivity of the confining layer [L/t]

L is the thickness of the confining layer [L]

h is the hydraulic head in aquifer [L]

k is the index in the z direction

This quasi three-dimensional model minimizes the computer-memory required for the simulation.

Selection of Model Grid System

The construction of the grid system for the model required considerable effort because of the complex geologic conditions in Cache Valley. As a first step in gaining understanding of the groundwater and subsurface geology, a "peg" model of the basin was constructed on the assembled 1:25,000 topographic maps utilizing the best well logs from the files of the Logan District Office of the Utah Water Rights Division and from the selected hydrologic data reported by McGreevy and Bjorklund (1970) for Cache Valley. Each peg represented one well with information on well depth, well yield, water level, and stratigraphic information. Additional information on geohydrologic sections in Cache Valley, Utah and Idaho, came from a USGS open file report (McGreevy and Bjorklund 1971). Finally some valuable assistance came through consultations with Dr. J. Stewart Williams, a retired geologist, of Logan, Utah.

Data are insufficient for complete definition of the aquifer system with all the individual hydrogeologic units. Local artesian aquifers do not persist laterally, and for all practical purposes cannot be separated. The most efficient and reasonable modeling approach is to combine several hydrogeologic units into a larger unit with equivalent overall storage properties. Thus, for the model, the groundwater system was divided into an artesian aquifer overlain by a confining bed, which in turn was overlain by an unconfined water-table aquifer.

The grid used to model the aquifer is shown in Figure 4. A block-centered, finite-difference grid with variable grid spacing was used. The grid consisted of 23 rows and 39 columns, or 897 nodes for one aquifer layer. The grid spacing ranged from 0.5 mile to 2 miles on a side. Since the quasi three-dimensional approach eliminates the layer of nodes representing the confining bed, two layers of nodes were used, one represents the confined and the other the unconfined aquifer.

In designing the grid system, smaller (or shorter) grid spacings were used in areas where a large number of wells are located, the hydraulic gradient is steep, or the transmissivity

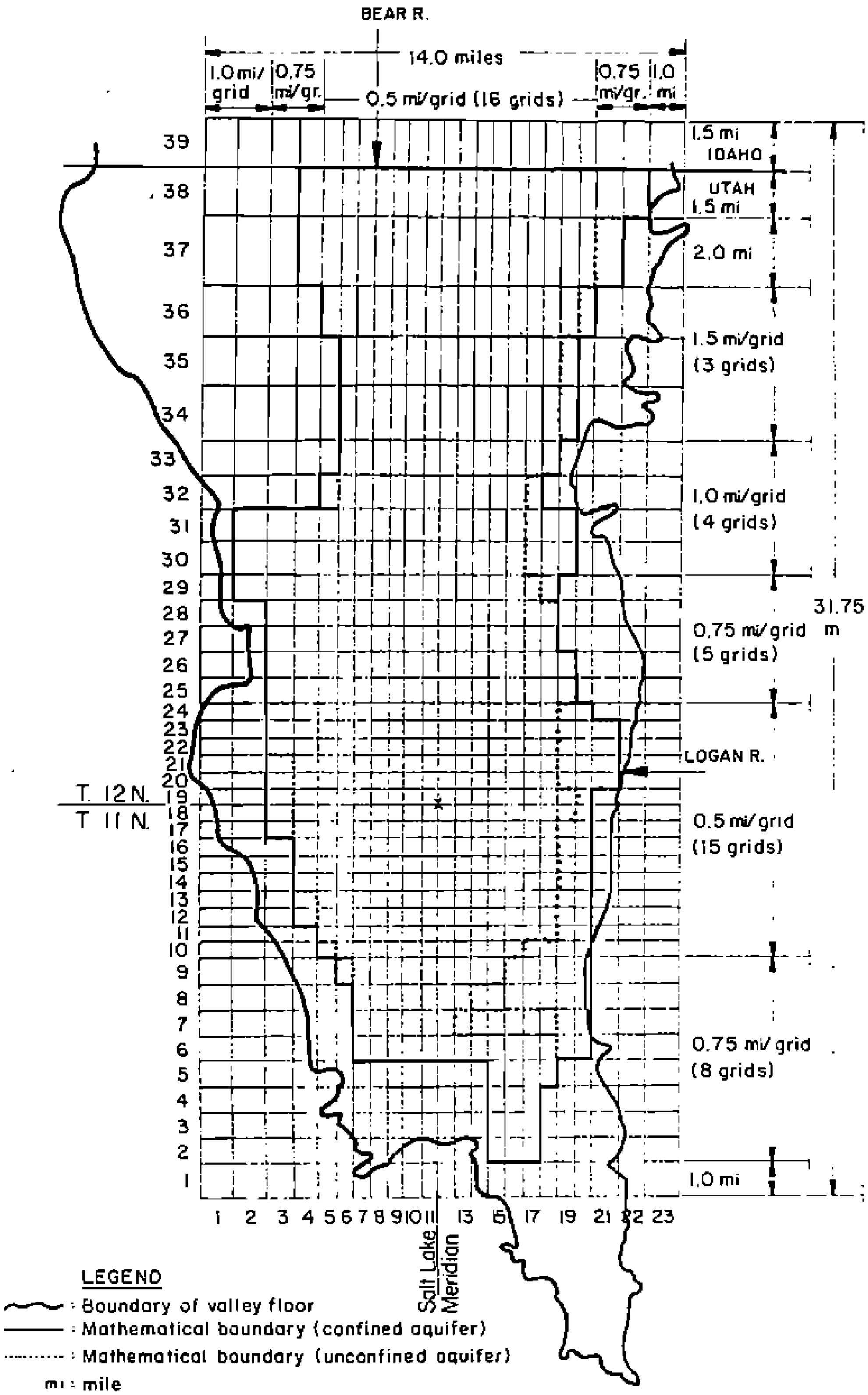

Figure 4. Model grid system and boundaries.

or hydraulic conductivity varies greatly over short distances. A restriction on the spacing ratio $x_j/x_{j-1} \leq 1.5$ between any two adjacent grids was followed in order to reduce truncation errors and resulting convergence problems. The grid system was not changed during the calibration.

Parameters

Required input data were obtained by collection and interpretation from historical data, field measurements, reasonable assumptions and estimations, and by varying values during calibration until a best-fit condition was obtained. Some parameters, such as the type of model, grid system, initial water levels, ground surface elevations, bottom elevations of water table unit, and boundary conditions, were set before the model was constructed and were not varied. Other parameters were changed during calibration. These were transmissivity, hydraulic conductivity (unconfined aquifer), storage coefficient, recharge, leakance (the resistance to vertical flow in the confining bed), maximum evapotranspiration rate, river node coefficients and spring node coefficients.

The values for some parameter matrices were obtained by overlaying the grid on a map of plotted parameter values. For example, the initial head matrix was obtained by overlaying the grid on a map of the initial potentiometric surface and determining the head value at each node. The ground surface elevations, river node elevations, and spring node elevations were obtained from 1:25,000 topographic maps by using the same procedure. Detailed description of how these parameters were obtained are presented in later sections.

Boundary conditions and recharges

The model can represent two kinds of boundaries: constant head and constant flux. Zero-flux boundaries, where nodes have zero transmissivity (hydraulic conductivity), are set along the entire border of each layer of the model as a computational expediency; and consequently, the flux across the outer border is zero. Non-zero constant head or constant flux boundaries are then placed just inside this border at selected points to represent inflows and outflows. Cutler Reservoir and Hyrum Reservoir are represented by constant head nodes using the local normal depths of the reservoirs as heads. The river channels of the Bear River and the Cub River upstream from their junction to the Idaho-Utah state line are also represented by constant head nodes. In this area these channels are cut deeply into the ancient lakebed sediments and the constant head nodes represent the natural conditions better than would river nodes, and also separate the two adjacent but independent shallow, unconfined aquifers. This representation is adequate so long as the water levels in the rivers do not change greatly during the year.

In Cache Valley, the principal recharge areas are along the margins of the valley and are underlain by permeable unconsolidated materials including beds of gravel and sand. Runoff infiltrates where the streams flow from the canyons onto coarse-grained deposits to recharge the underlying groundwater reservoir. Most of the recharge is from perennial streams that provide a constant source, but some water is contributed by intermittent and ephemeral streams as well as by direct rainfall and snowmelt along the mountain front. Recharge from irrigation water comes from the seepage under irrigation canals and ditches and from irrigated land. Most of the recharge takes place along the edges of the valley where water infiltrates most readily and where much irrigation water is applied. Recharge occurs also by water moving directly into the aquifers from rocks in the adjacent mountains as subsurface inflow (Bjorklund and McGreevy 1971). Recharge from the mountains and other sources along the edge of the valley were treated as constant finite-flux boundaries and recharge "wells" were placed just inside the no-flow boundary at nodes where the recharge is assumed to take place (see Figure 5). In the lower parts of the valley, some infiltration reaches the shallow unconfined aquifers, but infiltrated water does not reach the confined aquifers because of the upward artesian gradient. The northern boundary of the area covered by the model is the Utah-Idaho state line. According to Bjorklund and McGreevy 1971 about 4,000 acre-feet of groundwater moves annually from Idaho into Utah. This includes 3,000 acre-feet in the area west of Bear River near Weston, Idaho and 1,000 acre-feet in the Cub River subvalley mostly east of Cub River. Recharge wells were assigned at nodes in those areas to simulate the flows.

The amount of water initially assigned to a recharge well was calculated by the equation:

$$\text{Recharge} = T \times L \times H \times 365 \times \text{conversion factor dependent on recharge units} \quad (4)$$

where

T is transmissivity [ft^2 per day]

L is width of the grid cell [ft]

H is the hydraulic gradient [ft per ft]

and reasonable estimates were made for the parameters from hydrologic and hydrogeologic data. These recharge estimates were then adjusted by trial-and-error during calibration.

The bottom of the confined aquifer is assumed to be impermeable to simulate the negligible subsurface outflow from Cache Valley.

Initial water levels for the confined aquifer

In the model, many hydrogeologic units are combined into a single layer confined aquifer with equivalent storage properties. The potentiometric head of the hypothetical combined confined aquifer represents an average for the actual aquifer system.

The potentiometric surface contour map of March 1969 from plate 4 in Bjorklund and McGreevy (1971) is the most complete water level contour map of the entire model area available for calibration. An apparent anomaly, in the form of a mound on the potentiometric surface in the middle of Cache Valley about 5 miles northwest of Logan, probably results from differences in artesian pressure in wells of different depths. Wells in the vicinity of the mound tap sand and gravel artesian aquifers at depths ranging from 480 to 760 feet below land surface, whereas wells in the surrounding area tap aquifers at much shallower depths (Bjorklund and McGreevy 1971). Another shortcoming of this map is that it only shows the unconfined or perched water levels in two areas--the Little Bear River area south of Hyrum and the area between the Bear River and the Cub River channel south of the Idaho-Utah state line.

Because of the deficiencies of the map, adjustments were made based on interpretation of other data to produce the 1969 map shown in Figure 6. The geohydrologic sections related to the model area were examined from the open file report by McGreevy and Bjorklund (1971). Water levels of two wells in the Bear River delta between the Bear River and the Cub River were measured with the help of Mike Turnipseed of the Division of Water Rights, Logan office. All the well information from the Division of Water Rights and from available reports and measurements were carefully studied. The water levels used to draw the contour map of Figure 6

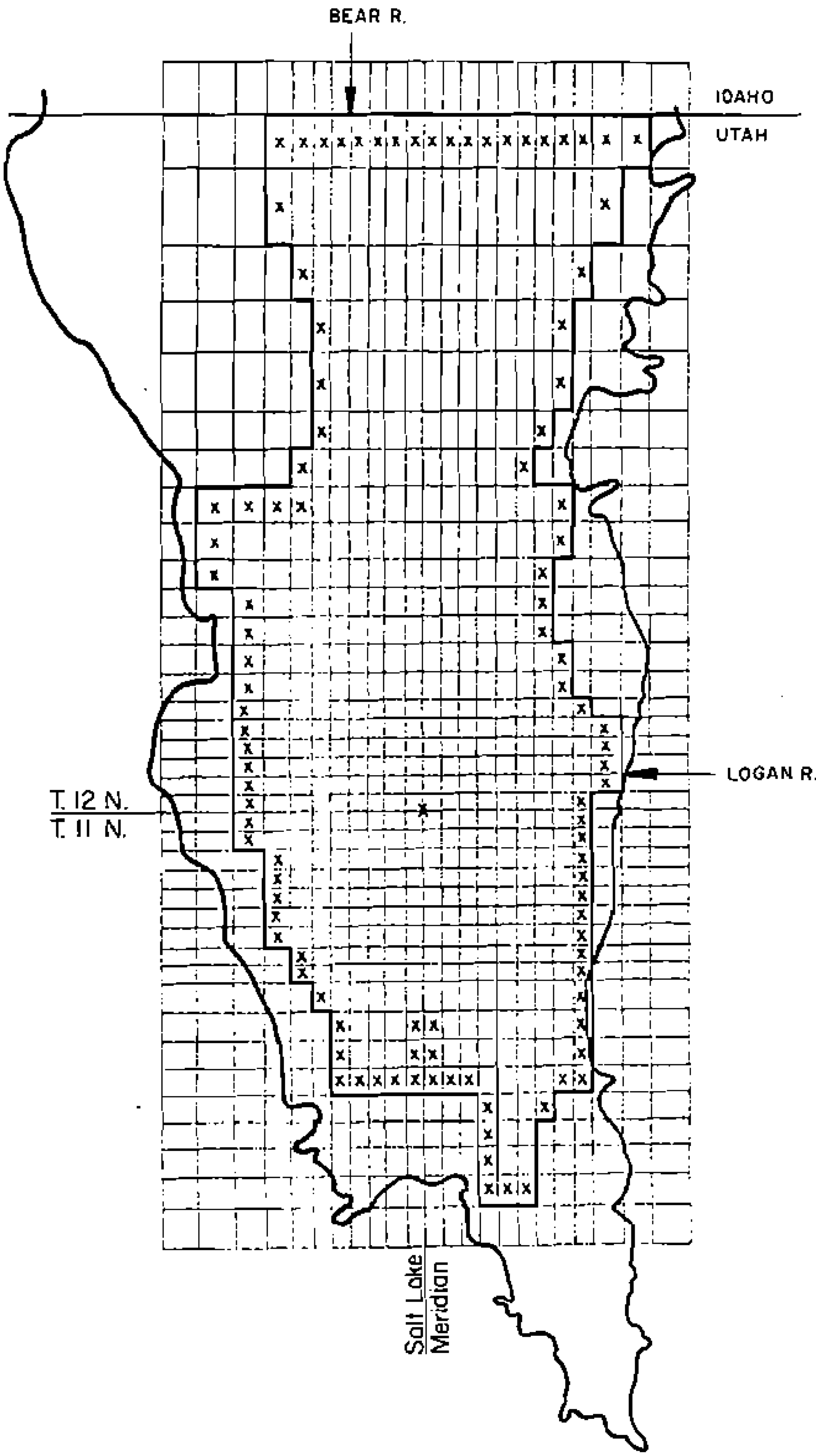

Figure 5. Nodes of recharge wells (constant finite-flux boundaries) for layer 1 confined aquifer).

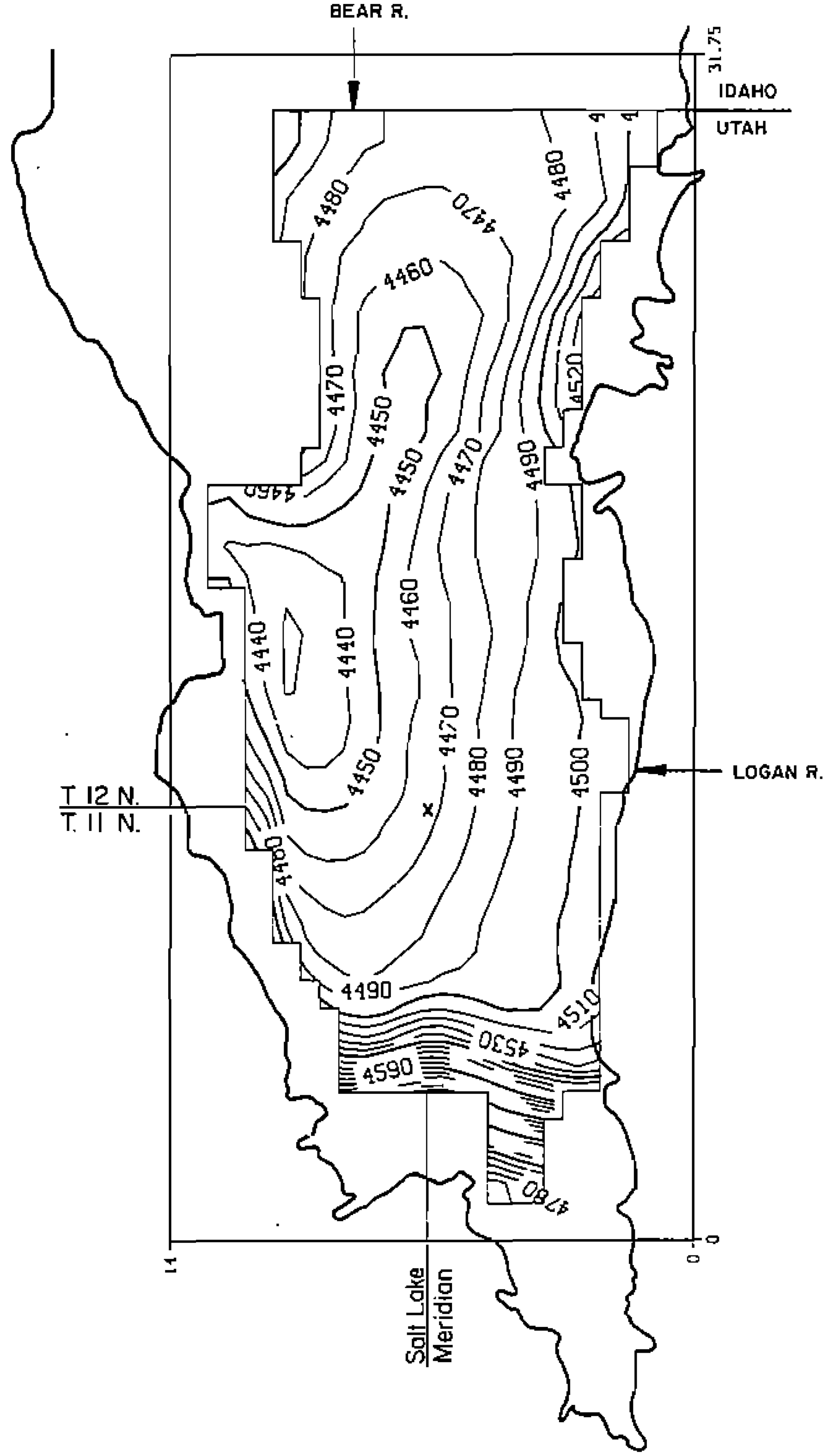

Figure 6. The observed potentiometric surface contour map of the confined aquifer of March 1969 (based on Bjorklund and McGreevy 1971).

have been taken from the wells which demonstrate consistency in depth and flow rate. Thus, the estimates of the potentiometric surface plotted on Figure 6 were based on all the information available as adjusted by consideration of related data and reasonable judgment.

A model grid system map was overlaid on the modified piezometric contour map of Figure 6 and the piezometric head at each node was recorded to give the initial well water levels for the confined aquifer in the model.

Initial water levels for the unconfined aquifer

The geologic conditions in Cache Valley in Utah provided a basis for separating the unconfined groundwater aquifer into three regions. The first region is the area east of Bear River, west of Cub River, and south of the state line. The deposits in this area are the reworked sand and silt as the Bear River eroded into its delta near Preston. In most of the area, the sand and silt is approximately 30 feet thick and covers lake-bottom clays that have very low permeability. Groundwater is unconfined and is near the land surface. The water level contour map in this area is given on plate 4 in Bjorklund and McGreevy (1971). The starting head for the model at each node was estimated by overlying the model grid on the contour map.

The water table is near the land surface in a second region that covers most of the area with flowing wells in Cache Valley (see plate 3 in Bjorklund and McGreevy 1971). This shallow aquifer is partly recharged by water seeping upward from the artesian aquifers and partly by water seeping downward from irrigation canals, ditches, irrigated fields, and infiltrated rainfall. The aquifer is discharged by evapotranspiration, irrigation, springs, and natural and artificial drains. The shape and slope of the water table in this second region is presumed to be generally about the same as the wet or damp land surface in the artesian areas (Bjorklund and McGreevy 1971). The starting water table head for each node was estimated from the ground surface elevation.

The third unconfined region is the local perched groundwater zone south of Hyrum. This shallow water table is perched in thin deposits of gravel on layers of silt or interbedded clay. The perched water table contour map shown on plate 4 in Bjorklund and McGreevy (1971) was adjusted to obtain initial head values.

A water level contour map including the three different unconfined regions in March 1969 is shown on Figure 7. Nodes between the three unconfined aquifer regions are assigned as constant head nodes in the model and are shown as the dashed lines in Figure 7.

Transmissivity of the confined aquifer

The boundaries of the principal groundwater aquifer and of areas where groundwater conditions are generally similar (Figure 3) were outlined on a grid system base map. The major rivers and streams were also drawn on the same base map. Transmissivity values determined by pumping and recovery tests, as listed in reports or publications or in test records obtained from the Water Rights Division, were collected and marked on the base map according to their locations. Starting from those nodes where the transmissivity values were already known from aquifer tests, estimates were made of the transmissivity values for the nearby areas. In general, transmissivity values decreased from the mountains toward the valley floor, but higher values occurred along rivers and streams.

The transmissivity values range between 330,000 and 1,000 ft^2 per day over the model area. The initial transmissivity estimates were varied during the calibration of the model

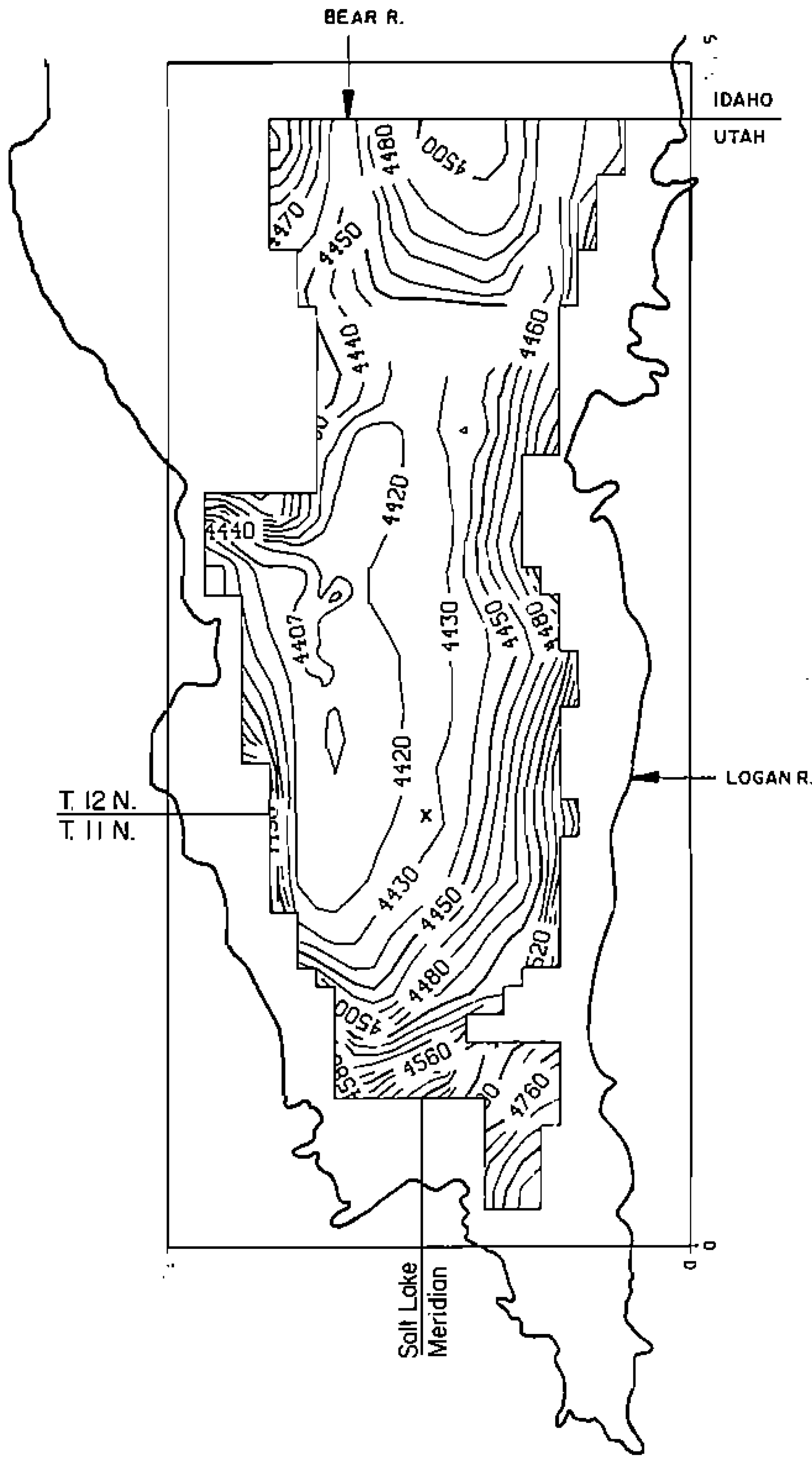

Figure 7. The observed water level contour map of the water-table aquifer for March 1969.

until the set of transmissivities was obtained which minimized the difference between the simulated and observed potentiometric surfaces. Figure 8 shows the transmissivity contours of the confined aquifer as adjusted by calibration of the model.

Hydraulic conductivity of the unconfined aquifer

The geologic map of Cache Valley of Utah and Idaho shown on plate 1 in Bjorklund and McGreevy (1971) delimit the different geologic units for the model region. The description of the composition and water-bearing properties of each geologic unit formation are given in Table 4 in the same document. A grid system base map was overlaid on the geologic map, and the initial values of hydraulic conductivity were then assigned to each node according to the aquifer properties. The calibration procedure was similar to that already described for the confined aquifer and values were in the range from 0.00005 to 0.002 feet per second after adjustment by the calibration. The hydraulic conductivity contour map of the unconfined aquifers with interval value 0.0002 is shown in Figure 9.

Storage coefficient

For steady-state aquifer conditions, no changes occur with passing of time. To represent such conditions during model calibration a storage coefficient of zero was set at all the nodes of all the layers to eliminate the time dependent term in Equation 1. In transient-state calibration, however, initial storage coefficients were assumed and then varied in order to improve the agreement of measured with calculated water levels.

Generally for confined aquifers, the storage coefficient values range between 0.001 and 0.00001, while in unconfined aquifers, the range is 0.5 to 0.05. In the Cache Valley the observed storage coefficients for confined aquifers cover only part of the expected range. The confined aquifer storage coefficients were obtained by a procedure similar to estimate transmissivity values. The estimation process began by marking storage coefficient values from aquifer tests on a grid system base map. Storage coefficient values at nearby nodes were based on geologic and hydrologic information. The values of the storage coefficients so obtained for the confined aquifer range from 0.0001 to 0.0004, as shown in Figure 10.

Since little information was available on storage coefficient values for the unconfined aquifers, an estimated initial value of 0.1 was used for each node in the storage coefficient matrix. During the calibration no changes were made in the unconfined aquifer storativity because the water levels are not sensitive to variation in the unconfined storage coefficients.

Leakance

Since horizontal flow in the confining bed was ignored, the aquifer system was simulated as a quasi three-dimensional model with resultant savings in computer time and storage. The confining beds were not represented by layers of nodes; instead, the flow through the confining bed was incorporated in the vertical components of hydraulic conductivity of the adjacent aquifers. In usual modeling practice where adequate leakance data are available, this is accomplished by computing the trial leakance (TK) values using Equation 5 and then inputing these into the model:

$$TK_{(i,j,k)} = \frac{2(bK_{zz})_{k+1}\,(bK_{zz})_k}{(bK_{zz})_k\,Z_{k+1} + (bK_{zz})_{k+1}\,Z_k} \qquad (5)$$

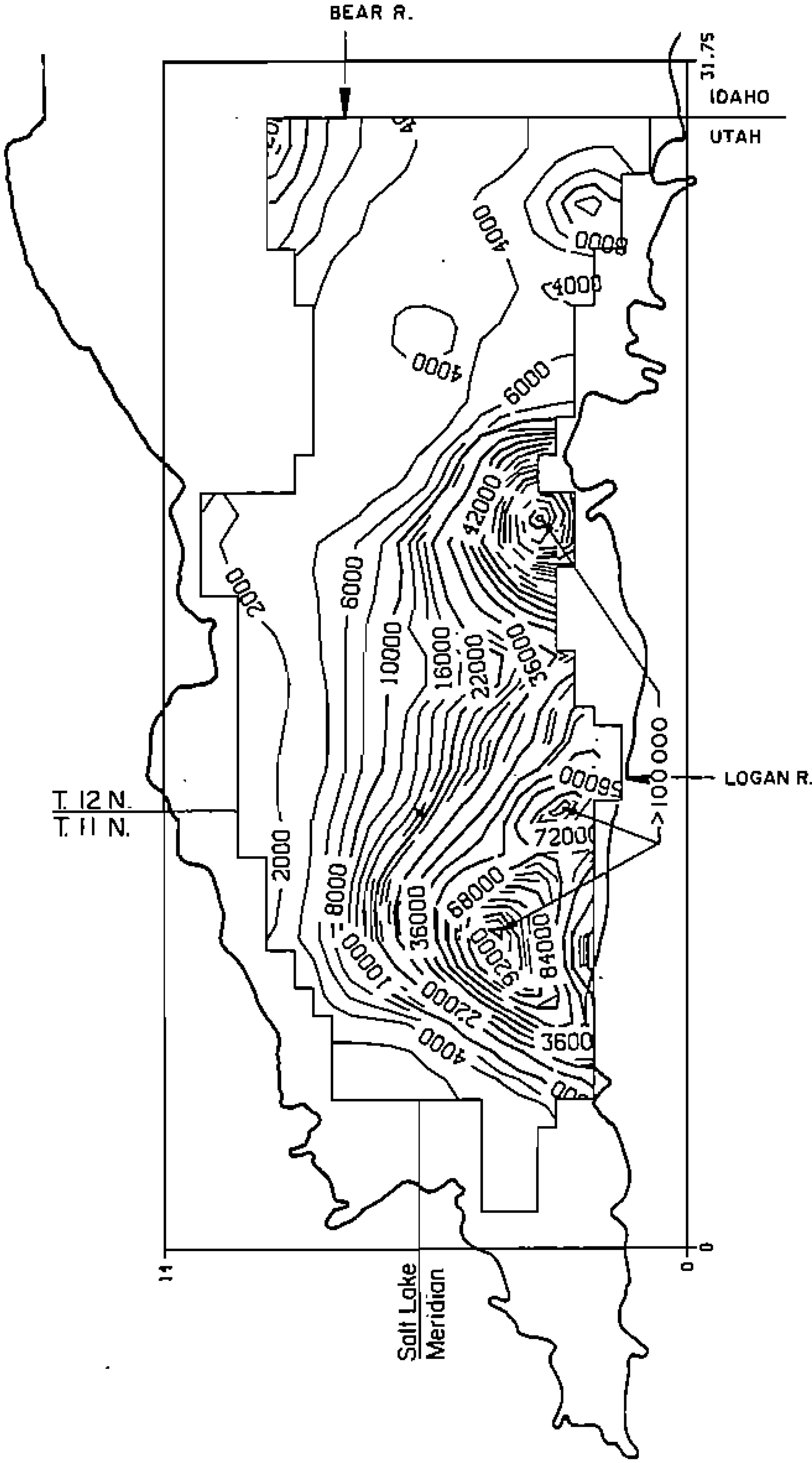

Figure 8. Transmissivity of the confined aquifer resulting from calibration of the model.

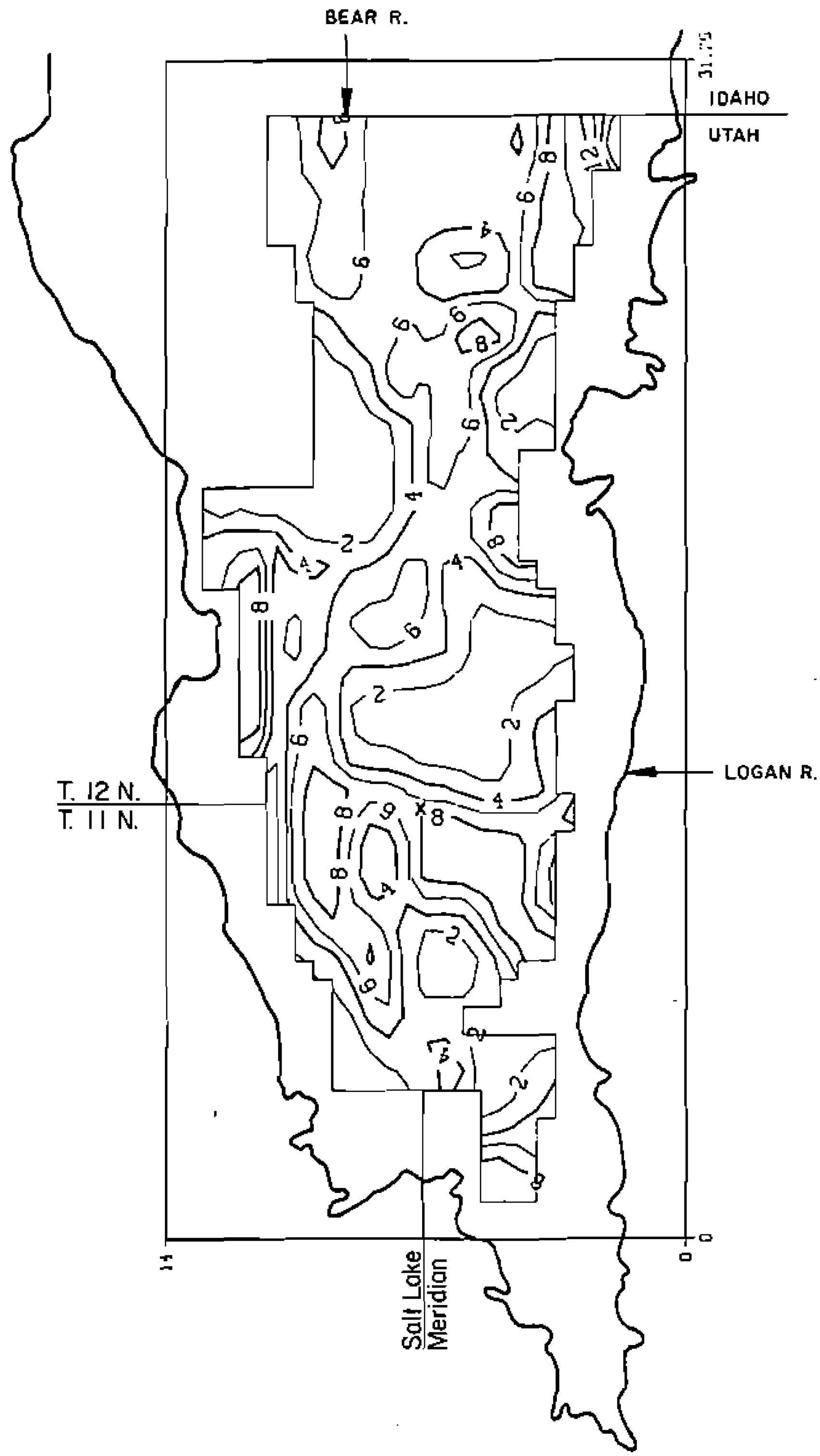

Figure 9. Hydraulic conductivity of the unconfined aquifer resulting from calibration. Contour values have been multiplied by 10,000.

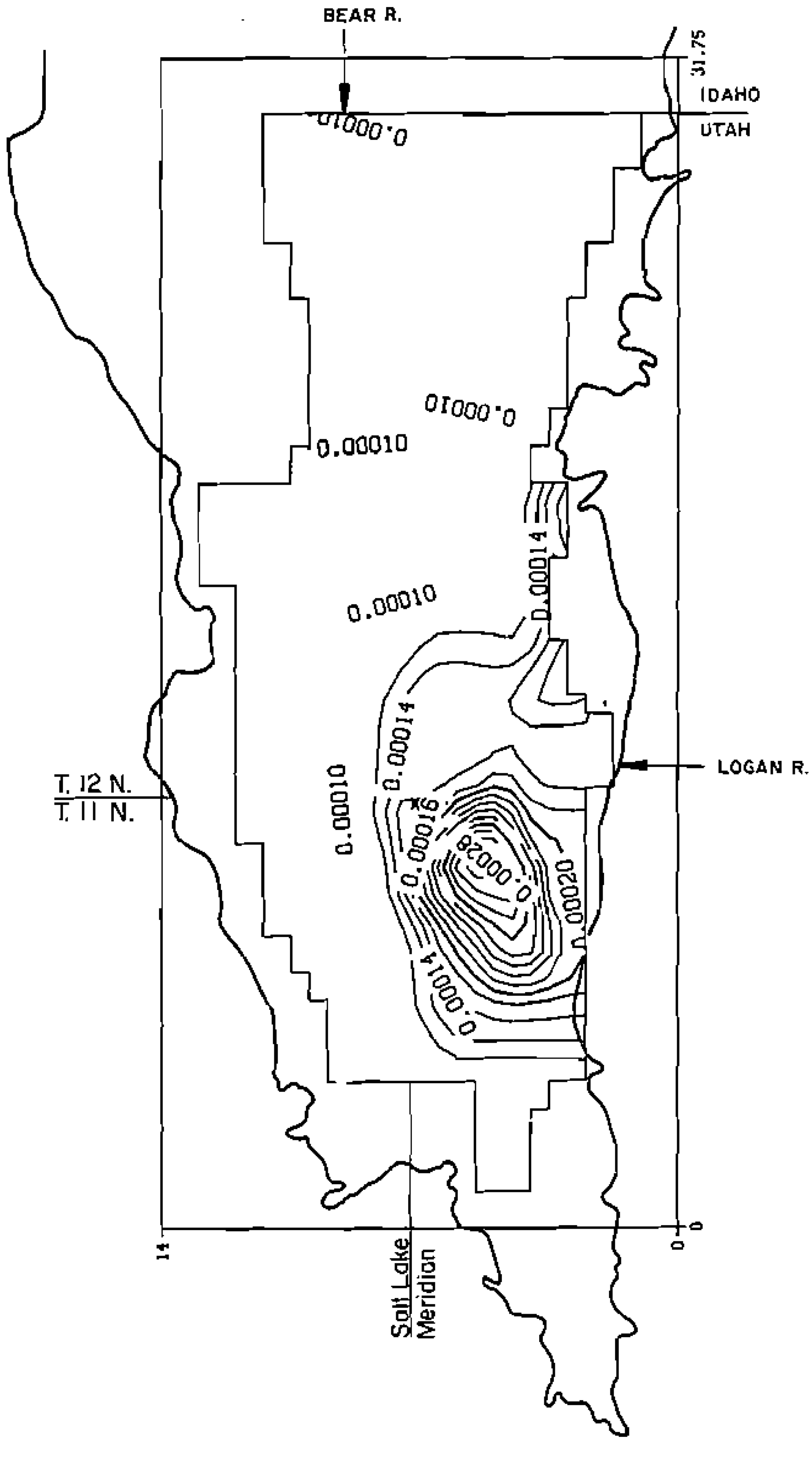

Figure 10. Storage coefficient value of the confined aquifer resulting from calibration.

where

K_{zz} = vertical hydraulic conductivity for the confining bed [L/t]

b = thickness of the confining bed [L]

Z = thickness of the aquifer [L]

i,j,k = nodal point indices in x, y, and z directions

The leakance values are then equal to the ratio K_{zz}/b for each confining bed and leakance is defined as the vertical hydraulic conductivity (ft/s) per unit thickness (ft) between layers of the model.

Since few data on leakance were available for Cache Valley, Equation 5 could not be used to obtain trial leakance values. Instead the same initial value (1×10^{-10} ft/sec per ft) was assigned at all the nodes. Then the leakance was varied during the steady-state calibration to improve agreement between measured and calculated potentiometric surfaces. Leakance values strongly affected both the convergence to a solution and also the water level. This sensitivity of the model to the leakance values gave a good basis for adjustment of the leakance during calibration. The final values resulting from the calibration ranged from 3.5×10^{-12} to 3.5×10^{-9} feet per second per foot and are tabulated in Appendix C.

Bottom elevation of water table unit

The thickness of the water table unit ranged from 30 feet to about 200 feet depending on the different geologic units and locations (see Table 4 in Bjorklund and McGreevy 1971). The thickness in the center of Cache Valley is about 50 feet and increases toward the edges of the valley. To obtain the bottom elevation of the water table unit, the model grid system was plotted on the 1:25,000 topographic map. The ground surface elevation for each node was determined from the contour lines. The water table aquifer thickness was estimated from Bjorklund nd McGreevy (1971) based on other nearby geologic data. The bottom elevation of the water table unit for the each node was then calculated from the ground surface elevation by substracting the estimated thickness of the water table unit.

River node leakage

The total accretion from groundwater to streams is estimated to be about 140,000 acre-feet annually within the Cache Valley. Many streams or creeks originate at springs within the valley, collect additional water from springs, seeps, and drains along the way, and flow to the Bear River or one of its tributaries. The principal rivers and creeks that originate outside the valley, gain flow within the valley from springs and seeps along their courses or from tributaries that originate within the valley (Bjorklund and McGreevy 1971).

The effects of the streams on the groundwater were simulated by the method described by Prickett and Lonnquist (1971, p. 33) using Darcy's law. The method assumes that a pervious layer forms the bed of the stream and separates the stream from the aquifer. Seepage from the stream to the aquifer becomes constant when the water level in the aquifer falls below the bottom of the streambed. Under these assumptions, the rate of flow through the streambed per unit grid block area is calculated by the equation

$$QR_{river} = [K * A * (RH-PHI)/b]/\Delta X_j \Delta Y_i$$

$$= RC * (RH-PHI) \qquad (6)$$

where

QR_{river} is the infiltration rate of the stream into the aquifer (taken as positive when the flow is from the stream to the aquifer) [ft/sec]

K is the hydraulic conductivity of the streambed [ft/sec]

b is the thickness of the streambed layer [ft]

A is the area of the streambed within the model cell [ft^2]

RH is the elevation of the river surface [ft]

PHI is the head in the top layer aquifer or the elevation of the bottom of river bed, whichever is greater [ft]

RC is the river node coefficient, representing K*A/($b\Delta X_j \Delta Y_i$) and varied during the calibration [1/sec]

The 75 river nodes in the model (Figure 11) are used to simulate interaction with the rivers including Bear River, Logan River, Blacksmith Fork River, Little Bear River, Spring Creek, Summit Creek, and High Creek. In these locations the infiltration rates depend on river stage and groundwater elevation as in Equation 6. River nodes only exist in areas with unconfined aquifers, and mostly occur in the central valley floor. Where streams exit from canyons and recharge the groundwater by infiltration directly into coarse beds near the mountains, conditions are better represented by constant finite flux nodes as explained earlier and summarized in Figure 5. The river channels of Bear River and Cub River upstream of their junction are treated as constant head nodes instead of river nodes in order to separate the two unconfined aquifers and to more realistically represent infiltration conditions in that area.

Spring nodes leakage

In Cache Valley, many springs, seeps, and drains discharge water from the shallow unconfined aquifers. In the flowing well areas, part of the discharge moves upward from the artesian aquifers into the shallow unconfined aquifer (Bjorklund and McGreevy 1971).

Spring nodes were assigned in the model wherever one or more relatively large spring was located within a grid. The flow rate per unit grid block of the spring node (ft^3/sec) is simulated by

$$QR_{spring} = - FLD * (PHI - ELD) \quad (7)$$

where "-" sign represents water discharge from the aquifers.

FLD is a spring node coefficient varied during the calibration [ft^2/sec].

PHI is the water head level of the unconfined aquifer [ft].

ELD is the altitude of the spring above mean sea level as determined from topographic maps or with a hand level where necessary [ft].

There are 21 spring nodes assigned in the model (see Figure 11). Most of the springs are assigned the spring altitude and discharge in McGreevy and Bjorklund (1970).

Evapotranspiration

The annual evapotranspiration from the 22,440 acres of wet lands in Cache Valley in Utah is estimated to be about 63,000 acre-feet (Bjorklund and McGreevy 1971), which includes evaporation from the land surface and transpiration by phreatic vegetation. It occurs mostly in the wet meadow lands in the lower parts of the valley, where the potentiometric surface of the groundwater reservoir is

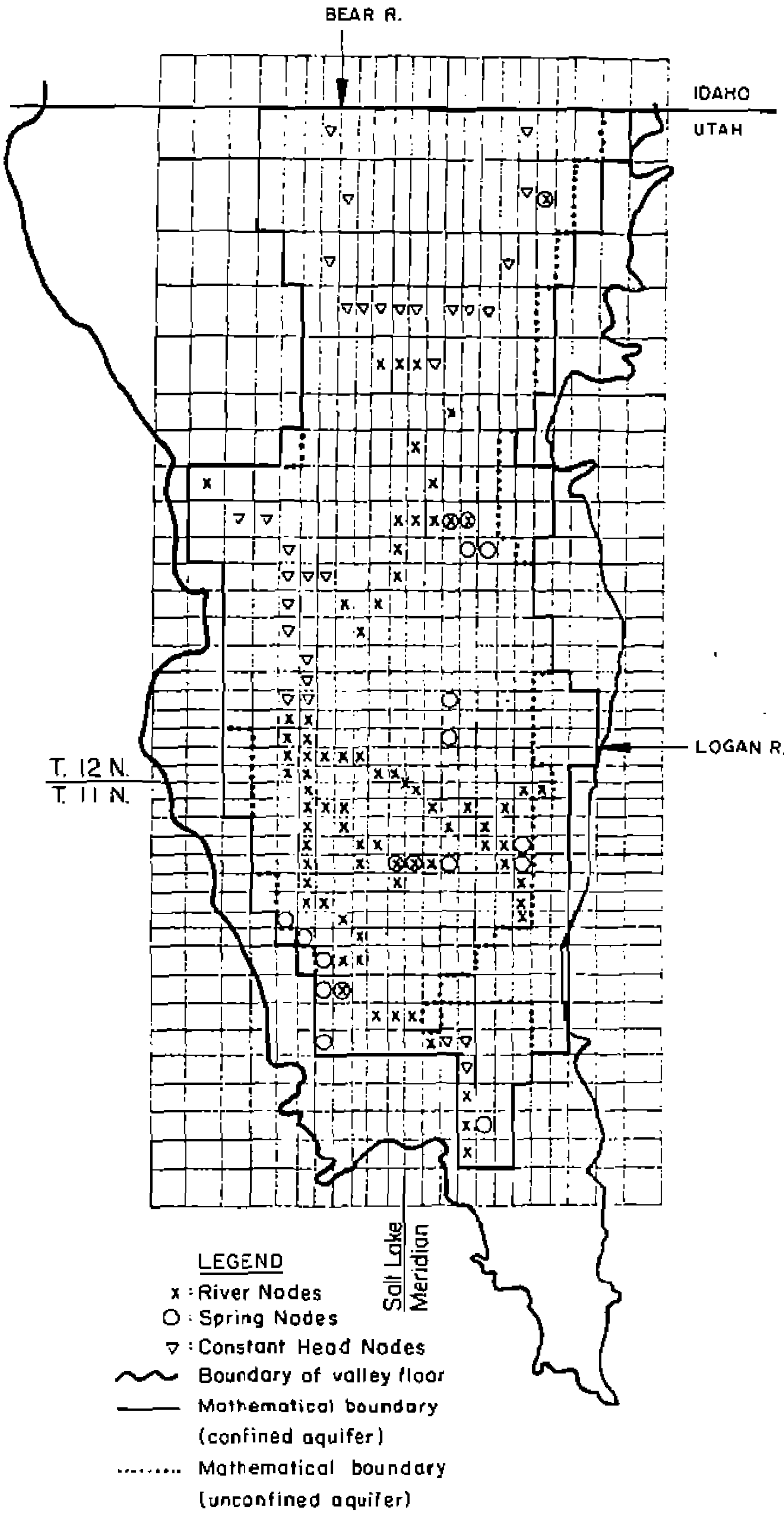

Figure 11. Location of river nodes, spring nodes, and constant head nodes.

above the land surface (Bjorklund and McGreevy 1971).

The three-dimensional computer simulation model obtained from the USGS did not include evapotranspiration. In Cache Valley, evapotranspiration is an important groundwater loss. To better match the true situation, evapotranspiration was added to the model by modification of the computer code. To avoid numerical difficulties or oscillations during convergence, evapotranspiration was treated as a linear function of depth below the land surface (Figure 12) (Trescott et al. 1976) in the relationship:

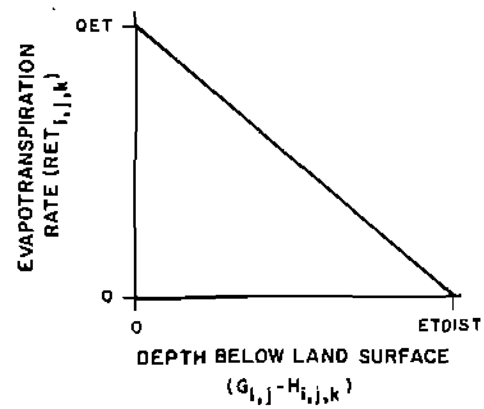

Figure 12. The linear relationship between the evapotranspiration and the depth below the land surface.

$$RET_{i,j,k} = \begin{cases} QET & \text{for } [H_{i,j,k} \geq G_{i,j}] \\ QET - \frac{QET}{ETDIST}(G_{i,j} - H_{i,j,k}) & \text{for } [ETDIST > (G_{i,j} - H_{i,j,k});\ H_{i,j,k} < G_{i,j}] \\ 0 & \text{for } [ETDIST \leq (G_{i,j} - H_{i,j,k})] \end{cases} \quad (8)$$

where

$RET_{i,j,k}$ = evapotranspiration rate [ft^3/sec per ft^2]

QET = maximum evapotranspiration rate [ft^3/sec per ft^2]

$ETDIST$ = depth below ground surface at which evapotranspiration ceases [ft]

$G_{i,j}$ = ground surface elevation at node i,j [ft]

$H_{i,j,k}$ = water level elevation at node i,j,k

Pumpage

At present, there are totally about 2,950 wells, including both flowing and pumping wells, in Cache Valley within Utah (Logan District Office of the Utah Water Rights Division). Detailed information on discharge, pumping duration, and drilling logs are not available for many of the wells, especially for smaller private wells. Without discharge data, it is impossible to sum the discharge from the wells within a grid cell for a node total. An approximate method for estimating well discharge by node was substituted.

First, all the discharge wells in Cache Valley were classified as "large" or "small" wells according to whether the flow rate was greater than 350 gallons per minute. The large wells were identified and located individually on the grid system map. The number of small wells in each grid cell (node) is tabulated in Figure 13. An annual mean discharge of small wells was estimated by subtracting from the total annual pumpage reported in "Groundwater Conditions in Utah" the

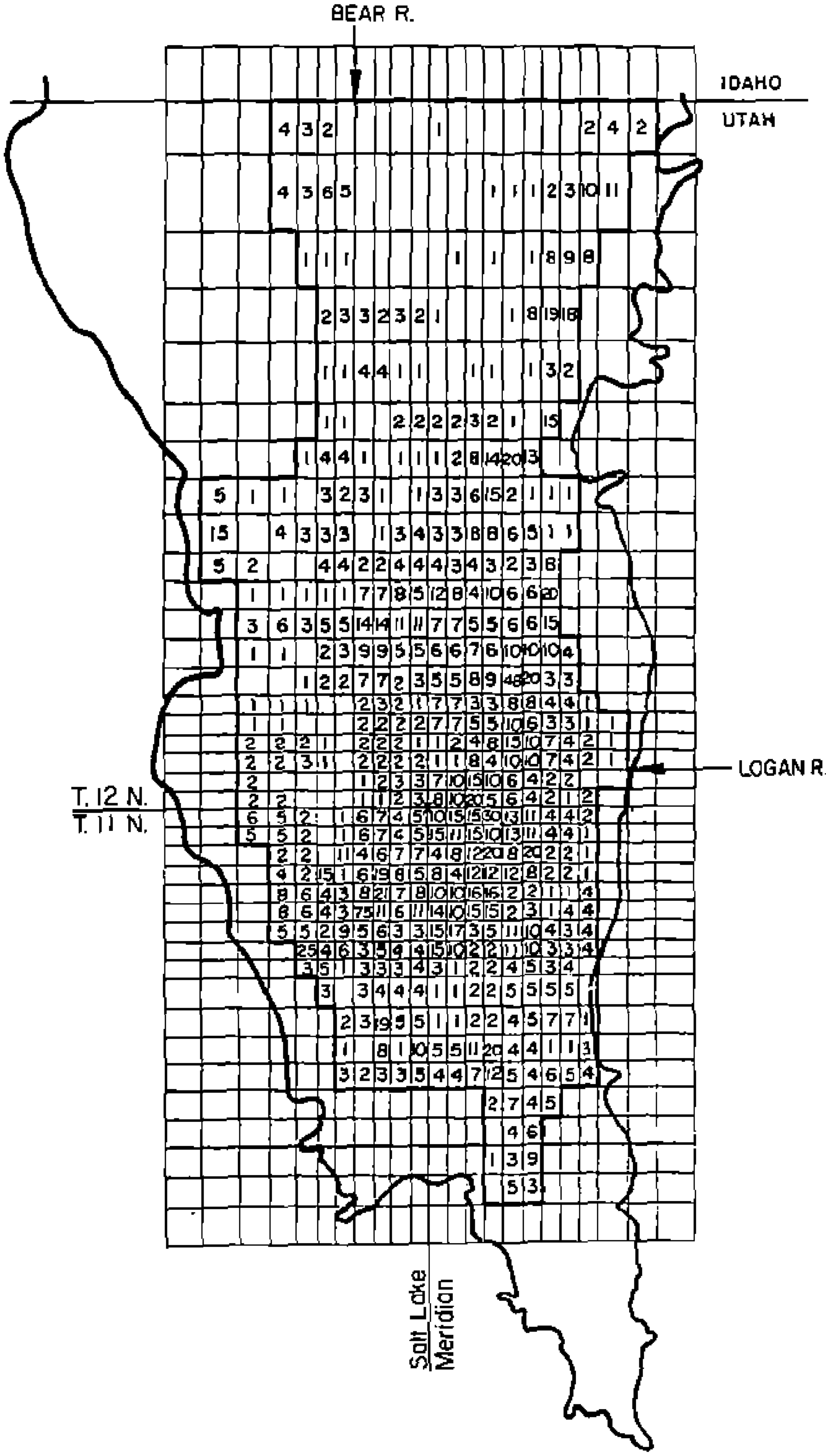

Figure 13. Total number of "small" wells within each grid cell.

annual discharge from all the large wells and then dividing by the total number of small wells. The total pumpage for each cell was then taken as the product of mean small-well discharge, times the number of small wells, plus the discharge of the large wells within the cell.

Most large irrigation and municipal wells are pumped at full capacity for 3 months or less, usually starting when surface water supplies diminish in mid June, through August or September. Some of the large wells are used only in dry years. A detailed review of electric power use records would be one way to reconstruct the pumping history of large wells. From a personal communication with the Preston Office of the Utah Power and Light Company, it was learned that existing power company records summarize the total power usage from the pumping of both groundwater from well and surface water from rivers and canals. There is no way to identify groundwater pumping power separately except by detailed analysis of old records.

Because the resources for such a study were not available, an alternative method was used to estimate larger well pumpage. Guided by the pumping histories of a few typical large wells, it is assumed that the large wells are pumped at rated flow rate during 4 hours each day for 5 months of the years.

MODEL CALIBRATION

The purpose of calibration is to match observed groundwater conditions with the simulation as closely as possible by adjusting the model parameters within hydrologically reasonable limits. The model is calibrated by repetitively running the computer program using available hydrogeologic data, noting differences between simulated and recorded conditions and varying selected model parameters to improve the match. If the model can be calibrated to reproduce historical field measurements, then one has greater confidence in its ability to predict what will happen to the groundwater under various assumed conditions in the future.

Developing the Cache Valley model involved both a steady-state calibration and a transient-state calibration. First, under steady-state conditions starting from assumed March 1969 heads, the model parameters were adjusted so that the iterative solution closely matched the potentiometric surface of March 1969 in Figures 6 and 7. The transient-state calibration includes two steps: first, a simulation to reproduce the potentiometric surface of March 1969 after adding the non-zero storage coefficient values to the parameters determined from the steady-state calibration; and second, simulations under transient conditions to match year by year the annual water level change maps from 1969 through 1972. Besides the agreement between the calculated and historical water levels, another check on the accuracy of the simulation was to compare computed recharge and discharge values with the historical water budget analysis for each pumping period.

Steady-State Calibration

Groundwater levels in the main aquifer in Cache Valley in Utah have not changed significantly since 1935, although seasonal fluctuations occur (Bjorklund and McGreevy 1971). The valley is an overflowing groundwater basin, where water levels are stabilized. The hydrographs in plate 2 of Bjorklund and McGreevy (1971) also indicate that the natural recharge-discharge relationship has not been changed much by the withdrawal of water from wells.

The steady-state simulation was calibrated against the water level maps of March 1969 and using these same water levels as the initial values in the computation. The aquifers were not truly in a steady-state condition during 1969, but the assumption of the steady-state conditions is quite reasonable as water-level changes were small and local in nature during 1969.

During the steady-state calibration, a storage coefficient of zero was set at every node, thereby eliminating the time dependent term in Equation 1. After a series of steady-state calibrations were done, the sensitivity of the model to variations in the hydraulic parameters was better understood than before the calibration. In the Cache Valley model, the first and most important parameter to be adjusted was the vertical hydraulic conductivity or leakance, because of its important role in the iteration convergence in the model. This sensitivity is easy to understand because upward leakage to the water-table aquifer is the principal means of natural discharge from the artesian aquifer over 200 square miles of the Cache Valley area. The leakage could not be measured directly, so leakance values were varied at many nodes during calibrations in order to balance the total recharge and discharge. The general calibration procedure for adjusting leakance values proceeded by steps. First, a multiplication factor of leakance value common to all nodes ("FAC", see Appendix B) was adjusted until the maximum difference between computed and observed values became small. Then more detailed individual variation for each node was done to improve the convergence and further reduce the error differences.

The aquifer transmissivity and horizontal hydraulic conductivity also strongly affect the model. These parameters are adjusted according to the following guidelines: If the calculated water levels in an area are lower than observed water levels, then the transmissivity and hydraulic conductivity values at nearby nodes should be decreased; but if the calculated water levels are higher, larger values should be used. Other parameters such as river node coefficients, spring node coefficients and the recharge flow across the boundaries were also adjusted. The maximum evapotranspiration rate is a sensitive parameter and is varied during the calibration by comparing the computed value to the reported 63,000 acre-feet of total annual evapotranspiration in Cache Valley in Utah. It is assumed that 1969 is an "average" evapotranspiration year.

The computed steady-state water level maps are shown in Figures 14 and 15 for the confined and unconfined aquifers respectively. The comparison between computed and observed water levels after steady-state calibration showed the maximum absolute difference in the confined aquifer was about 7 feet and in the unconfined aquifer was about 9 feet. The mean absolute difference was about 1.8 feet in the confined aquifer and about 2.3 feet in the unconfined aquifer. The map showing the computed differences between the steady-state calibrated water levels and the observed water levels is given in Appendix E. Along the edge of the basin, steep groundwater gradients sometimes caused difficulty in matching water levels.

Transient-State Calibration

The transient-state calibrations began by using the observed water level conditions of March 1969 as initial values as shown in Figures 6 and 7. The parameter values resulting from the steady-state calibration were used as starting values along with the assumed non-zero storage coefficients. Parameters were adjusted in successive simulations to reproduce the March 1969 conditions. The calculated water level conditions of March 1969, after transient-state calibration adjustments are shown in Figures 16 and 17. The maximum absolute difference value between the computed and the initial observed water level was about 8 feet in the confined aquifer and about 8 feet in the unconfined aquifer. The mean absolute difference value was about 1.66 feet in the confined aquifer and 1.64 feet in the unconfined aquifer. Comparing with the mean difference values of 1.79 feet and 2.30 feet from the steady-state calibration, the overall water level agreement for the condition of March 1969 was somewhat improved by the transient-state calibration.

The next step in transient-state calibration started from the calculated water level condition of March 1969 and simulated the effects of three successive one year periods. Model parameters were adjusted to achieve the best match year by year with water level change maps until March 1972. Those maps shown in Figures 18a, 19a, and 20a were taken from the water level change maps as shown in the annual reports on "Groundwater Conditions in Utah." Except for the parameters whose values do physically change from year to year (the storage

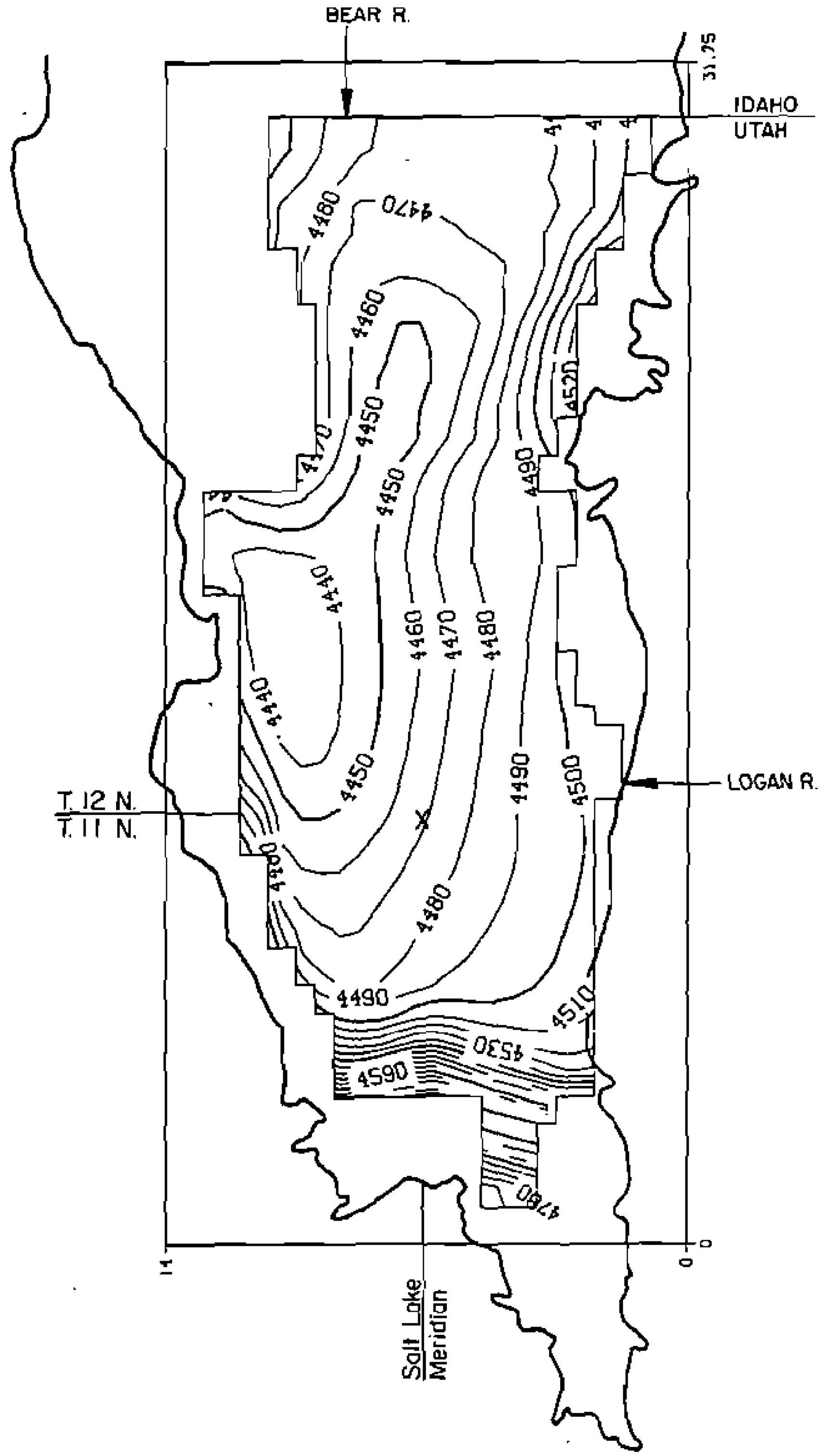

Figure 14. Calculated steady-state water level contour map of confined aquifer.

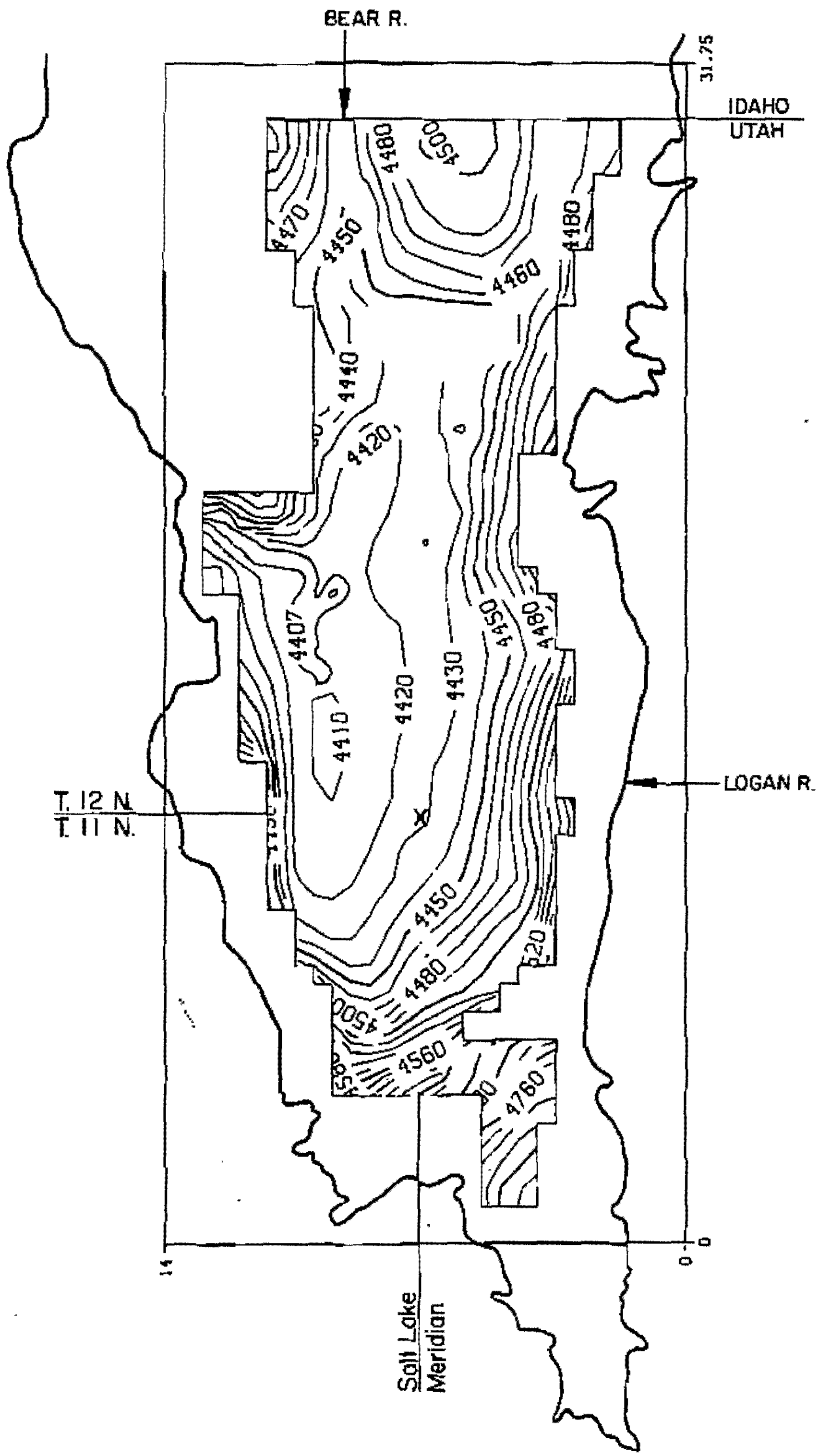

Figure 15. Calculated steady-state water level contour map of unconfined aquifer.

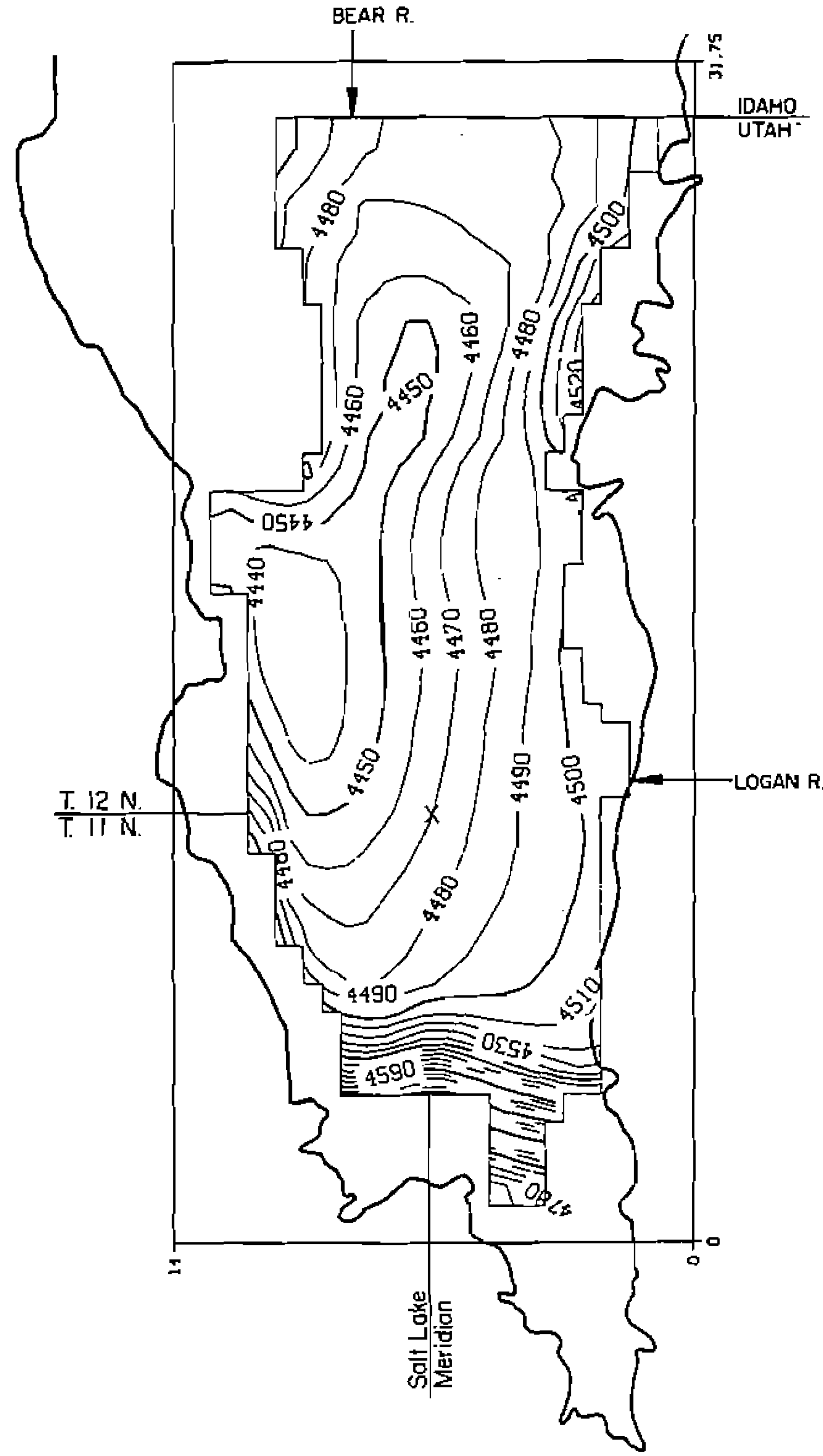

Figure 16. Calculated water level contour map of confined aquifer of March 1969.

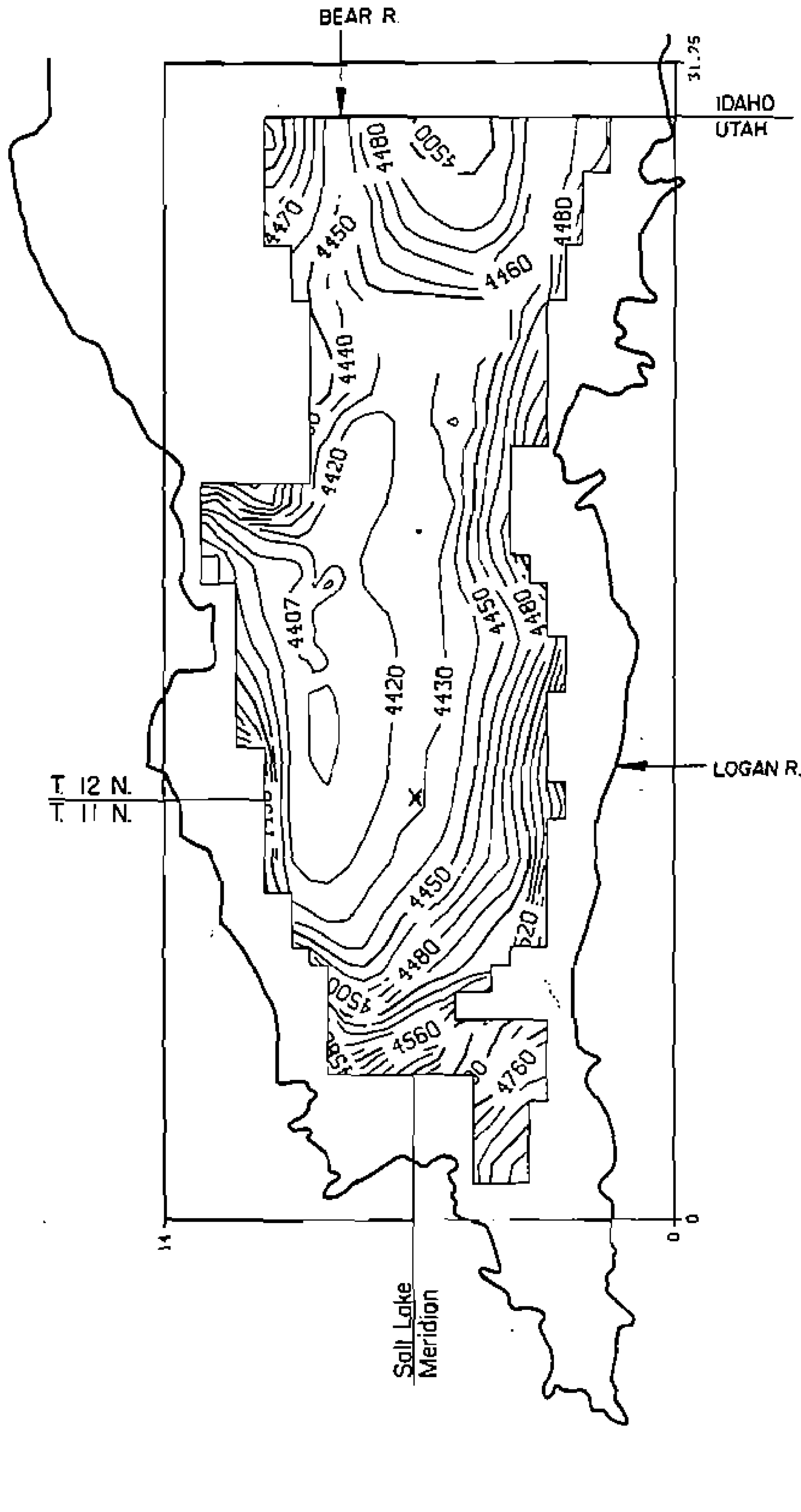

Figure 17. Calculated water level contour map of unconfined aquifer of March 1969.

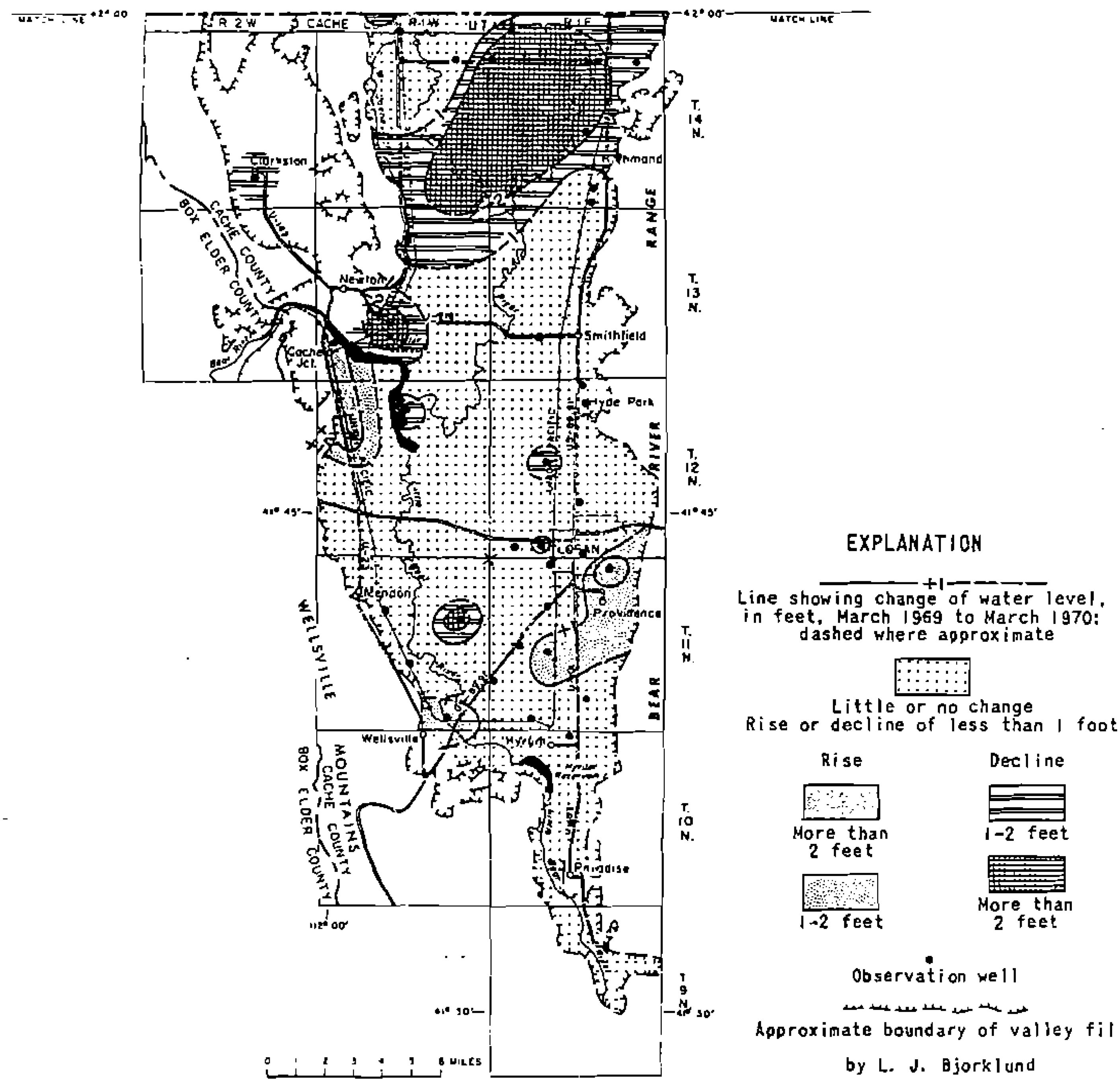

Figure 18a. Observed water level change map of confined aquifer from March 1969 to March 1970. (From "Groundwater Conditions in Utah" 1970.)

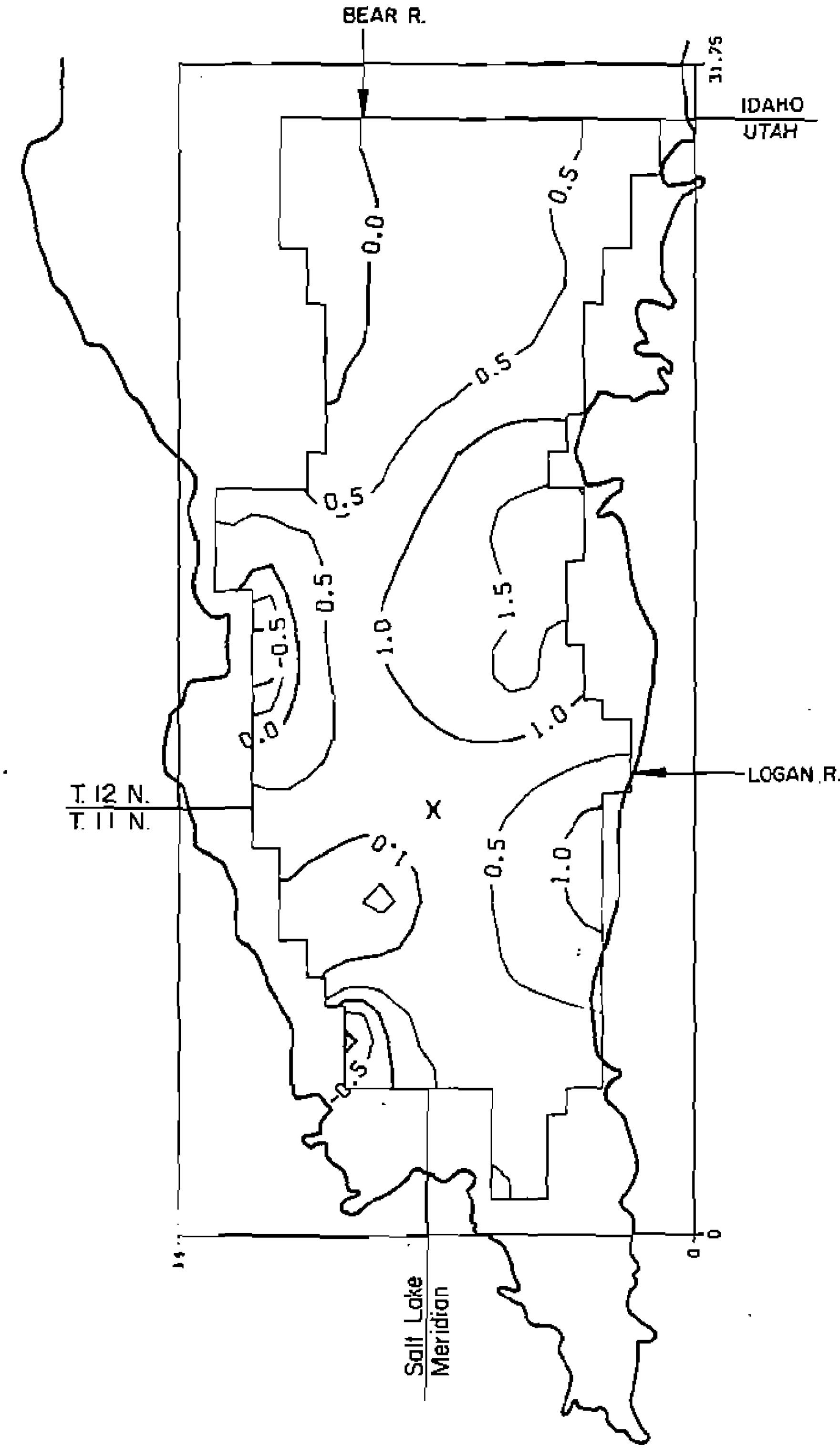

Figure 18b. Calculated water level change map of confined aquifer from March 1969 to March 1970.

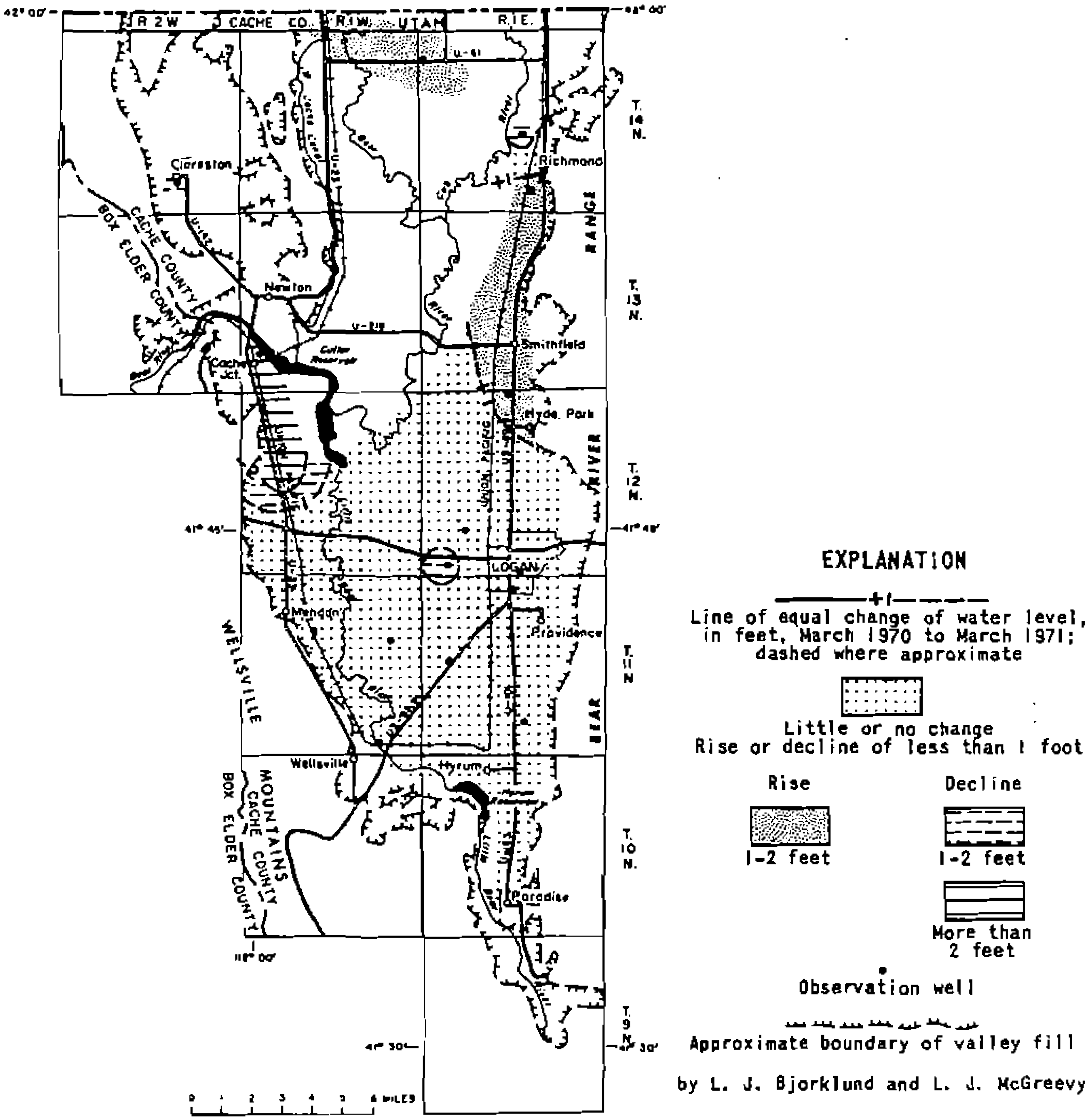

Figure 19a. Observed water level change map of confined aquifer from March 1970 to March 1971. (From "Groundwater Conditions in Utah" 1971.)

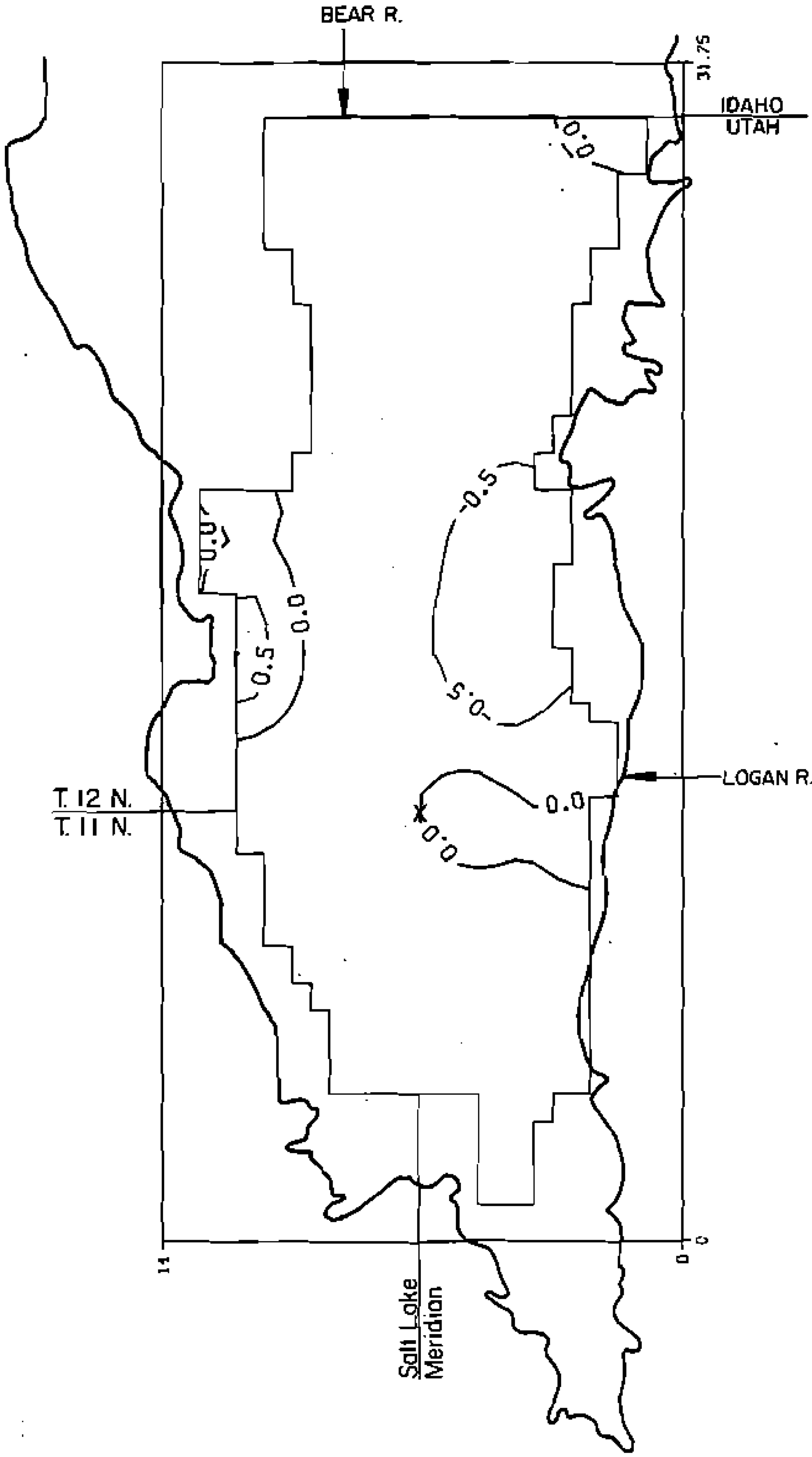

Figure 19b. Calculated water level change map of confined aquifer from March 1970 to March 1971.

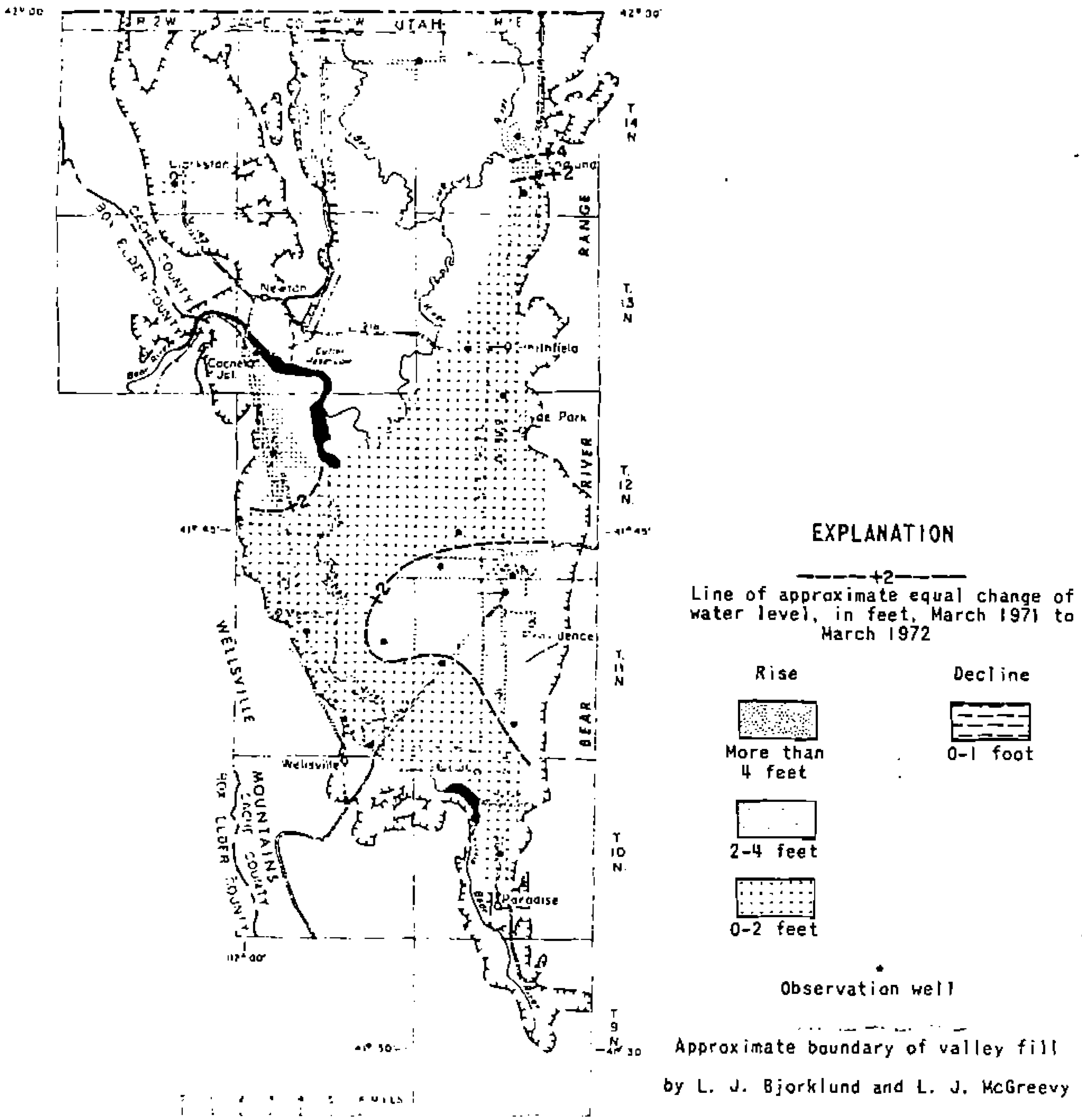

Figure 20a. Observed water level change map of confined aquifer from March 1971 to March 1972. (From "Groundwater Conditions in Utah" 1972.)

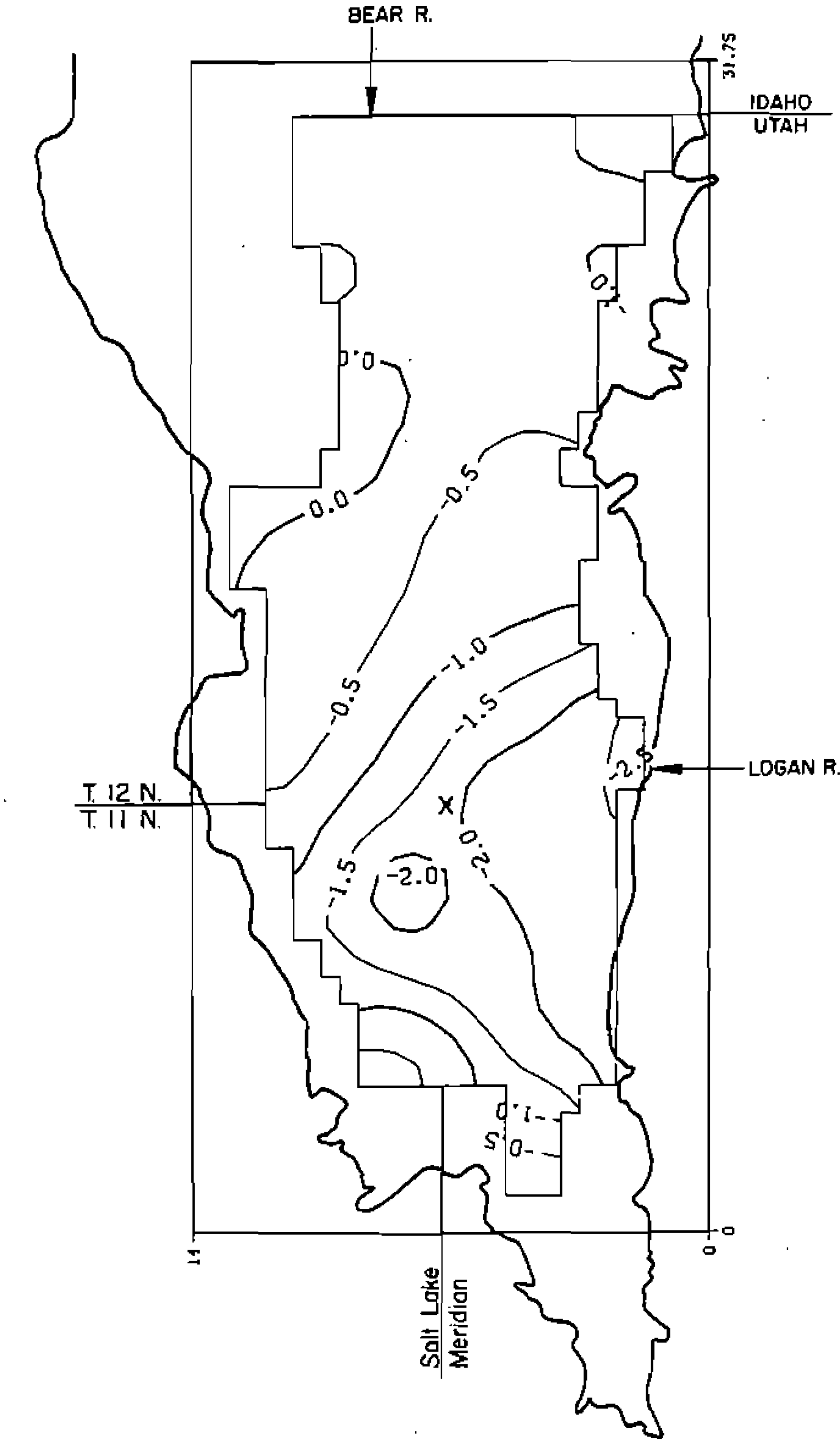

Figure 20b. Calculated water level change map of confined aquifer from March 1971 to March 1972.

coefficients, total pumpage, pumping pattern and recharge flux for each pumping period), the parameter values were not changed during the transient-state calibrations. The parameter values, primarily pumping pattern and recharge flux, were then adjusted until computed water level changes matched observed changes as closely as possible. The calculated water level change maps for the confined aquifer for each of the 3 years are shown in Figures 18b, 19b, and 20b.

The transient-state calibration was started from the calculated water levels rather than the observed for two reasons: first, the observed values were already in the solution ready for the next step; and second, starting from calculated values accumulates errors in the computation and is thus a more difficult test of the model. The model was not sensitive to variation in storage coefficients. A sensitivity study showed that storage coefficients up to 100 times larger or smaller than those used in other simulations did not seriously change model predictions.

The comparison between observed and computed water-level changes for some observation wells over a few years are shown in Figure 21. The model does respond well to different pumpage rates, different pumping patterns and different recharge for each pumping period. While the total amount of annual discharge from the wells was quite well known, other information such as pumping patterns and recharge for each year were not available and had to be assumed first and then adjusted in the calibration process.

The transient-state model parameter input data for generating the water level conditions of March 1969 and the resulting computer output are listed in Appendices C and D.

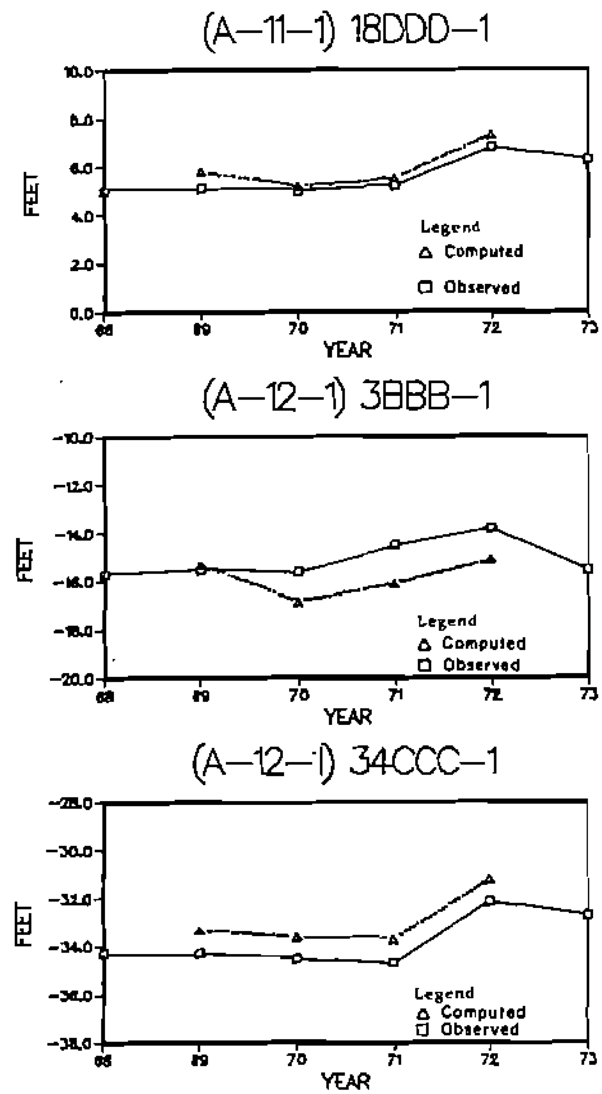

Figure 21a. Comparison between computed and observed water level changes in selected wells.

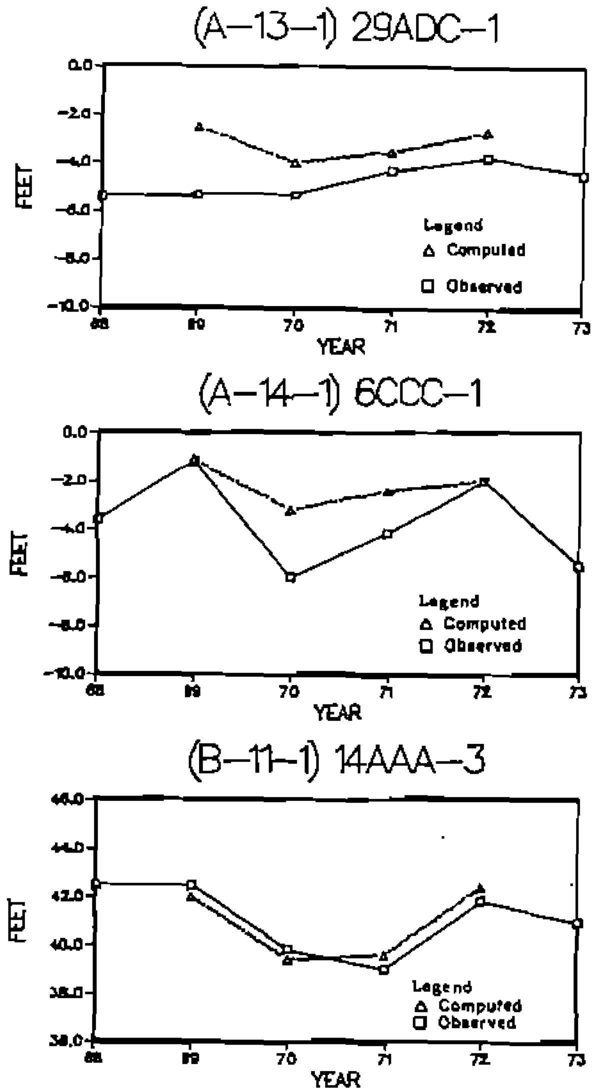

Figure 21b. Comparison between computed and observed water level changes in selected wells.

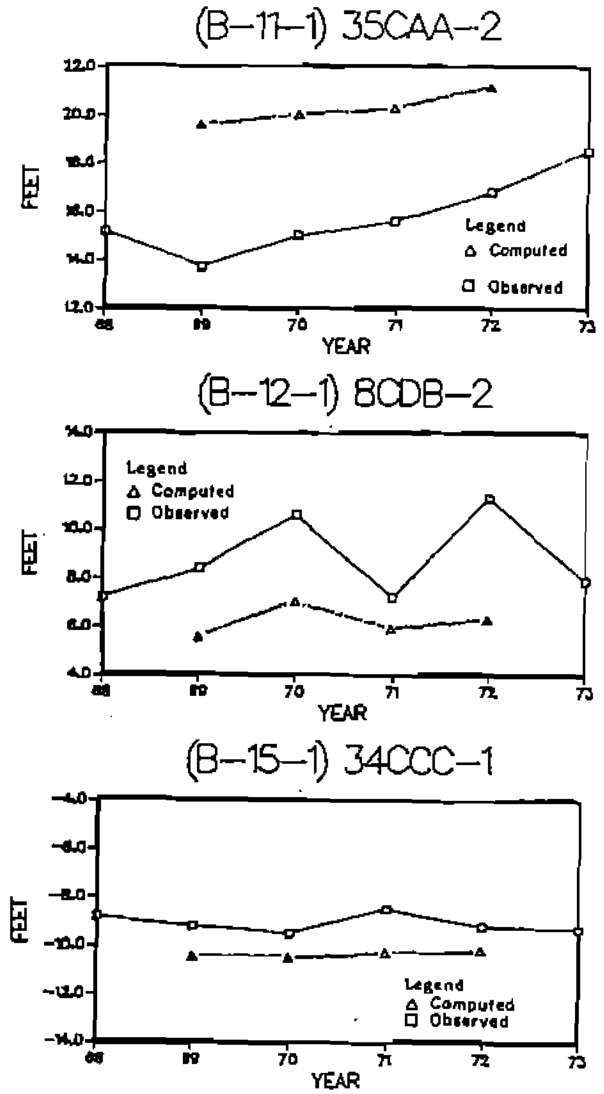

Figure 21c. Comparison between computed and observed water level changes in selected wells.

USE OF THE MODEL FOR MANAGEMENT PURPOSES

Three predictive simulations were made to examine the effects of alternative levels of groundwater development. All three began from the calculated water level configuration of March 1969. The boundary conditions and initial conditions were not changed except for the three levels of development represented by the sets of wells shown in Table 2. All the new wells were assumed to pump water entirely from the confined aquifer.

The first management study examined the effect of drilling two wells, one located at the mouth of Smithfield Canyon (at 18,30) with pumping rate of 3000 gallon per minute (gpm) and another located next to the Natural Resources Building on the campus of Utah State University (at 20,21) with 4500 gpm. Both wells were arbitrarily assumed to pump for 4 hours a day for 5 months of the one year simulation.

The next higher level of new development assumed eight additional irrigation wells, each with a flow rate of 2250 gpm and the same pumping schedule as before. The locations for the wells are shown in Table 2 and Figure 4.

The third predictive simulation assumed the same wells as the second simulation, but the flow rates were twice as large for all wells except the well at node (18,30) where the flow was four times as large. The additional wells and pumping rates in the simulations are somewhat arbitrarily chosen to represent what might happen if such development took place.

The Cache Valley groundwater model computes annual changes in water level

Table 2. New well locations and pumping rates for three predictive simulations.

Preditive Simulation	Well location (node number)	Maximum Pumping rate (gpm)
1*	(20,21)	4500
	(18,30)	3000
2	(20,21)	4500
	(18,30)	3000
	(8,13)	2250
	(8,14)	2250
	(9,13)	2250
	(9,14)	2250
	(8,26)	2250
	(8,27)	2250
	(9,26)	2250
	(9,27)	2250
3	(20,21)	9000
	(18,30)	12000
	(8,13)	4500
	(8,14)	4500
	(9,13)	4500
	(9,14)	4500
	(8,26)	4500
	(8,27)	4500
	(9,27)	4500
	(9,26)	4500

*Locations and pumping rates of the wells in simulation 1 were provided by the Logan Office, Utah Division of Water Rights.

in one increment for the year. Irrigation wells may pump only during the irrigation season. Municipal wells may pump more or less continuously. The model converts the pumping rate into a uniform rate per year. For example, if a well is pumping 4 hours each day for the 5 irrigation months at a flow rate of 10 cfs or 4500 gpm, when converted into a uniform rate per year, the rate will be 0.685 cfs for the entire year.

The water level drawdown maps for the confined aquifer caused by the additional wells under the three year-long management simulations are shown in Figures 22, 23, and 24. Comparison of these maps with the observed and computed water level maps, Figures 6, 7, 14, 15, 16, and 17, shows how the Cache Valley model can be used to estimate the response of the groundwater basin to various development schemes. The Cache Valley model is available as a tool to assist in the better understanding and management of the groundwater basin.

Those wishing to apply the model in solving Cache Valley groundwater management problems should become generally familiar with the program documentation provided by Trescott (1975) and Trescott and Larson (1976). Moreover, the appendices of this report are especially valuable for those wishing to use the Cache Valley model.

Appendix A gives a complete listing of the computer program. Appendix B describes in detail all the necessary input data and their preparation. Appendix C lists the model input for the Cache Valley model and contains the parameter conditions. Appendix D presents the Cache Valley model computer output for the transient-state calibration of March 1969.

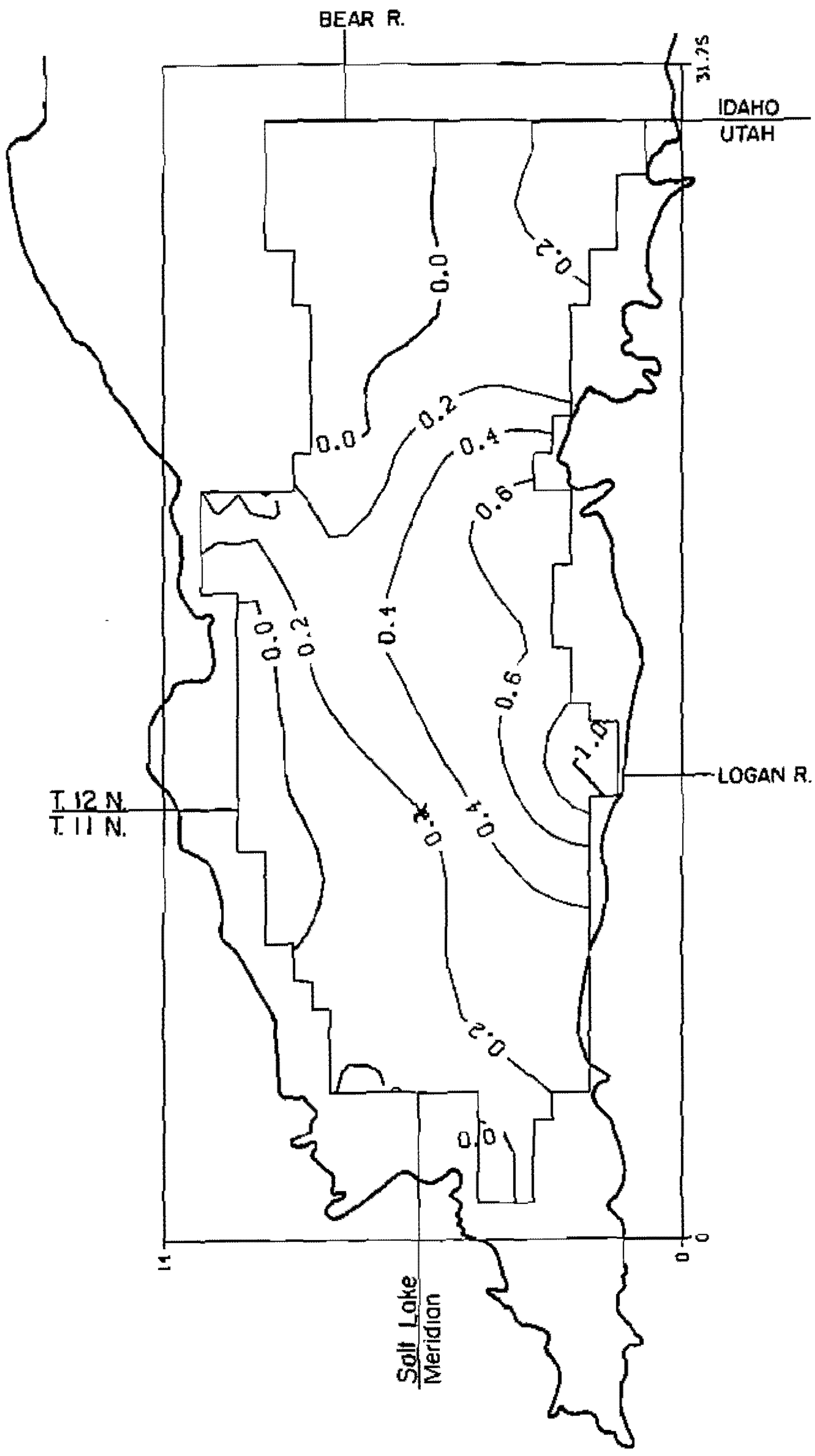

Figure 22. Water level change map of confined aquifer of predictive simulation 1.

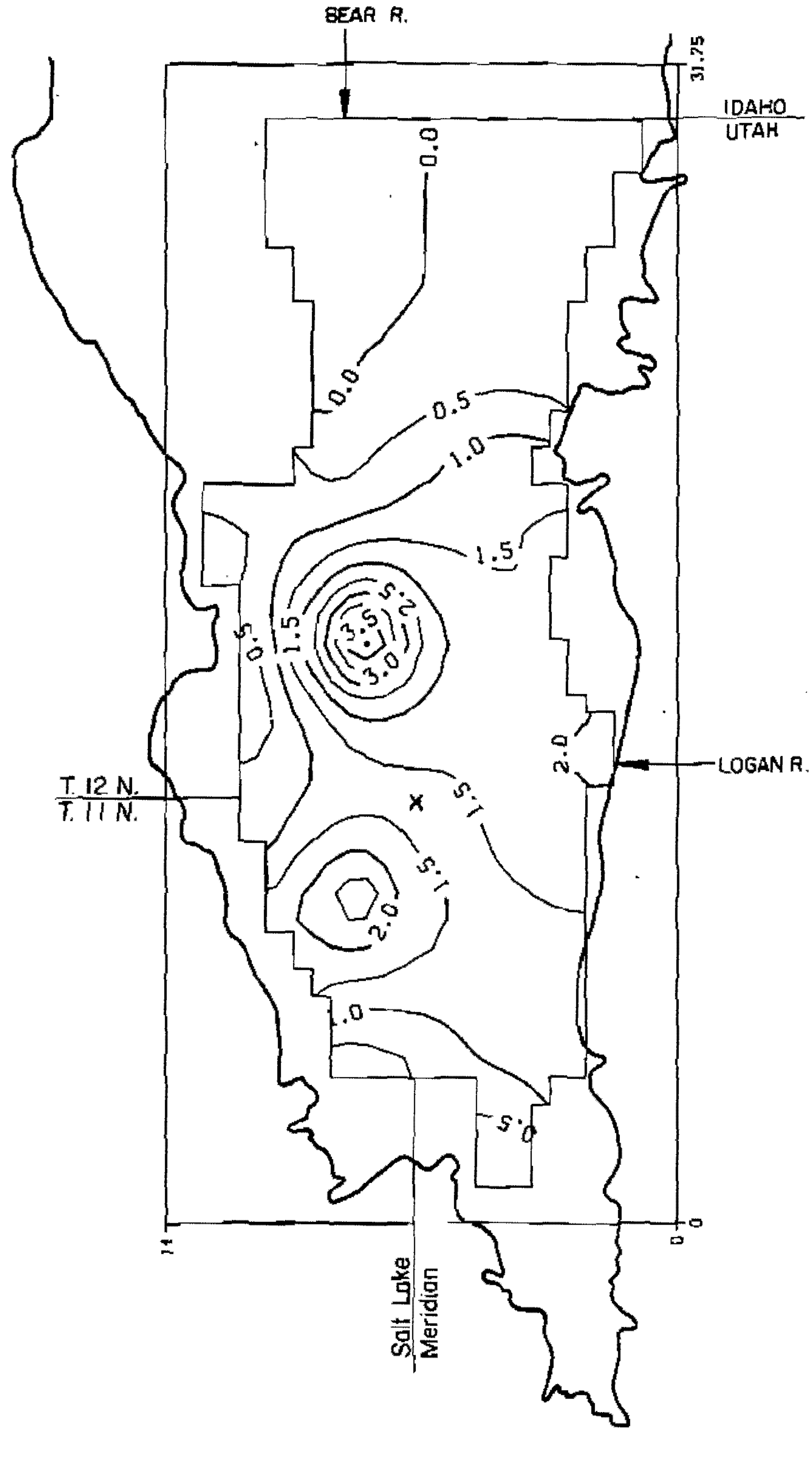

Figure 23. Water level change map of confined aquifer of predictive simulation 2.

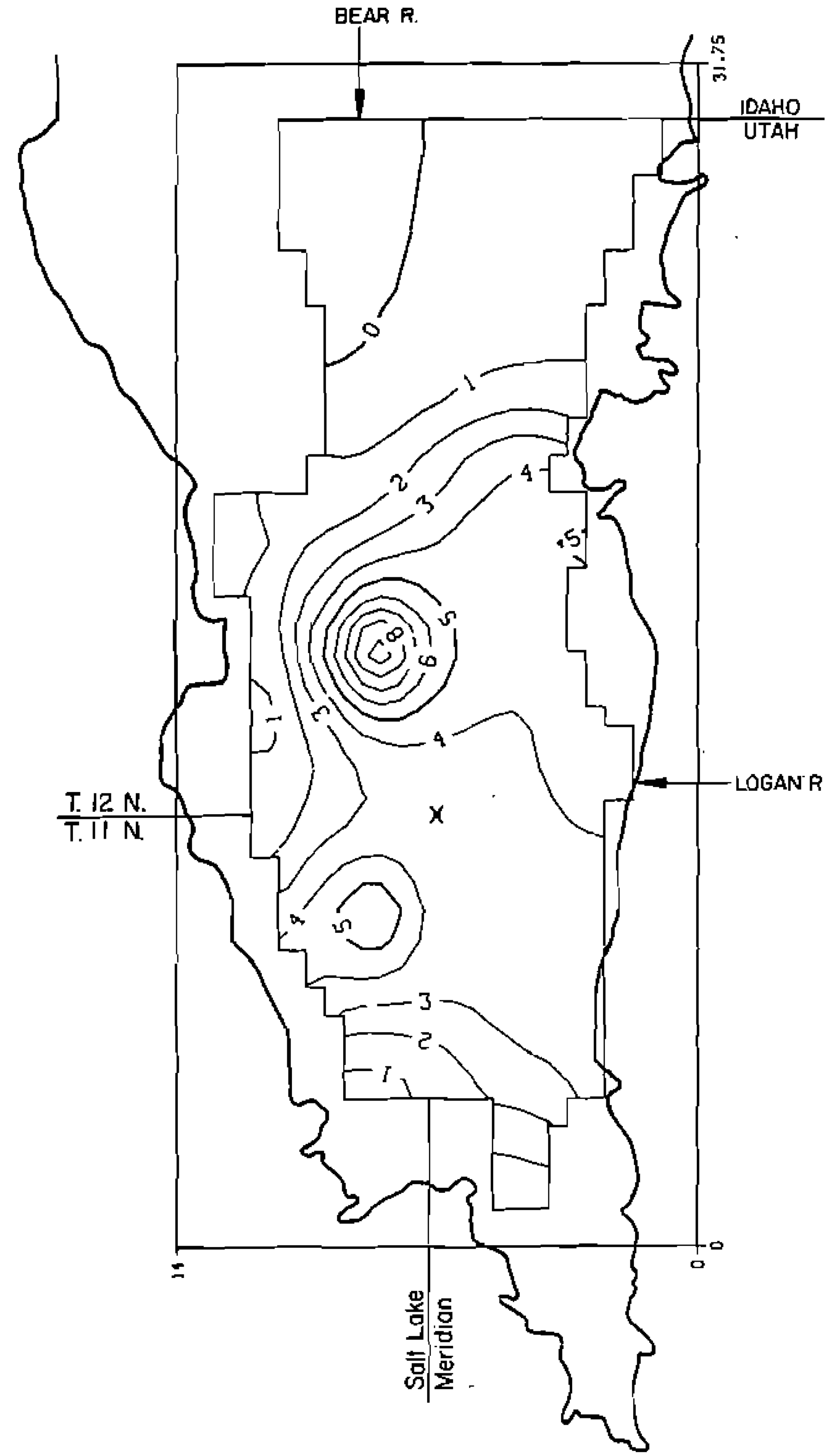

Figure 24. Water level change map of confined aquifer of predictive simulation 3.

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Orderly groundwater development to supply increasing demands requires better information on aquifer systems and tools that can be used to predict how they will respond to different management plans. Quantitative prediction contributes to more efficient water use decisions. This report describes the development, calibration, and use of a quantitative, predictive management model for the groundwater basin of Cache Valley in northern Utah.

More physical information and field data simplify model calibration. In Cache Valley, complicated geologic conditions, a large number of pumping and flowing wells without discharge information on pumping rates and pumping patterns, and limited information on other parameters added to the work required in calibrating the model.

The development of the Cache Valley groundwater model as described above illustrates how a model can be adapted, calibrated, and applied, given complicated hydrologic, hydraulic and geologic conditions in the model area and limited historical data and field measurements. The model represents a complex natural system with one unconfined and one confined aquifer. The single layer confined aquifer represents several real aquifer layers by using equivalent storage properties. The potentiometric head of the hypothetical single confined aquifer represents average head conditions over several separate confined aquifers. River nodes, spring nodes and constant head nodes are used to simulate real interactions of rivers, streams, springs or reservoirs with the aquifers. The river channels of the Bear River and Cub River were represented by constant head nodes rather than river nodes, as a strategy to separate the two unconfined aquifers and save computer time and storage. Modification of the computer code by adding "evapotranspiration" was necessary because phreatic evapotranspiration plays such an important role in groundwater conditions in Cache Valley. The large number of wells and the sparse information about well discharge and pumping duration required lumping the drafts from many small wells together at nodes so as to keep the total annual draft in line with the known water budget. This method is believed to be accurate enough for the model construction under the limitations of time and financial support for the project.

The mouths of the Logan River and Smithfield Canyon are two of the major groundwater recharge zones. Large amounts of water enter the basin there because of the high transmissivity (over 100,000 ft^2 per day) and the availability of recharge from the rivers. Smaller amounts of recharge occur at the mouths of smaller, intermittent or ephemeral streams, such as Blacksmith Fork, Providence Canyon, High Creek, Cherry Creek, Summit Creek, Spring Creek, etc.

The quantity of water entering Cache Valley is equal to the quantity leaving the valley plus or minus the change in storage within the valley. Under natural conditions, the change in groundwater storage is small, and discharge is approximately equal to recharge. Deep subsurface outflow from the valley is believed to be negligible. The average annual amount of water withdrawal from wells in Cache Valley is about 26,000 acre-feet, and about 82 percent of the amount is in Utah. This percentage is an average number estimated from the records of the past years. According to the model, the amount of recharge into the confined aquifer less the pumpage is the total amount of upward leakage, since there is no subsurface outflow and an impermeable bottom boundary is assumed in the model. This amount of upward leakage is about 58,000 acre-feet annually and represents a conservative estimate of the additional groundwater that can be withdrawn from the confined aquifer. However, increased withdrawals will lower the head and diminish the discharge from some flowing wells in the artesian areas. Increased withdrawals would also dry up some wet areas and reduce nonproductive evapotranspiration. This pumping could, however, have an adverse effect on wildlife wet lands habitat and would have to be managed carefully. The model provides a quantitative tool for calculating these effects.

The Smithfield-Hyrum-Wellsville area (area 1 in Figure 3) is the largest and most productive aquifer system in Cache Valley. Although this overflowing groundwater area is the most intensely developed in the valley, little long-term change in water levels has occurred (Bjorklund and McGreevy 1971). This area has great potential for further groundwater development because it has high transmissivity (from about 10,000 to over 100,000 ft^2 per day) and is supplied large amounts of water by recharge from rivers and streams into permeable sands and gravels at the canyon mouths. Other significant recharge is from the irrigation canals which are located along the edges of the valley where water infiltrates most readily. Probably the best sites for developing future large wells are around the mouths of Smithfield Canyon, the Logan River, and Blacksmith Fork. The water level change maps resulting from the predictive simulations shown in Figures 22, 23 and 24 give some indication of water level changes under future development.

The grid system map, shown in Figure 13, summarizes the locations and numbers of existing wells within each grid cell area. This map is helpful in visualizing the effects of well pumpage on drawdown. The observed water level change map from March 1969 to March 1970 in Figure 18a shows three regions with more drawdown than surrounding areas. Comparing this with the well location map of Figure 13, these regions are also observed to have more wells. Apparently, the larger drawdown resulted from larger pumpage because of the many wells in the region. While there is no evident overdraft, in some of these intensive pumping centers, attention should be given to controlling local development so as to reduce the extra drawdown due to well interference.

To improve the model and increase the reliability of its predictions, future groundwater investigations in Cache Valley should include more detailed study of the geologic formations, especially for the Bear River delta area, south of Utah-Idaho state line and between the Bear River and Cub River channel. No really deep wells have been drilled in this area. Potentially productive confined aquifers should lie beneath the delta deposits in the older deposits, but they have not been explored. More effort should go into collecting accurate well logs for all new wells that are drilled.

Another region needing more investigation is near Benson where some deeper wells are located. The more than 1000 feet thick Quaternary deposits need further definition. In the present model, the simulated water levels of the confined aquifer in this area are somewhat lower than the observed water levels in the deepest wells, due to the upward groundwater gradient in the deeper aquifers that is not now simulated.

An expanded observation well network needs to be established where water levels can be measured in each layer annually or monthly. Well pumping tests also should be done near Benson, Wellsville, Amalga, and in the Bear River delta area near the state line in order to obtain better aquifer characteristics information. More complete data on discharge schedules for both pumping and flowing wells should be collected to improve the estimates of the total draft and its distribution during the year.

After several years of collecting additional data, it could be used to recalibrate and to improve the present yearly model. It might also be possible, using the new data and simulation information from the improved yearly model, to develop a more useful monthly or seasonly model for the Cache Valley in Utah. The model should also be extended to cover the portion of Cache Valley in Idaho. The techniques and methods developed for the Cache Valley model could also be applied to other geologically and hydrologically similar areas.

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Appendix A

Computer Program Listing

```
33   C     ------------------------------------------------------------------
33   C     FINITE-DIFFERENCE MODEL FOR SIMULATION OF GROUND-WATER FLOW IN
33   C     THREE DIMENSIONS, SEPTEMBER, 1975 BY P.C. TRESCOTT, U. S. G. S.
33   C     WITH CONTRIBUTIONS TO MAIN, DATAI AND SOLVE BY S.P. LARSON
33   C     ------------------------------------------------------------------
33   C
33   C     SPECIFICATIONS:
33         CHARACTER *4NAME,INFT,IOFT
33         CHARACTER *4IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IORE,IPU1,IPU2,ITK
36         CHARACTER *4ICHK,IEQN,IEVAP,IALT,IDNPP,IMAPP
33   C
33         DIMENSION Y(40100),L(36),HEADNG(33),NAME(48),INFT(2,3),IOFT(9,4)
33        1,DUM(3)
33   C
33         COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,NP,N
33        1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NC
33        2H,IDK1,IDK2,IWATER,IORE,IP,JP,IO,JO,KQ,IK,JK,K5,IPU1,IPU2,ITK,IID
36        3,IEQN,IEVAP,IALT,IDNPP,IMAPP
33         COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,DET,EVDIST
36         COMMON /SARRAY/ ICHK(15),LEVEL1(9),LEVEL2(9)
33   C
33         DATA NAME/2*4H    ,4H   S,4HTART,4HING ,4HHEAD,4H    ,4H STO,4HRAG
33        1E,4H COE,4HFFIC,4HIENT,2*4H    ,4H  TR,4HANSM,4HISSI,4HVITY,5*4H
33        2    ,4H  TK,4H  HY,4HDRAU,4HLIC ,4HCOND,4HUCTI,4HVITY,2*4H    ,4HBOT
33        3T,4HOM E,4HLEVA,4HTION,2*4H    ,4H   R,4HECHA,4HRGE ,4HRATE,4H  LA
33        4,4HND S,4HURFA,4HCE E,4HLEVA,4HTION/
33         DATA INFT/4H(20G,4H4.0),4H(8F1,4H0.4),4H(10G,4H8.0)/
33         DATA IOFT/4H(1H0,4H,I2,,4H2X,2,4H0F6.,4H1/(5,4HX,20,4HF6.1,4H))  ,
33        14H    ,4H(1H0,4H,I5,,4H14F9,4H.5/(,4H1H  ,,4H5X,1,4H4F9.,4H5)) ,4H
33        2    ,4H(1H0,4H,I5,,4H10E1,4H2.5/,4H(1H ,4H,5X,,4H10E1,4H2.5),4H)
33        3,4H(1H0,4H,I5,,4H10E1,4H1.3/,4H(1H ,4H,5X,,4H10E1,4H1.3),4H)    /
33   C
33         DEFINE FILE 2(8,1520,U,KKK)
33   C     ..................................................................
33   C
33   C     ---READ TITLE, PROGRAM SIZE AND OPTIONS---
33         READ (5,200) HEADNG
33         WRITE (6,190) HEADNG
36         READ(5,140)IO,JO,KO,ITMAX,NCH,NSP,NRIV
33         IF(IO*JO*KO.LT.40000) GO TO 52411
33         WRITE(6,52412)IO,JO,KO
33   52412 FORMAT('EXCEEDED DIMENSION  3I5)
33         STOP
33   52411 WRITE(6,180)IO,JO,KO,ITMAX,NCH,NSP,NRIV
33         READ (5,210) IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IORE,IPU1,IPU2,ITK
36        1,IEQN,IEVAP,IALT,IDNPP,IMAPP
33         WRITE (6,220) IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IORE,IPU1,IPU2,ITK
36        1,IEQN,IEVAP,IALT,IDNPP,IMAPP
33         IERR=0
33         INO=NSP
33   C
33   C     ---COMPUTE DIMENSIONS FOR ARRAYS---
33         J1=JO-1
31         I1=IO-1
33         K1=KO-1
33         I2=IO-2
33         J2=JO-2
33         K2=KO-2
33         IMAX=MAX0(IO,JO)
33         NCD=MAX0(1,NCH)
33         ITMX1=ITMAX+1
33         ISIZ=IO*JO*KO
33         IK1=IO*JO
33         IK2=MAX0(IK1*K1,1)
33         ISUM=2*ISIZ+1
33         L(1)=1
33         DO 30 I=2,14
33         IF (I.NE.8) GO TO 20
33         L(8)=ISUM
33         ISUM=ISUM+IK2
33         IF (IK2.EQ.1) GO TO 10
33         IK=IO
33         JK=JO
33         K5=K1
33         GO TO 30
33      10 IK=1
33         JK=1
33         K5=1
33         GO TO 30
33      20 L(I)=ISUM
33         ISUM=ISUM+ISIZ
33      30 CONTINUE
33         L(15)=ISUM
33         ISUM=ISUM+JO
33         L(16)=ISUM
33         ISUM=ISUM+IO
33         L(17)=ISUM
33         ISUM=ISUM+KO
33         L(18)=ISUM
33         ISUM=ISUM+IMAX
33         L(19)=ISUM
33         ISUM=ISUM+KO*3
33         L(20)=ISUM
33         ISUM=ISUM+ITMX1
33         L(21)=ISUM
33         ISUM=ISUM+3*NCD
33         L(22)=ISUM
33         ISUM=ISUM+NCD
33         L(23)=ISUM
33         IF (IWATER.NE.ICHK(6)) GO TO 40
33         ISUM=ISUM+IK1
33         L(24)=ISUM
33         ISUM=ISUM+IK1
33         IP=IO
33         JP=JO
33         GO TO 50
33      40 ISUM=ISUM+1
33         L(24)=ISUM
33         ISUM=ISUM+1
33         IP=1
33         JP=1
33      50 L(25)=ISUM
```

```
      IF (IORE.NE.ICHK(7)) GO TO 60
      ISUM=ISUM+ISIZ
      IO=IO
      JO=JO
      KO=KO
      GO TO 70
   60 ISUM=ISUM+1
      IO=1
      JO=1
      KO=1
   70 IF(NSP.EQ.0) GO TO 75
      L(26)=ISUM
      ISUM=ISUM+ISIZ
      L(27)=ISUM
      ISUM=ISUM+NSP
      L(28)=ISUM
      ISUM=ISUM+NSP
      GO TO 76
   75 L(26)=ISUM
      ISUM=ISUM+1
      L(27)=ISUM
      ISUM=ISUM+1
      L(28)=ISUM
   76 IF(NRIV.EQ.0) GO TO 77
      L(29)=ISUM
      ISUM=ISUM+ISIZ
      L(30)=ISUM
      ISUM=ISUM+NRIV
      L(31)=ISUM
      ISUM=ISUM+NRIV
      L(32)=ISUM
      ISUM=ISUM+NRIV
      GO TO 71
   77 L(29)=ISUM
      L(30)=ISUM+1
      L(31)=ISUM+2
      L(32)=ISUM+3
      ISUM=ISUM+4
   71 IF(IALT.EQ.ICHK(13)) GO TO 72
      L(33)=ISUM
      ISUM=ISUM+1
      L(34)=ISUM
      ISUM=ISUM+1
      L(35)=ISUM
      ISUM=ISUM+1
      GO TO 78
   72 L(33)=ISUM
      ISUM=ISUM+ISIZ
      L(34)=ISUM
      ISUM=ISUM+ISIZ
      L(35)=ISUM
      ISUM=ISUM+ISIZ
   78 IF (IEVAP.NE.ICHK(12)) GO TO 66
      L(36)=ISUM
      ISUM=ISUM+IK1
      GO TO 79
   66 L(36)=ISUM
   79 WRITE (6,170) ISUM
C
C     ---PASS INITIAL ADDRESSES OF ARRAYS TO SUBROUTINES---
      L1=L(1)
      L2=L(2)
      L3=L(3)
      L4=L(4)
      L5=L(5)
      L6=L(6)
      L7=L(7)
      L8=L(8)
      L9=L(9)
      L15=L(15)
      L16=L(16)
      L17=L(17)
      L19=L(19)
      L23=L(23)
      L24=L(24)
      L25=L(25)
      L26=L(26)
      L28=L(28)
      L29=L(29)
      L30=L(30)
      L27=L(27)
      L31=L(31)
      L32=L(32)
      L33=L(33)
      L34=L(34)
      L35=L(35)
      L36=L(36)
      CALL DATAI(Y(L1),Y(L2),Y(L3),Y(L4),Y(L5),Y(L6),Y(L7),Y(L8),Y(L9),
     1Y(L15),Y(L16),Y(L17),Y(L19),Y(L23),Y(L24),Y(L25),Y(L26),Y(L27),Y(L
     228),Y(L29),Y(L30),Y(L31),Y(L32),Y(L2),Y(L33),Y(L34),Y(L35),Y(L36))
      L18=L(18)
      L20=L(20)
      CALL STEP(Y(L1),Y(L2),Y(L3),Y(L4),Y(L5),Y(L6),Y(L7),Y(L8),Y(L9),Y(
     1L15),Y(L16),Y(L17),Y(L19),Y(L18),Y(L20))
      L10=L(10)
      L11=L(11)
      L12=L(12)
      L13=L(13)
      L14=L(14)
      CALL SOLVE(Y(L1),Y(L2),Y(L3),Y(L4),Y(L5),Y(L6),Y(L7),Y(L8),Y(L9),
     1Y(L15),Y(L16),Y(L17),Y(L19),Y(L10),Y(L11),Y(L12),Y(L13),Y(L14),Y(L
     220),Y(L25),Y(L23),Y(L26),Y(L27),Y(L28),Y(L29),Y(L30),Y(L31),Y(L32)
     3,NSP,NRIV,Y(L24),Y(L26))
      CALL COEF(Y(L1),Y(L2),Y(L3),Y(L4),Y(L5),Y(L6),Y(L7),Y(L8),Y(L9),
     1Y(L15),Y(L16),Y(L17),Y(L19),Y(L23),Y(L24),Y(L25))
      L21=L(21)
      L22=L(22)
      CALL CHECKI(Y(L1),Y(L2),Y(L3),Y(L4),Y(L5),Y(L6),Y(L7),Y(L8),Y(L9)
     1,Y(L15),Y(L16),Y(L17),Y(L19),Y(L2[illegible]
     2Y(L28),Y(L29),Y(L30),Y(L31),Y(L32),NSP,NRIV,Y(L24),Y(L26),[illegible]
      CALL PRNTOI(Y(L1),Y(L2),Y(L4),Y(L5),Y(L7),Y(L15),Y(L19))
C
```

```
C      START COMPUTATIONS
C
C      ---READ AND WRITE DATA FOR GROUPS II AND III---
       CALL DATAIN
       IRN=1
       NIJ=IO*JO
       DO 80 K=1,KO
       LOC=L(2)+(K-1)*NIJ
    80 CALL ARRAY(Y(LOC),INFT(1,2),IOFT(1,1),NAME(1),IRN,DUM)
       DO 90 K=1,KO
       LOC=L(5)+(K-1)*NIJ
    90 CALL ARRAY(Y(LOC),INFT(1,1),IOFT(1,2),NAME(7),IRN,DUM)
       DO 100 K=1,KO
       LOC=L(4)+(K-1)*NIJ
       LL1=L(19)+K-1
       LL2=L(19)+KO+K-1
       LL3=L(17)+2*KO+K-1
       CALL ARRAY(Y(LOC),INFT(1,3),IOFT(1,2),NAME(13),IRN,DUM)
       Y(LL1)=DUM(1)
       Y(LL2)=DUM(2)
       Y(LL3)=DUM(3)
   100 WRITE (6,230) K,Y(LL1),Y(LL2),Y(LL3)
       IF (ITK.NE.ICHK(10)) GO TO 120
       DO 110 K=1,K1
       LOC=L(8)+(K-1)*NIJ
   110 CALL ARRAY(Y(LOC),INFT(1,1),IOFT(1,3),NAME(19),IRN,DUM)
   120 IF (IWATER.NE.ICHK(6)) GO TO 130
       K=KO
       CALL ARRAY(Y(L23),INFT(1,1),IOFT(1,3),NAME(25),IRN,DUM)
       CALL ARRAY(Y(L24),INFT(1,1),IOFT(1,1),NAME(31),IRN,DUM)
   130 IF(IORE.NE.ICHK(7)) GO TO 132
       DO 131 K=1,KO
       LOC=L(25)+(K-1)*NIJ
   131 CALL ARRAY(Y(LOC),INFT(1,1),IOFT(1,4),NAME(37),IRN,DUM)
   132 IF(IEVAP.NE.ICHK(12)) GO TO 135
       K=KO
       CALL ARRAY(Y(L36),INFT(1,2),IOFT(1,1),NAME(43),IRN,DUM)
   135 CALL NDAT
       IF(NSP.NE.0) CALL DDAT(NSP)
       IF(NRIV.NE.0) CALL DDAT2(NRIV)
C
C      ---COMPUTE TRANSMISSIVITY FOR UNCONFINED LAYER---
       IF (IWATER.EQ.ICHK(6)) CALL TRANS(1)
C
C      ---COMPUTE T COEFFICIENTS---
       CALL TCOF
C
C      ---COMPUTE ITERATION PARAMETERS---
       CALL ITER
       GO TO 142
C
C      ---READ RECHARGE FLUX FOR A NEW PUMPING PERIOD---
   140 DO 141 K=1,KO
       LOC=L(25)+(K-1)*NIJ
   141 CALL ARRAY(Y(LOC),INFT(1,1),IOFT(1,4),NAME(37),IRN,DUM)
C
C      ---READ TIME PARAMETERS AND PUMPING DATA FOR NEW PUMPING PERIOD-
   142 CALL NEWPER
C
       KT=0
       IFINAL=0
C
C      ---START NEW TIME STEP COMPUTATIONS---
   150 CALL NEWSTP
C
C      ---START NEW ITERATION IF MAXIMUM NO. ITERATIONS NOT EXCEEDED---
       CALL NEWITA
C
C      ---PRINT OUTPUT AT DESIGNATED TIME STEPS---
       CALL OUTPUT
C
C      ---LAST TIME STEP IN PUMPING PERIOD ?---
       IF (IFINAL.NE.1) GO TO 150
C
C      ---CHECK FOR NEW PUMPING PERIOD---
       IF (KP.LT.NPER) GO TO 140
C
       STOP
C
C      ---FORMATS---
C
C
C
   160 FORMAT (8I10)
   170 FORMAT ('0',54X,'WORDS OF VECTOR Y USED =',I7)
   180 FORMAT ('0',62X,'NUMBER OF ROWS =',I5/60X,'NUMBER OF COLUMNS =',I5
      1/61X,'NUMBER OF LAYERS =',I5//39X,'MAXIMUM PERMITTED NUMBER OF ITE
      2RATIONS =',I5//48X,'NUMBER OF CONSTANT HEAD NODES =',I5,
      3 /,55X,'NUMBER OF SPRING NODES =',I5,
      4 /,56X,'NUMBER OF RIVER NODES =',I5)
   190 FORMAT('1',32A4,A3)
   200 FORMAT (20A4)
   210 FORMAT (16(A4,1X))
   220 FORMAT ('-SIMULATION OPTIONS:   ',15(A4,2X))
   230 FORMAT (1H0,44X,'DIRECTIONAL TRANSMISSIVITY MULTIPLICATION FACTORS
      1 FOR LAYER',I3,/,76X,'X =',G15.7/76X,'Y =',G15.7/76X,'Z =',G15.7)
       END
       SUBROUTINE DATAI(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FAC
      1T,PERM,BOTTOM,ORE,ID,FLD,ELD,IDR,RH,RC,RB,A,NWELL,AWELL,RCF,GFNO)
C      ------------------------------------------------------------------
C      READ AND WRITE DATA
C      ------------------------------------------------------------------
C
C      SPECIFICATIONS:
       REAL *4 ID,IDR,NWELL
       CHARACTER *4 INFT,IOFT,IN
       CHARACTER *8XLABEL,YLABEL,TITLE,MESUR
       CHARACTER *4ICHK,VF1,VF2,VF3,DIGIT,IEQN,IEVAP,IALT,IDRP,INAPP
       CHARACTER *4IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IORE,IPU1,IPU2,ITK
       CHARACTER *1SYM,PRNT,BLANK
C
       COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
```

```
      IVEL,HUNT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IEPR,I2,J2,K2,IMAX,ITMX1,NC
     2H,IDK1,IDK2,IWATER,IORE,IP,JP,IO,JO,KO,IK,JK,K5,IFU1,IFU2,ITK,INO
     3,IEON,IEVAP,IALT,INPP,IMAPP
      COMMON /SPARAM/ TMAX,COLT,DELT,ERR,TEST,SUM,SUMP,OR,QET,ETDIST
      COMMON /SARRAY/ ICHK(16),LEVEL1(9),LEVEL2(9)
      COMMON /CK/ ETFLXT,STORT,QRET,CHST,CHDT,RFLXT,PUMPT,CFLUXT,SFLXT
      COMMON /PR/ XLABEL(3),YLABEL(6),TITLE(8),XN1,MESUR,PRNT(122),BLANK
     1(60),DIGIT(122),VF1(6),VF2(5),VF3(7),XSCALE,DINCH,SYM(17),XN(100),
     2YN(13),NA(4),N1,N2,N3,YSCALE,FACT1,FACT2
C
      DIMENSION PHI(IO,JO,KO), STRT(IO,JO,KO), OLD(IO,JO,KO), T(IO,JO,KO
     1), S(IO,JO,KO), TR(IO,JO,KO), TC(IO,JO,KO), TK(IK,JK,K5), WELL(IO,
     2JO,KO), DELX(JO), DELY(IO), DELZ(KO), FACT(KO,3), PERM(IP,JP), BOT
     3TOM(IP,JP),QRE(IO,JO,KO),TF(3),A(IO,JO),IN(6),IOFT(9),INFT(2)
     4 ,ID(IO,JO,KO),FLD(1),ELD(1),IDR(IO,JO,KO),RH(1),RC(1),RS(1)
     5,BWELL(IO,JO,KO),HWELL(IO,JO,KO),RCF(IO,JO,KO),GRND(IO,JO)
C
      RETURN
C     ......................................................................
C     ***********************
      ENTRY DATAIN
C     ***********************
C
C     ---READ AND WRITE SCALAR PARAMETERS---
      READ (5,330) NPER,KTH,ERR,LENGTH,QET,ETDIST
      WRITE (6,340) NPER,KTH,ERR,QET,ETDIST
      READ (5,460) XSCALE,YSCALE,DINCH,FACT1,(LEVEL1(I),I=1,9),FACT2,(LE
     1VEL2(I),I=1,9),MESUR
      IF (XSCALE.NE.0.) WRITE (6,470) XSCALE,YSCALE,MESUR,MESUR,DINCH,FA
     1CT1,LEVEL1,FACT2,LEVEL2
C
C     ---READ CUMULATIVE MASS BALANCE PARAMETERS---
      READ (5,450) SUM,SUMP,PUMPT,CFLUXT,QRET,CHST,CHDT,RFLXT,STORT,ETFL
     1XT,SFLXT
      IF (IDK1.EQ.ICHK(4)) GO TO 20
      IF (IFU1.NE.ICHK(8)) GO TO 50
C
C     ---READ INITIAL HEAD VALUES FROM CARDS---
      DO 10 K=1,KO
      DO 10 I=1,IO
   10 READ (5,360) (PHI(I,J,K),J=1,JO)
      GO TO 30
C
C     ---READ INITIAL HEAD AND MASS BALANCE PARAMETERS FROM DISK---
   20 READ (4) PHI,SUM,SUMP,PUMPT,CFLUXT,QRET,CHST,CHDT,RFLXT,STORT,ETFL
     1XT,SFLXT
      REWIND 4
   30 WRITE (6,430) SUM
      DO 40 K=1,KO
      WRITE (6,440) K
      DO 40 I=1,IO
   40 WRITE (6,350) I,(PHI(I,J,K),J=1,JO)
C
   50 DO 60 K=1,KO
      DO 60 I=1,IO
      DO 60 J=1,JO
      WELL(I,J,K)=0.
      TR(I,J,K)=0.
      TC(I,J,K)=0.
      IF (K.NE.KO) TK(I,J,K)=0.
   60 CONTINUE
      RETURN
C     ***********************
      ENTRY ARRAY(A,INFT,IOFT,IN,IRN,TF)
C     ***********************
      READ (5,330) FAC,IVAR,IPRN,TF,IRECS,IRECD
      IC=4*IRECS+2*IVAR+IPRN+1
      GO TO (70,70,90,90,120,120), IC
   70 DO 80 I=1,IO
      DO 80 J=1,JO
   80 A(I,J)=FAC
      WRITE (6,280) IN,FAC,K
      GO TO 140
   90 IF (IC.EQ.3) WRITE (6,290) IN,K
      DO 110 I=1,IO
      READ (5,INFT) (A(I,J),J=1,JO)
      DO 100 J=1,JO
  100 A(I,J)=A(I,J)*FAC
  110 IF (IC.EQ.3) WRITE (6,IOFT) I,(A(I,J),J=1,JO)
      GO TO 140
  120 READ (2'IRN) A
      IF (IC.EQ.6) GO TO 140
      WRITE (6,290) IN,K
      DO 130 I=1,IO
  130 WRITE (6,IOFT) I,(A(I,J),J=1,JO)
  140 IF (IRECD.EQ.1) WRITE (3'IRN) A
      IRN=IRN+1
      RETURN
C     ***********************
      ENTRY NOAT
C     ***********************
      DO 150 K=1,KO
      DO 150 I=1,IO
      DO 150 J=1,JO
      IF (I.EQ.1.OR.I.EQ.IO.OR.J.EQ.1.OR.J.EQ.JO) T(I,J,K)=0.
      IF (IDK1.NE.ICHK(4).AND.IFU1.NE.ICHK(8)) PHI(I,J,K)=STRT(I,J,K)
      IF (K.NE.KO.OR.IWATER.NE.ICHK(6)) GO TO 150
      IF (I.EQ.1.OR.I.EQ.IO.OR.J.EQ.1.OR.J.EQ.JO) PERM(I,J)=0.
  150 CONTINUE
C     ............................... DELX ...............................
      READ (5,330) FAC,IVAR,IPRN
      IF (IVAR.EQ.1) READ (5,330) (DELX(J),J=1,JO)
      DO 170 J=1,JO
      IF (IVAR.NE.1) GO TO 160
      DELX(J)=DELX(J)*FAC
      GO TO 170
  160 DELX(J)=FAC
  170 CONTINUE
      IF (IVAR.EQ.1.AND.IPRN.NE.1) WRITE (6,370) (DELX(J),J=1,JO)
      IF (IVAR.EQ.0) WRITE (6,390) FAC
C     ............................... DELY ...............................
      READ (5,330) FAC,IVAR,IPRN
```

```
      IF (IVAR.EQ.1) READ (5,330) (DELY(I),I=1,IO)
      DO 190 I=1,IO
      IF (IVAR.NE.1) GO TO 180
      DELY(I)=DELY(I)*FAC
      GO TO 190
  180 DELY(I)=FAC
  190 CONTINUE
      IF (IVAR.EQ.1.AND.IPRN.NE.1) WRITE (6,380) (DELY(I),I=1,IO)
      IF (IVAR.EQ.0) WRITE (6,310) FAC
C     ................................ DELZ ..............................
      READ (5,330) FAC,IVAR,IPRN
      IF (IVAR.EQ.1) READ (5,330) (DELZ(K),K=1,KO)
      DO 210 K=1,KO
      IF (IVAR.NE.1) GO TO 200
      DELZ(K)=DELZ(K)*FAC
      GO TO 210
  200 DELZ(K)=FAC
  210 CONTINUE
      IF (IVAR.EQ.1.AND.IPRN.NE.1) WRITE (6,390) (DELZ(K),K=1,KO)
      IF (IVAR.EQ.0) WRITE (6,320) FAC
C
C     ---INITIALIZE VARIABLES---
      B=0.
      D=0.
      F=0.
      H=0.
      SU=0.
      Z=0.
      IF (XSCALE.NE.0.) CALL MAP
      RETURN
C     ************************
      ENTRY DDAT(NSP)
C     ************************
      NK=1
      DO501 K=1,KO
      DO 500 I=1,IO
      READ 510, (ID(I,J,K),J=1,JO)
  510 FORMAT (80I1.0)
      DO 500 J=1,JO
      IF(ID(I,J,K).EQ.0.) GO TO 500
      ID(I,J,K) = FLOAT(NK)
      NK=NK+1
  500 CONTINUE
  501 CONTINUE
      NK=NK-1
      IF(NK.EQ.NSP) GO TO 520
      PRINT 515,NK,NSP
  515 FORMAT ('  ERROR***NK.NE.NSP     NK=',I5,5X,'NSP=',I5)
      STOP
  520 READ 330,FAC
      PRINT 521,FAC
  521 FORMAT(1H0,G10.4)
      READ 530, (FLD(I),I=1,NSP)
  530 FORMAT(40F2.0)
      PRINT 540,(FLD(I),I=1,NSP)
  540 FORMAT(/,(20(1X,F5.0)))
      DO 550 I=1,NSP
      FLD(I)=FLD(I)*FAC
  550 CONTINUE
      READ 330,FAC
      PRINT 521,FAC
      READ 560,(ELD(I),I=1,NSP)
      PRINT 540,(ELD(I),I=1,NSP)
  560 FORMAT (20F4.0)
      DO 570 I=1,NSP
  570 ELD(I)=ELD(I)*FAC
      RETURN
C     ************************
      ENTRY DDAT2(NRIV)
C     ************************
      NK=1
      DO 581 K=1,KO
      DO 580 I=1,IO
      READ 510,(IDR(I,J,K),J=1,JO)
      DO 580 J=1,JO
      IF(IDR(I,J,K).EQ.0.) GO TO 580
      IDR(I,J,K) = FLOAT(NK)
      NK = NK + 1
  580 CONTINUE
  581 CONTINUE
      NK = NK - 1
      IF(NK.EQ.NRIV) GO TO 600
      PRINT 585,NK,NRIV
  585 FORMAT('   ERROR***NK.NE.NRIV     NK=',I5,5X,'NRIV=',I5)
      STOP
  600 READ 330,FAC
      PRINT 521,FAC
      READ 560,(RH(I),I=1,NRIV)
      PRINT 540,(RH(I),I=1,NRIV)
      DO 610 I=1,NRIV
  610 RH(I) = RH(I)*FAC
      READ 330,FAC
      PRINT 521,FAC
      READ 560,(RB(I),I=1,NRIV)
      PRINT 540,(RB(I),I=1,NRIV)
      DO 620 I=1,NRIV
  620 RB(I) = RB(I)*FAC
      READ 330,FAC
      PRINT 521,FAC
      READ 625,(RC(I),I=1,NRIV)
  625 FORMAT(10F8.0)
      PRINT 635,(RC(I),I=1,NRIV)
  635 FORMAT(/,(14(1X,F8.0)))
      DO 630 I=1,NRIV
  630 RC(I)=RC(I)*FAC
      RETURN
C     ....................................................................
C     ---READ TIME PARAMETERS AND PUMPING DATA FOR A NEW PUMPING PERIOD-
C     ************************
      ENTRY NEWPEP
C     ************************
C
```

```
      READ (5,330) KP,KPM1,NWEL,TMAX,NUMT,CDLT,DELT
C
C     ---COMPUTE ACTUAL DELT AND NUMT---
      DT=DELT/24.
      TM=0.0
      DO 220 I=1,NUMT
      DT=CDLT*DT
      TM=TM+DT
      IF (TM.GE.TMAX) GO TO 230
  220 CONTINUE
      GO TO 240
  230 DELT=TMAX/TM*DELT
      NUMT=I
  240 WRITE (6,400) KP,TMAX,NUMT,DELT,CDLT
      DELT=DELT*3600.
      TMAX=TMAX*86400.
      SUMP=0.0
C
C     ---READ AND WRITE WELL PUMPING RATES---
      WRITE (6,410) NWEL
      IF (NWEL.EQ.0) GO TO 260
      IF(IALT.EQ.ICHK(13)) GO TO 261
      DO 250 II=1,NWEL
      READ (5,330) K,I,J,WELL(I,J,K)
      WRITE (6,420) K,I,J,WELL(I,J,K)
  250 WELL(I,J,K)=WELL(I,J,K)/(DELX(J)*DELY(I))
      GO TO 260
C
C     ---ALTERNATIVE---
  261 DO 251 K=1,KO
      DO 251 I=1,IO
      DO 251 J=1,JO
      RCF(I,J,K)=0.
      NWELL(I,J,K)=0.
  251 BWELL(I,J,K)=0.
  265 READ(5,330) AWELL,NBWEL,BWC,FBWELL,NCF,CFC
      IF(AWELL.EQ.9999.) GO TO 260
      DO 262 II=1,NBWEL
      READ(5,330) K,I,J,BWELL(I,J,K)
      BWELL(I,J,K)=BWELL(I,J,K)*BWC
  262 WRITE(6,420) K,I,J,BWELL(I,J,K)
      DO 267 II=1,NCF
      READ(5,330) K,I,J,RCF(I,J,K)
      RCF(I,J,K)=RCF(I,J,K)*CFC
  267 WRITE(6,420) K,I,J,RCF(I,J,K)
      WRITE(6,266) AWELL,NBWEL,BWC,FBWELL,NCF,CFC
  266 FORMAT(1H0,6D10.4)
      DO 263 K=1,KO
      DO 263 I=1,IO
  263 READ(5,440) (NWELL(I,J,K),J=1,JO)
  440 FORMAT(20G4.0)
      DO 264 K=1,KO
      DO 264 I=1,IO
      DO 264 J=1,JO
  264 WELL(I,J,K)=(NWELL(I,J,K)*AWELL+BWELL(I,J,K)*FBWELL+RCF(I,J,K))/
     1(DELX(J)*DELY(I))
      GO TO 265
  260 RETURN
C
C     ---FORMATS---
C
C
C
  280 FORMAT (1H0,52X,6A4,' =',G15.7,' FOR LAYER',I3)
  290 FORMAT (1H1,45X,6A4,' MATRIX, LAYER',I3/46X,41('-'))
  300 FORMAT ('0',72X,'DELX =',G15.7)
  310 FORMAT ('0',72X,'DELY =',G15.7)
  320 FORMAT ('0',72X,'DELZ =',G15.7)
  330 FORMAT (8G10.0)
  340 FORMAT ('0',51X,'NUMBER OF PUMPING PERIODS =',I5/47X,'TIME STEPS B
     1ETWEEN PRINTOUTS =',I5//51X,'ERROR CRITERIA FOR CLOSURE =',G15.7/
     254X,'EVAPOTRANSPIRATION RATE =',G15.7/56X,'EFFECTIVE DEPTH OF ET =
     3',G15.7/)
  350 FORMAT ('0',I2,2X,20F6.1/(5X,20F6.1))
  360 FORMAT (8F10.4)
  370 FORMAT (1H1,46X,40HGRID SPACING IN PROTOTYPE IN X DIRECTION/47X,40
     1('-')//('0',12F10.0))
  380 FORMAT (1H-,46X,40HGRID SPACING IN PROTOTYPE IN Y DIRECTION/47X,40
     1('-')//('0',12F10.0))
  390 FORMAT (1H-,46X,40HGRID SPACING IN PROTOTYPE IN Z DIRECTION/47X,40
     1('-')//('0',12F10.0))
  400 FORMAT ('-',50X,'PUMPING PERIOD NO.',I4,': ',F10.2,' DAYS'/51X,38(
     1'-')//53X,'NUMBER OF TIME STEPS=',I6//59X,'DELT IN HOURS =',F10.3//
     253X,'MULTIPLIER FOR DELT =',F10.3)
  410 FORMAT ('-',63X,I4,' WELLS'/63X,9('-')//50X,'K',9X,'I',9X,'J'     PU
     1MPING RATE'/)
  420 FORMAT (41X,3I10,2F13.5)
  430 FORMAT ('-',40X,' CONTINUATION - HEAD AFTER ',G20.7,' SEC PUMPING
     1'/42X,58('-'))
  440 FORMAT ('1',55X,'INITIAL  HEAD MATRIX, LAYER',I3/56X,30('-'))
  450 FORMAT (4G20.10)
  460 FORMAT (3G10.0,2(G10.0,7I1,1X),A8)
  470 FORMAT ('0',30X,'ON ALPHAMERIC MAP:'/40X,'MULTIPLICATION FACTOR FO
     1R X DIMENSION =',G15.7/40X,'MULTIPLICATION FACTOR FOR Y DIMENSION
     2=',G15.7/55X,'MAP SCALE IN UNITS OF  ',A11/50X,'NUMBER OF  ',A8,' P
     3ER INCH =',G15.7/43X,'MULTIPLICATION FACTOR FOR DRAWDOWN =',G15.7,
     4' PRINTED FOR LAYERS',9I2/47X,'MULTIPLICATION FACTOR FOR HEAD =',G
     515.7,' PRINTED FOR LAYERS',9I2)
      END

      SUBROUTINE STEP(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FACT
     1,DDN,TEST3)
C     ------------------------------------------------------------------
C     INITIALIZE DATA FOR A NEW TIME STEP AND PRINT RESULTS
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      CHARACTER *8XLABEL,YLABEL,TITLE,MESUP
      CHARACTER *4ICHK,VF1,VF2,VF3,DIGIT,IEQN,IEVAP,IALT,INFF,IMAPP
      CHARACTER *4IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IORE,IPU1,IPU2,ITK
      CHARACTER *1STR,PRNT,BLANK
C
```

```
      COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NC
     2H,IDK1,IDK2,IWATER,IORE,IP,JP,IQ,JQ,KQ,IK,JK,K5,IPU1,IPU2,ITK,INO
     3,IEQN,IEVAP,IALT,IDNPP,IMAPP
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,QET,ETDIST
      COMMON /SARRAY/ ICHK(16),LEVEL1(9),LEVEL2(9)
      COMMON /CK/ ETFLXT,STORT,QRET,CHST,CHDT,RFLXT,PUMPT,CFLUXT,SFLXT
      COMMON /PR/ XLABEL(3),YLABEL(6),TITLE(6),XN1,MESUR,PRNT(122),BLANK
     1(60),DIGIT(122),VF1(6),VF2(6),VF3(7),XSCALE,DINCH,SYM(17),XN(100),
     2YN(13),NA(4),N1,N2,N3,YSCALE,FACT1,FACT2
C
      DIMENSION PHI(IO,JO,KO), STRT(IO,JO,KO), OLD(IO,JO,KO), T(IO,JO,KO
     1), S(IO,JO,KO), TR(IO,JO,KO), TC(IO,JO,KO), TK(IK,JK,K5), WELL(IO,
     2JO,KO), DELX(JO), DELY(IO), DELZ(KO), FACT(KO,3), DDN(IMAX), TEST3
     3(ITMX1), ITTO(50)
      RETURN
C     ..................................................................
C     ***************************
      ENTRY NEWSTP
C     ***************************
      KT=KT+1
      IT=0
      DO 10 K=1,KO
      DO 10 I=1,IO
      DO 10 J=1,JO
   10 OLD(I,J,K)=PHI(I,J,K)
      DELT=CDLT*DELT
      SUM=SUM+DELT
      SUMP=SUMP+DELT
      DAYSP=SUMP/86400.
      YRSP=DAYSP/365.
      HRS=SUM/3600.
      SMIN=HRS*60.
      DAYS=HRS/24.
      YRS=DAYS/365.
      RETURN
C
C     ---PRINT OUTPUT AT DESIGNATED TIME STEPS---
C     ***************************
      ENTRY OUTPUT
C     ***************************
      IF (KT.EQ.NUMT) IFINAL=1
      ITTO(KT)=IT
      IF (IT.LE.ITMAX) GO TO 20
      IT=IT-1
      ITTO(KT)=IT
      IERR=2
C
C     ---IF MAXIMUM ITERATIONS EXCEEDED,WRITE RESULTS ON DISK OR CARDS---
      IF (IDK2.EQ.ICHK(5)) WRITE (4) PHI,SUM,SUMP,PUMPT,CFLUXT,QRET,CHST
     1,CHDT,RFLXT,STORT,ETFLXT,SFLXT
      IF (IPU2.EQ.ICHK(9)) WRITE (7,230) SUM,SUMP,PUMPT,CFLUXT,QRET,CHST
     1,CHDT,RFLXT,STORT,ETFLXT,SFLXT
C
   20 IF (IFLO.EQ.ICHK(3)) CALL CHECK
      IF (IERR.EQ.2) GO TO 30
      IF (MOD(KT,KTH).NE.0.AND.IFINAL.NE.1) RETURN
   30 WRITE (6,210) KT,DELT,SUM,SMIN,HRS,DAYS,YRS,DAYSP,YRSP
      IF (IFLO.EQ.ICHK(3)) CALL CWRITE
      IT=IT+1
      WRITE (6,180) (TEST3(J),J=1,IT)
      I3=1
      I5=0
  352 I5=I5+40
      I4=MIN0(KT,I5)
      WRITE (6,240) (I,I=I3,I4)
      WRITE (6,260)
      WRITE (6,250) (ITTO(I),I=I3,I4)
      WRITE (6,260)
      IF(KT.LE.I5) GO TO 353
      I3=I3+40
      GO TO 352
C
C     ---PRINT MAPS---
  353 IF (XSCALE.EQ.0.) GO TO 70
      IF (FACT1.EQ.0.) GO TO 50
      DO 40 IA=1,9
      II=LEVEL1(IA)
      IF (II.EQ.0) GO TO 50
   40 CALL PRNTA(1,II)
   50 IF (FACT2.EQ.0.) GO TO 70
      DO 60 IA=1,9
      II=LEVEL2(IA)
      IF (II.EQ.0) GO TO 70
   60 CALL PRNTA(2,II)
   70 IF (IDRAW.NE.ICHK(1)) GO TO 93
C
C     ---PRINT DRAWDOWN---
      DO 90 K=1,KO
      WRITE (6,200) K
      DO 90 I=1,IO
      DO 80 J=1,JO
   80 DDN(J)=STRT(I,J,K)-PHI(I,J,K)
   90 WRITE (6,170) I,(DDN(J),J=1,JO)
C
C     ---NEED DRAWDOWN BETWEEN PUMPING PERIOD ?---
   93 IF (IDNPP.NE.ICHK(14)) GO TO 100
      DO 95 K=1,KO
      DO 95 I=1,IO
      DO 95 J=1,JO
   95 STRT(I,J,K)=PHI(I,J,K)
  100 IF (IHEAD.NE.ICHK(2)) GO TO 120
C
C     ---PRINT HEAD MATRIX---
      DO 110 K=1,KO
      WRITE (6,190) K
      DO 110 I=1,IO
  110 WRITE (6,170) I,(PHI(I,J,K),J=1,JO)
C
C     ---WRITE ON DISK---
  120 IF (IERR.EQ.2) GO TO 130
      IF (KP.LT.NPER.OR.IFINAL.NE.1) RETURN
```

```
      IF (IDR2.EQ.ICHK(5)) WRITE (4) PHI,SUM,SUMP,PUMPT,CFLUXT,QRET,CHST
     1,CHDT,RFLXT,STORT,ETFLXT,SFLXT
C
C     ---PUNCHED OUTPUT---
  130 IF (IPU2.NE.ICHK(9)) GO TO 160
      IF (IERR.EQ.2) GO TO 140
      WRITE (7,230) SUM,SUMP,PUMPT,CFLUXT,QRET,CHST,CHDT,RFLXT,STORT,ETF
     1LXT,SFLXT
  140 DO 150 K=1,KO
      DO 150 I=1,IO
  150 WRITE (7,220)  (PHI(I,J,K),J=1,JO)
  160 IF (IERR.EQ.2) STOP
      RETURN
C
C     ---FORMATS---
C
C
C
  170 FORMAT ('0',I4,15(1X,F7.2)/(5X,15(1X,F7.2)))
  180 FORMAT ('0MAXIMUM HEAD CHANGE FOR EACH ITERATION:'/' ',39('-')/('0
     1',10F12.4))
  190 FORMAT ('1',55X,'HEAD MATRIX, LAYER',I3/56X,21('-'))
  200 FORMAT ('1',55X,'   DRAWDOWN, LAYER',I3/57X,18('-'))
  210 FORMAT (1H1,44X,57('-')/45X,'\',14X,'TIME STEP NUMBER =',I9,14X,'\
     1'/45X,57('-')//50X,29HSIZE OF TIME STEP IN SECONDS=,F14.2//55X,'TO
     2TAL SIMULATION TIME IN SECONDS=',F14.2/80X,8HMINUTES=,F14.2/82X,6H
     3HOURS=,F14.2/83X,5HDAYS=,F14.2/82X,'YEARS=',F14.2///45X,'DURATION
     4OF CURRENT PUMPING PERIOD IN DAYS=',F14.2/82X,'YEARS=',F14.2//)
  220 FORMAT (10F8.4)
  230 FORMAT (4G20.10)
  240 FORMAT ('0TIME STEP :',40I3)
  250 FORMAT ('0ITERATIONS:',40I3)
  260 FORMAT (' ',10('-'))
      END
      SUBROUTINE SOLVE(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FAC
     1T,EL,FL,GL,V,XI,TEST3,ORE,PERM,ID,FLD,ELD,IDR,RH,RC,RB,ISPRO,
     2IRIV,BOTTOM,GRND)
C     ------------------------------------------------------------------
C     SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *4 ID,IDR
      REAL    PHI,RHO,B,D,F,H,Z,SU,RHOP,W,WMIN,RHO1,RHO2,RHO3,XPART,YPART
      REAL    UX,UDR,ZPART,WMAX,XT,YT,ZT,DEN,TXM,TYM,TZM
      REAL    E,AL,BL,CL,A,C,G,WU,TU,U,DL,RES,SUPH,GLXI,ZPHI
      CHARACTER *4ICHK,IEQN,IEVAP,IALT,IDHPP,IMAPP
      CHARACTER *4IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IORE,IPU1,IPU2,ITK
C
      COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NC
     2H,IDK1,IDK2,IWATER,IORE,IP,JP,IQ,JQ,KQ,IK,JK,KS,IPU1,IPU2,ITK,IHD
     3,IEQN,IEVAP,IALT,IDHPP,IMAPP
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,QET,ETDIST
      COMMON /SARRAY/ ICHK(16),LEVEL1(9),LEVEL2(9)
C
      DIMENSION PHI(1), STRT(1), OLD(1), T(1), S(1), TR(1), TC(1), TK(1)
     1, WELL(1), DELX(1), DELY(1), DELZ(1), FACT(KO,3), RHOP(20), TEST3(
     21),BOTTOM(1),EL(1),FL(1),GL(1),V(1),XI(1),ORE(1)
     3,ID(1),FLD(1),ELD(1),PERM(1),IDR(1),RH(1),RC(1),RB(1)
     4,GRND(1)
      RETURN
C     ..................................................................
C     ****************************
      ENTRY ITER
C     ****************************
C     ---COMPUTE AND PRINT ITERATION PARAMETERS---
      WRITE (6,240)
      WMIN=1.E0
      DELT=1.
      P2=LENGTH-1
      NT=IO*JO*KO
      NIJ=IO*JO
      XT=3.14159**2/(2.*JO*JO)
      YT=3.14159**2/(2.*IO*IO)
      ZT=3.14159**2/(2.*KO*KO)
      RHO1=0.E0
      RHO2=0.E0
      RHO3=0.E0
      DO 40 K=1,KO
      DO 40 I=2,I1
      DO 40 J=2,J1
      N=I+(J-1)*IO+(K-1)*NIJ
      IF (T(N).EQ.0.) GO TO 40
      D=TR(N-IO)/DELX(J)
      F=TR(N)/DELX(J)
      B=TC(N-1)/DELY(I)
      H=TC(N)/DELY(I)
      SU=0.E0
      Z=0.E0
      IF (K.NE.1) Z=TK(N-NIJ)/DELZ(K)
      IF (K.NE.KO) SU=TK(N)/DELZ(K)
      TXM=AMAX1(D,F)
      TYM=AMAX1(B,H)
      TZM=AMAX1(SU,Z)
      DEN=AMIN1(D,F)
      IF (DEN.EQ.0.E0) DEN=TXM
      IF (DEN.EQ.0.E0) GO TO 20
      RHO1=AMAX1(RHO1,TYM/DEN)
   20 DEN=AMIN1(B,H)
      IF (DEN.EQ.0.E0) DEN=TYM
      IF (DEN.EQ.0.E0) GO TO 30
      RHO2=AMAX1(RHO2,TXM/DEN)
   30 DEN=AMIN1(SU,Z)
      IF (DEN.EQ.0.E0) DEN=TZM
      IF (DEN.EQ.0.E0) GO TO 40
      RHO3=AMAX1(RHO3,TXM/DEN)
   40 CONTINUE
      XPART=XT/(1.E0+RHO1)
      YPART=YT/(1.E0+RHO2)
      ZPART=ZT/(1.E0+RHO3)
      WMIN=AMIN1(WMIN,XPART,YPART,ZPART)
```

```
      UMAX=1.E0-UMIN
      READ 999,HMAX
  999 FORMAT(F10.5)
      PRINT 998,HMAX
  998 FORMAT(1X,5HHMAX=,F10.5)
      IF(HMAX.NE.0.) UMAX=HMAX
      PJ=-1.
      DO 50 I=1,LENGTH
      PJ=PJ+1.
   50 RHOP(I)=1.E0-(1.E0-UMAX)**(PJ/P2)
      WRITE (6,230) LENGTH,(RHOP(J),J=1,LENGTH)
      RETURN
C     ..............................................................
C
C     ---INITIALIZE DATA FOR A NEW ITERATION---
   60 IT=IT+1
      IF (IT.LE.ITMAX) GO TO 70
      WRITE (6,220)
      CALL OUTPUT
   70 IF (MOD(IT,LENGTH)) 80,80,90
C     **************************
      ENTRY NEWITA
C     **************************
   80 NTH=0
   90 NTH=NTH+1
      NIJ=IO*JO
      W=RHOP(NTH)
      TEST3(IT+1)=0.
      TEST=0.0
      BIG=0.
      DO 100 I=1,NT
      EL(I)=0.
      FL(I)=0.
      GL(I)=0.
      V(I)=0.
  100 XI(I)=0.
C
C     ---COMPUTE TRANSMISSIVITY AND T COEFFICIENTS FOR UPPER
C     HYDROLOGIC UNIT WHEN IT IS UNCONFINED---
      IF (IWATER.NE.ICHK(6)) GO TO 110
      CALL TRANS(0)
C
C     ---CHOOSE SIP NORMAL OR REVERSE ALGORITHM---
  110 IF (MOD(IT,2)) 120,120,170
  120 DO 150 K=1,KO
      DO 150 I=2,II
      DO 150 J=2,JI
      NMA=I+(J-1)*IO
      N=NMA+(K-1)*NIJ
      NIA=N+1
      NIB=N-1
      NJA=N+IO
      NJB=N-IO
      NKA=N+NIJ
      NKB=N-NIJ
      NKBB=N-2.*NIJ
C
C     ---SKIP COMPUTATIONS IF NODE OUTSIDE MODEL---
      IF (T(N).EQ.0..OR.S(N).LT.0.) GO TO 150
C
C     ---COMPUTE COEFFICIENTS---
      D=TR(NJB)/DELX(J)
      F=TR(N)/DELX(J)
      B=TC(NIB)/DELY(I)
      H=TC(N)/DELY(I)
      SU=0.E0
      Z=0.E0
      IF(K.EQ.1) GO TO 121
      Z=TK(NKB)
      IF(IEQN.EQ.ICHK(11)) Z=Z/DELZ(K)
  121 IF(K.EQ.KO) GO TO 122
      SU=TK(N)
      IF(IEQN.EQ.ICHK(11)) SU=SU/DELZ(K)
  122 RHO=S(N)/DELT
      QR=0.
      UXR = 0.
      UX = 0.
      ETQB=0.
      ETQD=0.
      IF(IQRE.EQ.ICHK(7)) QR=QRE(N)
      IF (K.NE.KO.OR.IEVAP.NE.ICHK(12)) GO TO 123
C
C     ---COMPUTE EXPLICIT AND IMPLICIT PARTS OF ET RATE---
      IF (PHI(N).LE.GRND(NMA)-ETDIST) GO TO 123
      IF (PHI(N).GT.GRND(NMA)) GO TO 127
      ETQB=QET/ETDIST
      ETQD=ETQB*(ETDIST-GRND(NMA))
      GO TO 123
  127 ETQD=QET
  123 IF(IRIV.LE.0) GO TO 125
      ND=IFIX(IDR(N))
      IF(ND.EQ.0) GO TO 125
      IF(PHI(N).GT.RB(ND).AND.PHI(N).LT.RH(ND)) GO TO 124
      IF(PHI(N).GT.RH(ND)) GO TO 126
      QR = QR+ RC(ND)*(RH(ND) - RB(ND))
      GO TO 125
  126 UXR=RC(ND)
      QR=QR+RC(ND)*RH(ND)
      GO TO 125
  124 UXR = RC(ND)
      QR=QR+RC(ND)*RH(ND)
  125 IF(ISPRG.LE.0) GO TO 130
      ND=IFIX(ID(N))
      IF(ND.EQ.0) GO TO 130
      IF(ELD(ND).GT.PHI(N)) GO TO 130
      UX = FLD(ND)
      QR = QR+FLD(ND)*ELD(ND)
C
C     ---SIP NORMAL ALGORITHM---
C     ---FORWARD SUBSTITUTE, COMPUTING INTERMEDIATE VECTOR V---
  130 E = -B -D -F -H -SU -Z -RHO -UX -UXR -ETQB
      IF (K.NE.K1) GO TO 131
```

```
      IF (PHI(N).GE.BOTTOM(NMA)) GO TO 131
      IF(PHI(NKA).GE.BOTTOM(NMA)) QR=QR-SU*BOTTOM(NMA)
      IF(PHI(NKA).GE.BOTTOM(NMA)) GO TO 129
      E=E+SU
      SU=0
      GO TO 131
  129 E=E+SU
  131 IF (K.NE.KO) GO TO 133
      IF (PHI(NKB).GE.BOTTOM(NMA)) GO TO 133
      IF(PHI(N).GE.BOTTOM(NMA)) QR=QR+Z*BOTTOM(NMA)
      IF(PHI(N).GE.BOTTOM(NMA)) GO TO 132
      E=E+Z
  132 Z=0
 133  CONTINUE
      BL=B/(1.+U*(EL(NIB)+GL(NIB)))
      CL=D/(1.+U*(FL(NJB)+GL(NJB)))
      C=BL*EL(NIB)
      G=CL*FL(NJB)
      UU=CL*GL(NJB)
      U=BL*GL(NIB)
      IF (K.EQ.1) GO TO 140
      AL=Z/(1.+U*(EL(NKB)+FL(NKB)))
      A=AL*EL(NKB)
      TU=AL*FL(NKB)
      DL=E+U*(A+C+G+UU+TU+U)-CL*EL(NJB)-BL*FL(NIB)-AL*GL(NKB)
      EL(N)=(F-U*(A+C))/DL
      FL(N)=(H-U*(G+TU))/DL
      GL(N)=(SU-U*(UU+U))/DL
      SUPH=0.E0
      IF (K.NE.KO) SUPH=SU*PHI(NKA)
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-SUPH-Z*P
     1HI(NKB)-WELL(N)-RHO*OLD(N)-QR+ETQD
      V(N)=(RES-AL*V(NKB)-BL*V(NIB)-CL*V(NJB))/DL
      GO TO 150
  140 DL=E+U*(C+G+UU+U)-CL*EL(NJB)-BL*FL(NIB)
      EL(N)=(F-U*C)/DL
      FL(N)=(H-U*G)/DL
      GL(N)=(SU-U*(UU+U))/DL
      SUPH=0.E0
      IF (K.NE.KO) SUPH=SU*PHI(NKA)
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-SUPH-WEL
     1L(N)-RHO*OLD(N)-QR+ETQD
      V(N)=(RES-BL*V(NIB)-CL*V(NJB))/DL
  150 CONTINUE
C
C     ---BACK SUBSTITUTE FOR VECTOR XI---
      DO 160 K=1,KO
      K3=KO-K+1
      DO 160 I=1,I2
      I3=IO-I
      DO 160 J=1,J2
      J3=JO-J
      N=I3+(J3-1)*IO+(K3-1)*NIJ
      IF (T(N).EQ.0..OR.S(N).LT.0.) GO TO 160
      GLXI=0.E0
      IF (K3.NE.KO) GLXI=GL(N)*XI(N+NIJ)
      XI(N)=V(N)-EL(N)*XI(N+IO)-FL(N)*XI(N+1)-GLXI
C
C     ---COMPARE MAGNITUDE OF CHANGE WITH CLOSURE CRITERIA---
      TCHK=ABS(XI(N))
      IF (TCHK.LE.BIG) GO TO 155
      BIG = TCHK
      IIN = I3
      JJN = J3
      KKN = K3
      BIGS = XI(N)
  155 PHI(N)=PHI(N)+XI(N)
  160 CONTINUE
      PRINT 251,IIN,JJN,KKN,BIGS
      IF (BIG.GT.ERR) TEST=1.
      TEST3(IT+1)=BIG
      IF (TEST.EQ.0.) RETURN
      GO TO 60
C     ..........................................................................
  170 DO 200 KK=1,KO
      K=KO-KK+1
      DO 200 II=1,I2
      I=IO-II
      DO 200 J=2,J1
      NMA=I+(J-1)*IO
      N=NMA+(K-1)*NIJ
      NIA=N+1
      NIB=N-1
      NJA=N+IO
      NJB=N-IO
      NKA=N+NIJ
      NKB=N-NIJ
      NKBB=N-2*NIJ
C
C     ---SKIP COMPUTATIONS IF NODE OUTSIDE AQUIFER---
      IF (T(N).EQ.0..OR.S(N).LT.0.) GO TO 200
C
C     ---COMPUTE COEFFICIENTS---
      D=TR(NJB)/DELX(J)
      F=TR(N)/DELX(J)
      B=TC(NIB)/DELY(I)
      H=TC(N)/DELY(I)
      SU=0.E0
      Z=0.E0
      IF(K.EQ.1) GO TO 171
      Z=TK(NKB)
      IF(IEQN.EQ.ICHK(11)) Z=Z/DELZ(K)
  171 IF(K.EQ.KO) GO TO 172
      SU=TK(N)
      IF(IEQN.EQ.ICHK(11)) SU=SU/DELZ(K)
  172 RHO=S(N)/DELT
      QR=0.
      UXR = 0.
      UX  = 0.
      ETQB=0.
      ETQD=0.
      IF(IQRE.EQ.ICHK(7)) QR=QRE(N)
```

```
      IF (K.NE.KO.OR.IEVAP.NE.ICHK(12)) GO TO 173
C
C     ---COMPUTE EXPLICIT AND IMPLICIT PARTS OF ET RATE---
      IF (PHI(N).LE.GRND(NMA)-ETDIST) GO TO 173
      IF (PHI(N).GT.GRND(NMA)) GO TO 177
      ETQB=QET/ETDIST
      ETQD=ETQB*(ETDIST-GRND(NMA))
      GO TO 173
  177 ETQD=QET
  173 IF(IRIV.LE.0) GO TO 175
      ND = IFIX(IOR(N))
      IF(ND.EQ.0) GO TO 175
      IF(PHI(N).GT.RB(ND).AND.PHI(N).LT.RH(ND)) GO TO 174
      IF(PHI(N).GT.RH(ND)) GO TO 176
      QR = QR + RC(ND)*(RH(ND)-RB(ND))
      GO TO 175
  176 UQR=RC(ND)
      QR=QR+RC(ND)*RH(ND)
      GO TO 175
  174 UQR = RC(ND)
      QR=QR+RC(ND)*RH(ND)
  175 IF(ISPRG.LE.0) GO TO 180
      ND= IFIX(ID(N))
      IF(ND.EQ.0) GO TO 180
      IF(ELD(ND).GT.PHI(N)) GO TO 180
      UX = FLD(ND)
      QR = QR + FLD(ND)*ELD(ND)
C
C     ---SIP REVERSE ALGORITHM---
C     ---FORWARD SUBSTITUTE, COMPUTING INTERMEDIATE VECTOR V---
  180 E = -B -D -F -H -SU -Z -RHO -UX -UQR -ETQB
      IF (K.NE.KI) GO TO 181
      IF (PHI(N).GE.BOTTOM(NMA)) GO TO 181
      IF(PHI(NKA).GE.BOTTOM(NMA)) QR=QR-SU*BOTTOM(NMA)
      IF(PHI(NKA).GE.BOTTOM(NMA)) GO TO 179
      E=E+SU
      SU=0
      GO TO 181
  179 E=E+SU
  181 IF (K.NE.KO) GO TO 183
      IF (PHI(NKB).GE.BOTTOM(NMA)) GO TO 183
      IF(PHI(N).GE.BOTTOM(NMA)) QR=QR+Z*BOTTOM(NMA)
      IF(PHI(N).GE.BOTTOM(NMA)) GO TO 182
      E=E+Z
  182 Z=0
 183  CONTINUE
      BL=H/(1.+W*(EL(NIA)+GL(NIA)))
      CL=D/(1.+W*(FL(NJB)+GL(NJB)))
      C=BL*EL(NIA)
      G=CL*FL(NJB)
      UU=CL*GL(NJB)
      U=BL*GL(NIA)
      IF (K.EQ.KO) GO TO 190
      AL=SU/(1.+W*(EL(NKA)+FL(NKA)))
      A=AL*EL(NKA)
      TU=AL*FL(NKA)
      DL=E+W*(C+G+A+UU+TU+U)-AL*GL(NKA)-BL*FL(NIA)-CL*EL(NJB)
      EL(N)=(F-W*(C+A))/DL
      FL(N)=(B-W*(G+TU))/DL
      GL(N)=(Z-W*(UU+U))/DL
      ZPHI=0.E0
      IF (K.NE.1) ZPHI=Z*PHI(NKB)
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-SU*PHI(N
     1KA)-ZPHI-WELL(N)-RHO*OLD(N)-QR+ETQD
      V(N)=(RES-AL*V(NKA)-BL*V(NIA)-CL*V(NJB))/DL
      GO TO 200
  190 DL=E+W*(C+G+UU+U)-BL*FL(NIA)-CL*EL(NJB)
      EL(N)=(F-W*C)/DL
      FL(N)=(B-W*G)/DL
      GL(N)=(Z-W*(UU+U))/DL
      ZPHI=0.E0
      IF (K.NE.1) ZPHI=Z*PHI(NKB)
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-ZPHI-WEL
     1L(N)-RHO*OLD(N)-QR+ETQD
      V(N)=(RES-BL*V(NIA)-CL*V(NJB))/DL
  200 CONTINUE
C
C     ---BACK SUBSTITUTE FOR VECTOR XI---
      DO 210 K=1,KO
      DO 210 I=2,II
      DO 210 J=1,J2
      J3=JO-J
      N=I+(J3-1)*IO+(K-1)*NIJ
      IF (T(N).EQ.0..OR.S(N).LT.0.) GO TO 210
      GLXI=0.E0
      IF (K.NE.1) GLXI=GL(N)*XI(N-NIJ)
      XI(N)=V(N)-EL(N)*XI(N+IO)-FL(N)*XI(N-1)-GLXI
C
C     ---COMPARE MAGNITUDE OF CHANGE WITH CLOSURE CRITERIA---
      TCHK=ABS(XI(N))
      IF (TCHK.LE.BIG) GO TO 205
      BIG = TCHK
      IIN = I
      JJN = J3
      KKN = K
      BIGS = XI(N)
  205 PHI(N)=PHI(N)+XI(N)
  210 CONTINUE
      PRINT 251,IIN,JJN,KKN,BIGS
  251 FORMAT (1X,3I10,G20.7)
      IF (BIG.GT.ERR) TEST=1.
      TEST3(IT+1)=BIG
      IF (TEST.EQ.0.) RETURN
      GO TO 60
C     ..................................................................
C
C     ---FORMATS---
C
C
C
  220 FORMAT ('0EXCEEDED PERMITTED NUMBER OF ITERATIONS'/' ',39('*'))
  230 FORMAT (///1H0,I5,22H ITERATION PARAMETERS:,6E15.7/(28X,6E15.7))
```

```
  240 FORMAT ('-',44X,'SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE'/45X,
     143('_'))
      END
      SUBROUTINE COEF(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FACT
     1,PERM,BOTTOM,ORE)
C     ------------------------------------------------------------------
C     COMPUTE COEFFICIENTS
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      CHARACTER *4ICHK,IEQN,IEVAP,IALT,INPP,IMAPP
      CHARACTER *4IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IORE,IPU1,IPU2,ITK
C
      COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NC
     2H,IDK1,IDK2,IWATER,IORE,IP,JP,IO,JO,KO,IK,JK,K5,IPU1,IPU2,ITK,IND
     3,IEQN,IEVAP,IALT,IDNPP,IMAPP
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,QET,ETDIST
      COMMON /SARRAY/ ICHK(16),LEVEL1(9),LEVEL2(9)
C
      DIMENSION PHI(IO,JO,KO), STRT(IO,JO,KO), OLD(IO,JO,KO), T(IO,JO,KO
     1), S(IO,JO,KO), TR(IO,JO,KO), TC(IO,JO,KO), TK(IK,JK,K5), WELL(IO,
     2JO,KO), DELX(JO), DELY(IO), DELZ(KO), FACT(KO,3), PERM(IP,JP), BOT
     3TOM(IP,JP),ORE(IO,JO,KO)
      RETURN
C     ..................................................................
C     ---COMPUTE TRANSMISSIVITY FOR UPPER HYDROLOGIC UNIT WHEN
C     IT IS UNCONFINED---
C     ************************
      ENTRY TRANS(N3)
C     ************************
      DO 10 I=2,I1
      DO 10 J=2,J1
      IF (PERM(I,J).EQ.0.) GO TO 10
      T(I,J,KO)=PERM(I,J)*(PHI(I,J,KO)-BOTTOM(I,J))
      IF (T(I,J,KO).GT.0.) GO TO 10
      IF (WELL(I,J,KO).LT.0.) WRITE (6,60) I,J,KO
      IF (WELL(I,J,KO).GE.0.) WRITE (6,70) I,J,KO
      PERM(I,J)=0.
      T(I,J,KO)=0.
      TR(I,J-1,KO)=0.
      TR(I,J,KO)=0.
      TC(I,J,KO)=0.
      TC(I-1,J,KO)=0.
      IF (KO.NE.1) TK(I,J,K1)=0.
      PHI(I,J,KO)=1.E30
   10 CONTINUE
      IF (N3.EQ.1) RETURN
      N1=KO
      N2=KO
      N4=K1
      GO TO 20
C     ---COMPUTE T COEFFICIENTS---
C     ************************
      ENTRY TCOF
C     ************************
      N1=1
      N2=KO
      N4=1
   20 DO 40 K=N1,N2
      DO 40 I=1,I1
      DO 40 J=1,J1
      IF (T(I,J,K).EQ.0.) GO TO 40
      IF (T(I,J+1,K).EQ.0.) GO TO 30
      TR(I,J,K)=(2.*T(I,J+1,K)*T(I,J,K))/(T(I,J,K)*DELX(J+1)+T(I,J+1,K)*
     1DELX(J))*FACT(K,1)
   30 IF (T(I+1,J,K).EQ.0.) GO TO 40
      TC(I,J,K)=(2.*T(I+1,J,K)*T(I,J,K))/(T(I,J,K)*DELY(I+1)+T(I+1,J,K)*
     1DELY(I))*FACT(K,2)
   40 CONTINUE
      IF (KO.EQ.1.OR.ITK.EQ.ICHK(10)) RETURN
      DO 50 K=N4,K1
      DO 50 I=2,I1
      DO 50 J=2,J1
      IF (T(I,J,K+1).EQ.0.) GO TO 50
      T1=T(I,J,K)*FACT(K,3)
      T2=T(I,J,K+1)*FACT(K+1,3)
      TK(I,J,K)=(2.*T2*T1)/(T1*DELZ(K+1)+T2*DELZ(K))
   50 CONTINUE
      RETURN
C
C
   60 FORMAT ('-',20('*'),'WELL',2I3,' IN LAYER',I3,' GOES DRY',20('*'))
   70 FORMAT ('-',20('*'),'NODE',2I3,' IN LAYER',I3,' GOES DRY',20('*'))
      END
      SUBROUTINE CHECKI(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FA
     1CT,JFLO,FLOW,ORE,ID,FLD,ELD,IDR,RH,RC,RB,ISPRD,IRIV,BOTTOM,QRND,
     2RCF)
C     ------------------------------------------------------------------
C     COMPUTE A VOLUMETRIC BALANCE
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *4 ID,IDR,JFLO
      CHARACTER *4ICHK,IEQN,IEVAP,IALT,IDNPP,IMAPP
      CHARACTER *4IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IORE,IPU1,IPU2,ITK
C
      COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NC
     2H,IDK1,IDK2,IWATER,IORE,IP,JP,IO,JO,KO,IK,JK,K5,IPU1,IPU2,ITK,IND
     3,IEQN,IEVAP,IALT,IDNPP,IMAPP
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,QET,ETDIST
      COMMON /SARRAY/ ICHK(16),LEVEL1(9),LEVEL2(9)
      COMMON /CK/ ETFLXT,STORT,QRET,CHST,CHDT,RFLXT,PUMPT,CFLUXT,SFLXT
C
      DIMENSION PHI(IO,JO,KO), STRT(IO,JO,KO), OLD(IO,JO,KO), T(IO,JO,KO
     1), S(IO,JO,KO), TR(IO,JO,KO), TC(IO,JO,KO), TK(IK,JK,K5), WELL(IO,
     2JO,KO), DELX(JO), DELY(IO), DELZ(KO), FACT(KO,3), JFLO(NCH,3), FLO
     3W(NCH),ORE(IO,JO,KO),CHD1(8),CHD2(8),OREFLX(8),PUMP(8),
     4  ID(IO,JO,KO),FLD(1),ELD(1),IDR(IO,JO,KO),RH(1),RC(1),RB(1),
     5 CFLUX(8),STOR(8),FLUX(8),RVFLUX(8),FLXH(8),BOTTOM(IP,JP)
     6,INDEX1(99),INDEX2(99),DFLUX(99),ETFLUX(8)
```

```
     7,GRND(IO,JO),RCF(IO,JO,KO)
      RETURN
C     ..................................................................00011540
C     ********************                                              00011550
      ENTRY CHECK                                                       00011560
C     ********************                                              00011570
C     ---INITIALIZE VARIABLES---                                        00011580
      DO 5 K=1,KO                                                       00011590
      STOR(K)=0                                                         00011600
      CFLUX(K)=0                                                        00011610
      PUMP(K)=0                                                         00011620
      QREFLX(K)=0                                                       00011630
      CHD2(K)=0                                                         00011640
      CHD1(K)=0                                                         00011650
      FLUX(K) = 0                                                       00011660
      RFLUX(K)=0
      FLXN(K) = 0                                                       00011680
      ETFLUX(K)=0
    5 CONTINUE                                                          00011690
      KK=0
      ETFTR=0
      RFTR=0
      FLUXS=0
      FLUXTR=0
      STORTR=0
      QRETR=0
      CHDTR=0
      CHSTR=0
      PUMPTR=0
      CFLXTR=0
      II=0
C
C     ---NO MASS ACCUMULATIONS FROM PREVIOUS PUMPING PERIOD---
      IF (IMAPP.NE.ICHK(15)) GO TO 8
      ETFLXT=0
      RFLXT=0
      SFLXT=0
      STORT=0
      QRET=0
      CHDT=0
      CHST=0
      PUMPT=0
      CFLUXT=0
      SUMR=0
C     ..................................................................00011810
C                                                                       00011820
C     ---COMPUTE RATES,STORAGE AND PUMPAGE FOR THIS STEP---             00011830
    8 DO 220 K=1,KO
      DO 220 I=2,I1                                                     00011850
      DO 220 J=2,J1                                                     00011860
      IF (T(I,J,K).EQ.0.) GO TO 220                                     00011870
      AREA=DELX(J)*DELY(I)
      VOLUME=AREA*DELZ(K)
      IF (K.NE.KO.OR.ID(I,J,K).EQ.0) GO TO 9
      DN=PHI(I,J,K-1)                                                   00011900
      IF (PHI(I,J,KO-1).LT.BOTTOM(I,J)) DN=BOTTOM(I,J)
      X=(PHI(I,J,K)-DN)*TK(I,J,K-1)*AREA
      KK=KK+1                                                           00011930
      INDEX1(KK)=I                                                      00011940
      INDEX2(KK)=J                                                      00011950
      DFLUX(KK)=X                                                       00011960
    9 CONTINUE
      IF (S(I,J,K).GE.0.) GO TO 180                                     00011980
C                                                                       00011990
C     ---COMPUTE FLOW RATES TO AND FROM CONSTANT HEAD BOUNDARIES---     00012000
      II=II+1                                                           00012010
      FLOW(II)=0.                                                       00012020
      JFLO(II,1)=K                                                      00012030
      JFLO(II,2)=I                                                      00012040
      JFLO(II,3)=J                                                      00012050
      IF (S(I,J-1,K).LT.0..OR.T(I,J-1,K).EQ.0.) GO TO 30                00012060
      X=(PHI(I,J,K)-PHI(I,J-1,K))*TR(I,J-1,K)*DELY(I)
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)
      FLOW(II)=FLOW(II)+X
      IF (X) 10,30,20                                                   00012090
   10 CHD1(K)=CHD1(K)+X                                                 00012100
      GO TO 30                                                          00012110
   20 CHD2(K)=CHD2(K)+X
   30 IF (S(I,J+1,K).LT.0..OR.T(I,J+1,K).EQ.0.) GO TO 60
      X=(PHI(I,J,K)-PHI(I,J+1,K))*DELY(I)*TR(I,J,K)
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)
      FLOW(II)=FLOW(II)+X
      IF (X) 40,60,50                                                   00012160
   40 CHD1(K)=CHD1(K)+X                                                 00012170
      GO TO 60                                                          00012180
   50 CHD2(K)=CHD2(K)+X                                                 00012190
   60 IF (K.EQ.1) GO TO 90                                              00012200
      IF (S(I,J,K-1).LT.0..OR.T(I,J,K-1).EQ.0.) GO TO 90                00012210
      DN=PHI(I,J,K-1)                                                   00012220
      IF (K.EQ.KO.AND.PHI(I,J,K-1).LE.BOTTOM(I,J)) DN=BOTTOM(I,J)
      X=(PHI(I,J,K)-DN)*TK(I,J,K-1)*AREA
      FLOW(II)=FLOW(II)+X                                               00012260
      IF (X) 70,90,80                                                   00012270
   70 CHD1(K)=CHD1(K)+X                                                 00012280
      GO TO 90                                                          00012290
   80 CHD2(K)=CHD2(K)+X                                                 00012300
   90 IF (K.EQ.KO) GO TO 120                                            00012310
      IF (S(I,J,K+1).LT.0..OR.T(I,J,K+1).EQ.0.) GO TO 120               00012320
      UP=PHI(I,J,K)                                                     00012330
      IF (K.EQ.KO-1.AND.PHI(I,J,K).LT.BOTTOM(I,J)) UP=BOTTOM(I,J)
      X=(UP-PHI(I,J,K+1))*TK(I,J,K)*AREA
      FLOW(II)=FLOW(II)+X                                               00012380
      IF (X) 100,120,110                                                00012390
  100 CHD1(K)=CHD1(K)+X                                                 00012400
      GO TO 120                                                         00012410
  110 CHD2(K)=CHD2(K)+X                                                 00012420
  120 IF (S(I-1,J,K).LT.0..OR.T(I-1,J,K).EQ.0.) GO TO 150               00012430
      X=(PHI(I,J,K)-PHI(I-1,J,K))*TC(I-1,J,K)*DELX(J)
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)
      FLOW(II)=FLOW(II)+X
      IF (X) 130,150,140                                                00012460
  130 CHD1(K)=CHD1(K)+X                                                 00012470
```

```
      GO TO 150
  140 CHD2(K)=CHD2(K)+X
  150 IF (S(I+1,J,K).LT.0..OR.T(I+1,J,K).EQ.0.) GO TO 220
      X=(PHI(I,J,K)-PHI(I+1,J,K))*TC(I,J,K)*DELX(J)
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)
      FLOW(II)=FLOW(II)+X
      IF (X) 160,220,170
  160 CHD1(K)=CHD1(K)+X
      GO TO 220
  170 CHD2(K)=CHD2(K)+X
      GO TO 220
C     ---CHECK FOR EQUATION BEING SOLVED---
  180 IF(IEQN.EQ.ICHK(11)) GO TO 213
C
C     ---EQUATION 4---
C     ---RECHARGE AND WELLS---
      IF(IDRE.EQ.ICHK(7)) QREFLX(K)=QREFLX(K)+QRE(I,J,K)*AREA
      IF (WELL(I,J,K)) 190,210,190
  190 PUMP(K)=PUMP(K)+(WELL(I,J,K)*AREA-RCF(I,J,K))
      CFLUX(K)=CFLUX(K)+RCF(I,J,K)
C
C     ---COMPUTE VOLUME FROM STORAGE---
  210 STOR(K)=STOR(K)+S(I,J,K)*(OLD(I,J,K)-PHI(I,J,K))*AREA
      GO TO 209
C
C     ---EQUATION 3---
C     ---RECHARGE AND WELLS---
  213 IF(IDRE.EQ.ICHK(7)) QREFLX(K)=QREFLX(K)+QRE(I,J,K)*VOLUME
      IF(WELL(I,J,K)) 214,216,214
  214 PUMP(K)=PUMP(K)+(WELL(I,J,K)*VOLUME-RCF(I,J,K))
      CFLUX(K)=CFLUX(K)+RCF(I,J,K)
C
C     ---COMPUTE VOLUME FROM STORAGE
  216 STOR(K)=STOR(K)+S(I,J,K)*(OLD(I,J,K)-PHI(I,J,K))*VOLUME
  209 IF(K.NE.KO.OR.IEVAP.NE.ICHK(13)) GO TO 219
C
C     ---COMPUTE ET RATE---
      IF(PHI(I,J,K).GE.GRND(I,J)-ETDIST) GO TO 208
      ETQ=0.0
      GO TO 217
  208 IF(PHI(I,J,K).LE.GRND(I,J)) GO TO 218
      ETQ=QET
      GO TO 217
  218 ETQ=QET/ETDIST*(PHI(I,J,K)+ETDIST-GRND(I,J))
  217 ETFLUX(K)=ETFLUX(K)-ETQ*AREA
  219 IF(IRIV.LE.0) GO TO 212
C
C     ---COMPUTE LEAKAGE TO RIVER---
      ND = IFIX(TOP(I,J,K))
      IF(ND.EQ.0) GO TO 212
      IF(PHI(I,J,K).GT.RB(ND)) GO TO 211
      RVFLUX(K)=RC(ND)*(RH(ND)-RB(ND))*AREA+RVFLUX(K)
      GO TO 212
  211 RVFLUX(K)=(RH(ND)-PHI(I,J,K))*AREA*RC(ND)+RVFLUX(K)
  212 IF (ISPRG.LE.0) GO TO 220
C
C     ---COMPUTE LEAKAGE TO SPRING---
      ND = IFIX(ID(I,J,K))
      IF(ND.EQ.0) GO TO 220
      IF(ELD(ND).GT.PHI(I,J,K)) GO TO 220
      FLUX(K)=FLUX(K)+FLD(ND)*AREA*(ELD(ND) - STRT(I,J,K))
      FLXN(K)=FLXN(K)+FLD(ND)*AREA*(ELD(ND) - PHI(I,J,K))
  220 CONTINUE
C     ......................................................................
C
C     ---COMPUTE CUMULATIVE VOLUMES, TOTALS, AND DIFFERENCES---
      FLXPT=0.
      DO 221 K=1,KO
      ETFLXT=ETFLXT-ETFLUX(K)*DELT
      ETFTR=ETFTR+ETFLUX(K)
      RFLXT=RFLXT-RVFLUX(K)*DELT
      RVFTR=RVFTR+RVFLUX(K)
      FLUXS = FLXN(K) + FLUXS
      SFLXT = SFLXT - FLXN(K)*DELT
      FLUXTR = FLUX(K) + FLUXTR
      STORT = STORT + STOR(K)
      STOR(K) = STOR(K)/DELT
      STORTR = STORTR + STOR(K)
      QRET = QRET + QREFLX(K)*DELT
      QRETR = QRETR + QREFLX(K)
      CHDT = CHDT - CHD1(K)*DELT
      CHDTR = CHDTR + CHD1(K)
      CHST = CHST + CHD2(K)*DELT
      CHSTR = CHSTR + CHD2(K)
      PUMPT = PUMPT - PUMP(K)*DELT
      PUMPTR = PUMPTR + PUMP(K)
      CFLUXT = CFLUXT + CFLUX(K)*DELT
  221 CFLXTR=CFLXTR+CFLUX(K)
      TOTL1=STORT+QRET+CFLUXT+CHST+FLXPT
      TOTL2=CHDT+PUMPT+ETFLXT+SFLXT+RFLXT
      SUMR = QRETR + CFLXTR+CHSTR+CHDTR+PUMPTR+ETFTR + FLUXS  +
     1STORTR+RVFTR
      DIFF=TOTL2-TOTL1
      PERCNT=0.0
      IF (TOTL2.EQ.0.) GO TO 230
      PERCNT=DIFF/TOTL2*100.
  230 RETURN
C     ......................................................................
C
C     ---PRINT RESULTS---
C     ************************
      ENTRY CWRITE
C     ************************
C
      WRITE(6,260) STORTR, QRETR, STORT, CFLXTR , QRET, PUMPTR, CFLUXT,
     1RVFTR,CHST,FLXPT,CHSTR,TOTL1,CHDTR,FLUXTR,FLUXS,RFLXT,ETFTR,
     2CHDT,PUMPT,SUMR,SFLXT,ETFLXT,TOTL2,DIFF,PERCNT
      WRITE(6,300)
  300 FORMAT(//,42H RATES OF COMPONENTS FOR EACH LAYER IN CFS)
      DO 231 K=1,KO
      WRITE(6,310) K, CHD1(K), CHD2(K), QREFLX(K), PUMP(K),
     1 CFLUX(K), STOR(K), RVFLUX(K), FLXN(K), ETFLUX(K)
```

```
  231 CONTINUE
  310 FORMAT(6H LAYER,I3,8H  CHOUT=,G11.5,7H  CHIN=,G11.5,6H  DRE=,G11.5
     1,6H  PMP=,G11.5,8H  CFLUX=,G11.5,7H  STOR=,G11.5,/,9X,8H  RIVER=,
     * G11.5,9H  SPRING=,G11.5,4H ET=,G11.5)
      IF (NCH.EQ.0) GO TO 240
      WRITE (6,270)
      WRITE (6,280) ((IFIX(JFLO(I,J)),J=1,3),FLOW(I),I=1,NCH)
C
C     ---COMPUTE VERTICAL FLOW---
  240 X=0.
      Y=0.
      IF (KO.EQ.1) RETURN
      DO 250 I=2,I1
      DO 250 J=2,J1
      X=X+(PHI(I,J,1)-PHI(I,J,2))*TK(I,J,1)*DELX(J)*DELY(I)
      HZ=PHI(I,J,K1)
      IF(PHI(I,J,K1).LT.BOTTOM(I,J)) HZ=BOTTOM(I,J)
      IF(PHI(I,J,K1).LT.BOTTOM(I,J).AND.PHI(I,J,KO).LT.BOTTOM(I,J)) GO
     1TO 250
      Y=Y+(HZ-PHI(I,J,KO))*TK(I,J,K1)*DELX(J)*DELY(I)
 250  CONTINUE
      WRITE (6,290) Y,X
      DO 63 I=1,NX
63    WRITE(6,62)INDEX1(I),INDEX2(I),DFLUX(I)
62    FORMAT('0',8H SPRING ,2I10,E15.7)
      SPLK=0.0
      DO 64 I=1,INO
 64   SPLK=SPLK+DFLUX(I)
 65   WRITE(6,66)SPLK
 66   FORMAT('0',39H    TOTAL SPRING LKAGE FCHRO 2ND LAYER ,E15.7)
      RETURN
C
C     ---FORMATS---
C
C     ------------------------------------------------------------------
C
C
C
  260 FORMAT ('0',10X,'CUMULATIVE MASS BALANCE:',16X,'L**3',23X,'RATES F
     1OR THIS TIME STEP:',16X,'L**3/T'/11X,24('-'),43X,25('-')//20X,'SOU
     2RCES:',69X,'STORAGE =',F20.4/20X,8('-'),68X,'RECHARGE =',F20.4/22X
     3,'STORAGE =',F20.2,35X,'CONSTANT FLUX =',F20.4/26X,'RECHARGE =',F2
     4 0.2,41X,'PUMPING =',F20.4/21X,'CONSTANT FLUX =',F20.2,31X,'     RI
     5VER LEAKAGE =',F20.4/21X,'CONSTANT HEAD =',F20.2,34X,'CONSTANT HEA
     6D:'/27X,'LEAKAGE =',F20.2,46X,'IN =',F20.4/21X,'TOTAL SOURCES =',F
     720.2,45X,'OUT =',F20.4/9X,'LEAKAGE:'/20X,'DISCHARGES:',45X,'FROM
     8PREVIOUS PUMPING PERIOD =',F20.4/20X,11('-'),68X,'TOTAL =',F20.4/1
     98X,'   RIVER LEAKAGE =',F20.2,30X,'EVAPOTRANSPIRATION =',F20.4/21X
     *,'CONSTANT HEAD =',F20.2/19X,'QUANTITY PUMPED =',F20.2,34X,'SUM OF
     $ RATES =',F20.4/20X,'SPRING LEAKAGE =',F20.2/16X,'EVAPOTRANSPIRATI
     ION =',F20.2/19X,'TOTAL DISCHARGE =',F20.2/17X,'DISCHARGE-SOURCES
     $=',F20.2/15X,'PER CENT DIFFERENCE =',F20.2/)
  270 FORMAT ('1','FLOW RATES TO CONSTANT HEAD NODES:'/' ',34('-')//' ',
     13(9X,'K',4X,'I',4X,'J',5X,'RATE (L**3/T)')/' ',3(9X,'-',4X,'-',4X,
     2'-',5X,13('-'))/)
  280 FORMAT (/(1X,3(I10,2I5,G18.7)))
  290 FORMAT ('1','FLOW TO TOP LAYER =',G15.7,'   FLOW TO BOTTOM LAYER =
     1',G15.7,'       POSITIVE UPWARD')
      END
      SUBROUTINE PRNTAI(PHI,STRT,T,S,WELL,DELX,DELY)
C     ------------------------------------------------------------------
C     PRINT MAPS OF DRAWDOWN AND HYDRAULIC HEAD
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL K,Z,XN1
      CHARACTER *80LABEL,YLABEL,TITLE,MESUR
      CHARACTER *4(CHK,VF1,VF2,VF3,DIGIT,IEQN,IEVAP,IALT,IDNPP,IMAPP
      CHARACTER *4(DRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IDRE,IPU1,IPU2,ITK
      CHARACTER *16YN,PRNT,BLANK
C
      COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,I,J,K,NPER,KTH,ITMAX,LENGTH,KP,N
     1WEL,NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,INAX,ITMX1,NC
     2H,IDK1,IDK2,IWATER,IDRE,IP,JP,IQ,JQ,KQ,IK,JK,K5,IPU1,IPU2,ITK,INO
     3,IEQN,IEVAP,IALT,IDNPP,IMAPP
      COMMON /PR/ XLABEL(3),YLABEL(6),TITLE(6),XN1,MESUR,PRNT(122),BLANK
     1(60),DIGIT(122),VF1(6),VF2(6),VF3(7),XSCALE,DINCH,SYM(17),XN(100),
     2YN(13),NA(4),N1,N2,N3,YSCALE,FACT1,FACT2
C
      DIMENSION PHI(IO,JO,KO), STRT(IO,JO,KO), S(IO,JO,KO), WELL(IO,JO,K
     1O), DELX(JO), DELY(IO), T(IO,JO,KO)
      RETURN
C     ..................................................................
C
C     ---INITIALIZE VARIABLES FOR PLOT---
C     ********************
      ENTRY MAP
C     ********************
      YDIM=0.
      WIDTH=0.
      DO 10 J=2,J1
   10 WIDTH=WIDTH+DELX(J)
      DO 20 I=2,I1
   20 YDIM=YDIM+DELY(I)
   30 XSF=DINCH*XSCALE
      YSF=DINCH*YSCALE
      NYD=YDIM/YSF
      IF (NYD*YSF.LE.YDIM-DELY(I1)/2.) NYD=NYD+1
      IF (NYD.LE.12) GO TO 40
      DINCH=YDIM/(12.*YSCALE)
      WRITE (6,330) DINCH
      IF (YSCALE.LT.1.0) WRITE (6,340)
      GO TO 30
   40 NXD=WIDTH/XSF
      IF (NXD*XSF.LE.WIDTH-DELX(J1)/2.) NXD=NXD+1
      N4=NXD*N1+1
      N5=NXD+1
      N6=NYD+1
      N8=N2*NYD+1
      NA(1)=N1/2-1
      NA(2)=N1/2
      NA(3)=N1/2+3
```

```
05          NC=(N3-NB-10)/2
05          ND=NC+NR
05          NE=MAX0(NS,N6)
05          VF1(3)=DIGIT(ND)
05          VF2(3)=DIGIT(ND)
05          VF3(3)=DIGIT(NC)
05          XLABEL(3)=MESUR
05          YLABEL(6)=MESUR
05          DO 60 I=1,NE
05          NNX=NS-I
05          NNY=I-1
05          IF (NNY.GE.N6) GO TO 50
05          YN(I)=YSF*NNY/YSCALE
05       50 IF (NNX.LT.0) GO TO 60
05          XN(I)=XSF*NNX/YSCALE
05       60 CONTINUE
05          RETURN
05    C     ..................................................................
05    C
05    C     ********************
05          ENTRY PRNTA(NO,LA)
05    C     ********************
05    C     ---VARIABLES INITIALIZED EACH TIME A PLOT IS REQUESTED---
05          DIST=WIDTH-DELX(J1)/2.
05          JJ=J1
05          LL=1
05          Z=NODX*XSF
05          IF (NO.EQ.1) WRITE (6,300) (TITLE(I),I=1,3),LA
05          IF (NO.EQ.2) WRITE (6,300) (TITLE(I),I=4,6),LA
05          DO 290 I=1,N4
05    C
05    C     ---LOCATE X AXES---
05          IF (I.EQ.1.OR.I.EQ.N4) GO TO 70
05          PRNT(1)=SYM(12)
05          PRNT(NB)=SYM(12)
05          IF ((I-1)/N1*N1.NE.I-1) GO TO 90
05          PRNT(1)=SYM(14)
05          PRNT(NB)=SYM(14)
05          GO TO 99
05    C
05    C     ---LOCATE Y AXES---
05       70 DO 80 J=1,NB
05          IF ((J-1)/N2*N2.EQ.J-1) PRNT(J)=SYM(14)
05       80 IF ((J-1)/N2*N2.NE.J-1) PRNT(J)=SYM(13)
05    C
05    C     ---COMPUTE LOCATION OF NODES AND DETERMINE APPROPRIATE SYMBOL---
05       99 IF (DIST.LT.0..OR.DIST.LT.Z-XN1*XSF) GO TO 240
05          YLEN=DELY(2)/2.
05          DO 220 L=2,I1
05          J=YLEN*N2/YSF+1.5
05          IF (T(L,JJ,LA).EQ.0.) GO TO 160
05          IF (S(L,JJ,LA).LT.0.) GO TO 210
05          INDX3=0
05          GO TO (100,110), NO
05      100 K=(STRT(L,JJ,LA)-PHI(L,JJ,LA))*FACT1
05    C     -TO CYCLE SYMBOLS FOR DRAWDOWN, REMOVE C FROM COL. 1 OF NEXT CARD-
05    C     K=AMOD(K,10.)
05          GO TO 120
05      110 K=PHI(L,JJ,LA)*FACT2
05      120 IF (K) 130,160,140
05      130 IF (J-2.GT.0) PRNT(J-2)=SYM(13)
05          N=-K+.5
05          IF (N.LT.100) GO TO 150
05          GO TO 190
05      140 N=K+.5
05          IF (N.LT.100) GO TO 150
05          IF (N.GT.999) GO TO 190
05          INDX3=N/100
05          IF (J-2.GT.0) PRNT(J-2)=SYM(INDX3)
05          N=N-INDX3*100
05      150 INDX1=MOD(N,10)
05          IF (INDX1.EQ.0) INDX1=10
05    C     -TO CYCLE SYMBOLS FOR DRAWDOWN, REMOVE C FROM COL. 1 OF NEXT CARD-
05    C     IF (NO.EQ.1) GO TO 170
05          INDX2=N/10
05          IF (INDX2.GT.0) GO TO 180
05          INDX2=10
05          IF (INDX3.EQ.0) INDX2=15
05          GO TO 180
05      160 INDX1=15
05      170 INDX2=15
05      180 IF (J-1.GT.0) PRNT(J-1)=SYM(INDX2)
05          PRNT(J)=SYM(INDX1)
05          GO TO 220
05      190 DO 200 II=1,3
05          JI=J-3+II
05      200 IF (JI.GT.0) PRNT(JI)=SYM(11)
05      210 IF (S(L,JJ,LA).LT.0.) PRNT(J)=SYM(16)
05      220 YLEN=YLEN+(DELY(L)+DELY(L+1))/2.
05      230 DIST=DIST-(DELX(JJ)+DELX(JJ-1))/2.
05          JJ=JJ-1
05          IF (JJ.EQ.0) GO TO 240
05          IF (DIST.GT.Z-XN1*XSF) GO TO 230
05      240 CONTINUE
05    C
05    C     ---PRINT AXES,LABELS, AND SYMBOLS---
05          IF (I-NA(LL).EQ.0) GO TO 260
05          IF ((I-1)/N1*N1-(I-1)) 270,250,270
05      250 I116=1+(I-1)/6
05          WRITE(6,VF1) (BLANK(J),J=1,NC),(PRNT(J),J=1,NB),XN(I116)
05          GO TO 280
05      260 WRITE (6,VF2) (BLANK(J),J=1,NC),(PRNT(J),J=1,NB),YLABEL(LL)
05          LL=LL+1
05          GO TO 280
05      270 WRITE (6,VF3) (BLANK(J),J=1,NC),(PRNT(J),J=1,NB)
05    C
05    C     ---COMPUTE NEW VALUE FOR Z AND INITIALIZE PRNT---
05      280 Z=Z-2.*XN1*XSF
05          DO 290 J=1,NB
05      290 PRNT(J)=SYM(15)
05    C
05    C     ---NUMBER AND LABEL Y AXIS AND PRINT LEGEND---
```

```
05            WRITE (6,VF3) (BLANK(J),J=1,NC),(TN(I),I=1,N6)
05            WRITE (6,320) (YLABEL(I),I=1,6)
05            IF (NO.EQ.1) WRITE (6,310) FACT1
05            IF (NO.EQ.2) WRITE (6,310) FACT2
05            RETURN
05      C
05      C     ---FORMATS---
05      C
05      C     ________________________________________________________________
05      C
05      C
05        300 FORMAT ('1',49X,3A8,'LAYER',I4//)
05        310 FORMAT ('0EXPLANATION'/' ',11('-')///' R = CONSTANT HEAD BOUNDARY'/
05           1' *** = VALUE EXCEEDED 3 FIGURES'/' MULTIPLICATION FACTOR =',F8.3)
05        320 FORMAT ('0',39X,6A8)
05        330 FORMAT ('0',25X,10('*'),' TO FIT MAP WITHIN 12 INCHES, DINCH REVIS
05           1ED TO',G15.7,1X,10('*'))
05        340 FORMAT ('0',45X,'NOTE: GENERALLY SCALE SHOULD BE   OR = 1.0')
05            END
01            BLOCK DATA
01      C     __________
01      C
01      C     SPECIFICATIONS:
01            CHARACTER *8XLABEL,YLABEL,TITLE,MESUR
01            CHARACTER *4ICHK,VF1,VF2,VF3,DIGIT
01            CHARACTER *1SYM,PRNT,BLANK
01      C
03            COMMON /SARRAY/ ICHK(16),LEVEL1(9),LEVEL2(9)
01            COMMON /PR/ XLABEL(3),YLABEL(6),TITLE(6),XN1,MESUR,PRNT(122),BLANK
01           1(60),DIGIT(122),VF1(6),VF2(6),VF3(7),XSCALE,DINCH,SYM(17),XN(100),
01           2YN(13),NA(4),N1,N2,N3,TSCALE,FACT1,FACT2
01      C     ****************************************************************
01      C
01            DATA ICHK/'DRAW','HEAD','MASS','DK1','DK2','WATE','RECH','PUN1','P
03           1UN2','ITKR','EQN3','EVAP','ALT','DNPP','MAPP','9'/
01            DATA SYM/'1','2','3','4','5','6','7','8','9','0','*','\','-','+','
01           1 ','R','U'/
01            DATA PRNT/122*' '/,N1,N2,N3,XN1/6,10,133,.8333333333E-1/,BLANK/60*'
01           1 '/,NA(4)/1000/
01            DATA XLABEL/' X DIS- ','TANCE IN',' MILES '/,YLABEL/'DISTANCE','
01           1FORM OR','IGIN IN ','Y DIRECT','ION, IN ','MILES   '/,TITLE/'PLOT
01           2OF ','DRAWDOWN',' ','PLOT OF ','HYDRAULI','C HEAD'/
01            DATA DIGIT/'1','2','3','4','5','6','7','8','9','10','11','12','13'
01           1,'14','15','16','17','18','19','20','21','22','23','24','25','26',
01           2'27','28','29','30','31','32','33','34','35','36','37','38','39','
01           340','41','42','43','44','45','46','47','48','49','50','51','52','5
01           43','54','55','56','57','58','59','60','61','62','63','64','65','66
01           5','67','68','69','70','71','72','73','74','75','76','77','78',' 79
01           6','80','81','82','83','84','85','86','87','88','89','90','91','92'
01           7,'93','94','95','96','97','98','99','100','101','102','103',' 104'
01           8,'105','106','107','108','109','110','111','112','113','114','115'
01           9,'116','117','118','119','120','121','122'/
01            DATA VF1/'(1H ',',',' ',',','A1,F','10.2',')'/
01            DATA VF2/'(1H ',',',' ',',','A1,1','X,A8',')'/
01            DATA VF3/'(1H0',',',' ',',','A1,F','3.1,','12F1','0.2)'/
01      C     ****************************************************************
01            END
```

Appendix B

Program Input Data Documentation

DATA DECK INSTRUCTIONS

Group I: Title, Simulation Options and Problem Dimensions

This group of cards, which are read by the main program, contains data required to dimension the model. To specify an option on card 4 punch the characters underlined in the definition. For an option not used, that section of card 4 can be left blank.

Note: Default typing of variables applies for all data input.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
1	1-80	20A4	HEADING	Any title the user wishes to print on one line at the start of output.
2	1-52	13A4	"	
3	1-10	I10	IO	Number of rows
	11-20	I10	JO	Number of columns
	21-30	I10	KO	Number of layers
	31-40	I10	ITMAX	Maximum number of iterations per time step
	41-50	I10	NCH	Number of constant head nodes
	51-60	I10	NSP	Number of spring nodes
	61-70	I10	NRIV	Number of river nodes
4	1-4	A4	IDRAW	DRAW to print drawdown
	6-9	A4	IHEAD	HEAD to print hydraulic head
	11-14	A4	IFLO	MASS to compute a mass balance
	16-18	A3	IDK1	DK1 to read initial head, elapsed time, and mass balance parameters from unit 4 on disk

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
4	21-23	A3	IDK2	DK2 to write computed head, elapsed time, and mass balance parameters on unit 4 (disk)
	26-29	A4	IWATER	WATE if the upper hydrologic unit is unconfined
	31-34	A4	IQRE	RECH for a constant recharge that may be a function of space
	36-39	A4	IPU1	PUN1 to read initial head, elapsed time, and mass balance parameters from cards
	41-44	A4	IPU2	PUN2 to punch computed head, elapsed time, and mass balance parameters on cards
	46-49	A4	ITK	ITKR to read the value of TK(I,J,K) for simulation in which confining layers are not represented by layers of nodes. TK(I,J,K) = K_{zz}/b
	51-54	A4	IEQN	EQN3 if equation 3 (page 3, USGS Open File Report 75-438) is being solved; otherwise it is assumed that equation 4 is being solved (to represent a hydraulic unit by one layer of nodes).
	56-59	A4	IEVAP	EVAP to permit discharge by evapotranspiration.
	61-63	A3	IALT	ALT to have alternative method for well pumping rates (modified for Cache Valley Model), besides the initial method.
	66-69	A4	IDNPP	DNPP to compute drawdown between each pumping period.
	71-74	A4	IMAPP	MAPP to compute mass balance for each pumping period.

Group II: Scalar Parameters

The parameters required in every problem are underlined. The other parameters are required as noted; when not required, their location on the card can be left blank. The G format is used to read E, F and I format data. Minimize mistakes by always right-justifying data in the field. If F format data do not contain significant figures to the right of the decimal point, the decimal point can be omitted.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
1	1-10	G10.0	NPER	Number of pumping periods for the simulation
	11-20	G10.0	KTH	Number of time steps between printouts

Note: To print only the results for the final time step in a pumping period, make KTH greater than the expected number of time steps. The program always prints the results for the final time step.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
	21-30	G10.0	ERR	Error criteria for closure (L)

Note: When the head change at all nodes on subsequent iterations is less than this value (for example, 0.01 foot), the program has converged to a solution for the time step.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
	31-40	G10.0	LENGTH	Number of iteration parameters
	41-50	G10.0	QET	Maximum evapotranspiration rate (L/T)
	51-60	G10.0	ETDIST	Depth at which evapotranspiration ceases below land surface (L)
2	1-10	G10.0	XSCALE	Factor to convert model lenth unit to unit used in X direction on maps (e.g. to convert from feet to miles, XSCALE = 5280) For no maps, card 2 is blank
	11-20	G10.0	YSCALE	Factor to convert model length unit to unit used in Y direction on maps.
	21-30	G10.0	DINCH	Number of map units per inch
	31-40	G10.0	FACT1	Factor to adjust value of drawdown printed*
	41-49	9I1	LEVEL1(I)	Layers for which drawdown maps are to be printed. List the layers starting in column 41; the first zero entry terminates the printing of drawdown maps.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
2	51-60	G10.0	FACT2	Factor to adjust value of head printed*
	61-69	9I1	LEVEL2(I)	Layers for which head maps are to be printed. List layers starting in column 61; the first zero entry terminates the printing of head maps.
	71-78	A8	MESUR	Name of map length unit
3	1-20	G20.10	SUM	
	21-40	G20.10	SUMP	
	41-60	G20.10	PUMPT	Parameters in which elapsed time and cumulative volumes for mass balance are stored. For the start of a simulation insert three blank cards. For continuation of a previous run using cards as input, replace the three blank cards with the first three cards of punched output from the previous run. Using data from disk for input, leave the three blank cards in the data deck.
	61-80	G20.10	CFLUXT	
4	1-20	G20.10	QRET	
	21-40	G20.10	CHST	
	41-60	G20.10	CHDT	
	61-80	G20.10	RVFLXT	
5	1-20	G20.10	STORT	
	21-40	G20.10	ETFLXT	
	41-60	G20.10	SFLXT	

*Value of drawdown or head	FACT 1 or FACT 2	Printed Value
	0.01	1
	0.1	5
52.57	1.0	53
	10.0	526
	100.0	***

Group III: Array Data

Each of the following data sets (except data set 1) consists of a parameter card and, if the data set contains variable data, a set of data cards. If the data set requires data for each layer, a parameter card and data cards (for layers with variable data) are required for each layer. Each parameter card contains at least five variables:

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
Every Parameter Card	1-10	G10.0	FAC	If IVAR = 0, FAC is the value assigned to every element of the matrix for this layer. If IVAR = 1, FAC is the multiplication factor for the following set of data cards for this layer.
	11-20	G10.0	IVAR	= 0 if no data cards are to be read for this layer. = 1 if data cards for this layer follow.
	21-30	G10.0	IPRN	= 0 if input data for this layer are to be printed. = 1 if input data for the layer are not to be printed.
Transmissivity Parameter Cards also have these Variables	31-40	G10.0	FACT(K,1)	Multiplication factor for transmissivity in x direction
	41-50	G10.0	FACT(K,2)	Multiplication factor for transmissivity in y direction
	51-60	G10.0	FACT(K,3)	Multiplication factor for hydraulic conductivity in the z direction. (Not used when confining bed nodes are eliminated and TK values are read)

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
Every Parameter Card	61-70	G10.0	IRECS	= 0 if the matrix is being read from cards or if each element is being set equal to FAC.
				= 1 if the matrix is to be read from disk (unit 2).
	71-80	G10.0	IRECD	= 0 if the matrix is not to be stored on disk.
				= 1 if the matrix being read from cards or set equal to FAC is to be stored on disk (unit 2) for later retrieval.

When data cards are included, start each row on a new card. To prepare a set of data cards for an array that is a function of space, the general procedure is to overlay the finite-difference grid on a contoured map of the parameter and record the average value of the parameter for each finite-difference block on coding forms according to the appropriate format. In general, record only significant digits and no decimal points (except for data set 2); use the multiplication factor to convert the data to their appropriate values. For example, if DELX ranges from 1000 to 15000 feet, coded values should range from 1-15; the multiplication factor (FAC) would be 1000.

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
1	1-80	8F 10.4	PHI(I,J,K)	Head values for continuation of a previous run (L)

Note: For a new simulation this data set is omitted. Do not include a parameter card with this data set.

2	1-80	8F 10.4	STRT(I,J,K)	Starting head matrix (L)
3	1-80	20F 4.0	S (I,J,K)	Storage coefficient (dimensionless)

Note: This matrix is also used to locate constant head boundaries by coding a negative number at constant head nodes. At these nodes T must be greater than zero. If equation 3 is to be solved, read specific storage instead of storage coefficient.

4	1-80	10G 8.0	T(I,J,K)	Transmissivity (L^2/t)

Note 1) Zero values are required around the perimeter of the T matrix for each layer for reasons inherent in the computational scheme. This is done automatically by the program.

2) See the previous page for the additional requirements on the parameter cards for this data set.

3) If the upper active layer is unconfined and PERM and BOTTOM are to be read for this layer, insert a parameter card for this layer with only the values for FACT on it. If equation 3 is to be solved read hydraulic conductivity instead of transmissivity.

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
5	1-80	20F 4.0	TK(I,J,K)	K_{zz}/b

Note: This data set is read only if specified in the options. The number of layers of TK values = K' - 1. See the discussion of the treatment of confining layers.

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
6	1-80	20F 4.0	PERM(I,J)	Hydraulic conductivity (L/T) (see note 1 for data set 4)
7	1-80	20F 4.0	BOTTOM(I,J)	Elevation of bottom of water-table unit (L)

Note: Data sets 6 and 7 are required only for simulating unconfined conditions in the upper hydrologic unit.

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
8	1-80	20F 4.0	QRE(I,J,K)	Recharge rate (L/2)

Note: Omit if not used

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
9	1-80	8F 10.4	GRND(I,J)	Ground surface elevation
10	1-80	8G 10.0	DELX(J)	Grid spacing in x direction (L)
11	1-80	8G 10.0	DELY(I)	Grid spacing in y direction (L)
12	1-80	8G 10.0	DELZ(K)	Grid spacing in z direction (L)

Group IV: Spring Node Data Deck

This data deck contains arrays indicating the nodes which have springs and specifying the leakage factor and elevation of spring in each node.

ARRAY	COLUMNS	FORMAT	DEFINITION
ID(I,J,K)	1-80	80G 1.0	Indicator array for cells containing a spring node, 1 for spring, 0 for no spring.
FLD(ND)	1-80	40F 2.0	Leakage factor for each spring node
ELD(ND)	1-80	20F 4.0	Elevation for each spring node

The FLD, ELD arrays each preceded by a multiplication factor (FAC) card.

VARIABLE	COLUMNS	FORMAT	DEFINITION
FAC	1-10	G 10.0	The multiplication factor for the following set of data cards

Group V: River Node Data Deck

This data deck contains arrays indicating the nodes which have rivers and specifying the leakage factor and elevation of streambed and elevation of the bottom of the streambed layer.

ARRAY	COLUMNS	FORMAT	DEFINITION
IDR(I,J,K)	1-80	80G 1.0	Indicator array for cells containing a river node, 1 for river, 0 for no river
RH(NRIV)	1-80	20F 4.0	River water level for each river node
RB(NRIV)	1-80	20F 4.0	Bottom elevation of the streambed layer for each river node
RC(NRIV)	1-80	10F 8.0	Leakage factor for each river node

The RH, RB, RC arrays each preceded by a multiplication factor card.

VARIABLE	COLUMNS	FORMAT	DEFINITION
FAC	1-10	G 10.0	The multiplication factor for the following set of data cards
HMAX	1-10	F 10.5	Maximum iteration parameter, of the sequence of parameters computed by the equations in the problem are all close to 1.0 and if this results in slow convergence or even divergence, bypass the computations in the model and insert HMAX=0.99863 may give a satisfactory rate of convergence.

Group VI: Parameters that Change with the Pumping Period

The program has two options for the simulation period:

1. To simulate a given number of time steps, set TMAX to a value larger than the expected simulation period. The program will use NUMT, CDLT, and DELT as coded. If NUMT is greater than 50 change the dimension of ITTO in subroutine STEP to the appropriate size.

2. To simulate a given pumping period, set NUMT larger than the number required for the simulation period (for example, 50). The program will compute the exact DELT (which will be $\leq$ DELT coded) and NUMT to arrive exactly at TMAX on the last time step.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
1	1-10	G10.0	KP	Number of the pumping period
	11-20	G10.0	KPM1	Number of the previous pumping period
	Note: KPM1 is currently not used.			
	21-30	G10.0	NWEL	Number of wells for this pumping period
	31-40	G10.0	TMAX	Number of days in this pumping period
	41-50	G10.0	NUMT	Number of time steps
	51-60	G10.0	CDLT	Multiplying factor for DELT
	Note: 1.5 is commonly used.			
	61-70	G10.0	DELT	Initial time step in hours

The following data set depends on the variable IALT. DATA SET A is the case of original program, DATA SET B is the case of program modified for Cache Valley Model.

If NWEL = 0 the following set of cards is omitted.

DATA SET A (NWEL cards)

COLUMNS	FORMAT	VARIABLE	DEFINITION
1-10	G10.0	K	Layer in which well is located
11-20	G10.0	I	Row location of well
21-30	G10.0	J	Column location of well
31-40	G10.0	WELL(I,J,K)	Pumping rate (L^3/t), negative for a pumping well.

DATA SET B

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
2	1-10	G10.0	AWELL	Average discharge for "small" wells
	11-20	G10.0	NBWEL	Number of "big" wells
	21-30	G10.0	BWC	Discharge multiplication factor for big well for each pumping period
	31-40	G10.0	FBWELL	Time length factor of pumping for big well
	41-50	G10.0	NCF	Number of recharge constant flux node
	51-60	G10.0	CFC	Multiplication factor for constant flux

(NBWEL Cards)

COLUMNS	FORMAT	VARIABLE	DEFINITION
1-10	G10.0	K	Layer in which well located
11-20	G10.0	I	Row location of well
21-30	G10.0	J	Column location of well
31-40	G10.0	BWELL(I,J,K)	Pumping rate (L^3/t), negative for "big" well, negative value

(NCF Cards)

1-10	G10.0	K	Layer in which well located
11-20	G10.0	I	Row location of well
21-30	G10.0	J	Column location of well
31-40	G10.0	RCF(I,J,K)	Recharge constant flux rate (L^3/t), positive value

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
1	1-80	20G 4.0	NWELL(I,J,K)	Total number of "small" wells, within the cell, for each node

For each additional pumping period, another set of group VI cards is required (that is, NPER sets of group VI cards are required).

Appendix C

Model Input Data of Transient-state Calibration of March 1969

```
-----------CACHE VALLEY GROUND-WATER MODELING---------------

       23        39           3           50        30          31        75          1
DRAW HEAD MASS               WATE RECH               ITAP.     EVAP ALT  DHPP MAPP
        4         1          .01           3  3.40E-08          10.
     5280      5280            1        1.12                     1.                 MILES "



        1.        1          1
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.    4450.    4430.    4440.       0.
      0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
   4525.    4490.    4480.    4465.    4455.    4450.    4449.    4445.
   4439.    4440.    4439.    4437.    4435.    4430.    4435.       0.
      0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.    4490.    4485.    4480.    4470.    4445.
   4460.    4455.    4450.    4446.    4442.    4439.    4434.    4430.
   4428.    4429.    4429.    4430.    4436.    4440.    4439.       0.
      0.       0.       0.       0.    4490.    4505.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.    4485.    4480.    4479.    4475.    4470.    4466.    4460.
   4456.    4452.    4449.    4442.    4439.    4435.    4432.    4430.
   4430.    4431.    4430.    4430.    4437.    4441.    4458.    4478.
      0.       0.       0.    4479.    4483.    4497.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
   4486.    4480.    4477.    4473.    4470.    4467.    4463.    4459.
   4455.    4451.    4449.    4443.    4439.    4436.    4434.    4434.
   4435.    4435.    4435.    4435.    4440.    4442.    4450.    4470.
   4476.    4471.    4471.    4472.    4478.    4490.       0.
      0.       0.       0.       0.       0.    4575.    4535.    4477.
   4484.    4477.    4476.    4472.    4467.    4467.    4463.    4462.
   4456.    4453.    4450.    4445.    4441.    4440.    4439.    4439.
   4440.    4440.    4441.    4440.    4442.    1443.    4448.    4452.
   4463.    4462.    4462.    4467.    4474.    4485.       0.
      0.       0.       0.       0.       0.    1580.    4530.    4491.
   4483.    4477.    4475.    4474.    4470.    4458.    4464.    4461.
   4458.    4456.    4452.    4450.    4448.    4445.    4443.    4145.
   4446.    4447.    4448.    4447.    4447.    4446.    4447.    4450.
   4451.    4452.    4456.    4461.    4471.    4491.       0.
      0.       0.       0.       0.       0.    4605.    4535.    4500.
   4485.    4479.    4477.    4475.    4472.    4470.    4468.    4465.
   4461.    1461.    1457.    4456.    4455.    4454.    4451.    4452.
   4452.    4453.    4454.    4453.    4452.    4459.    4440.    4447.
   4449.    4449.    1450.    4460.    4470.    4480.       0.
      0.       0.       0.       0.       0.    4615.    4545.    4510.
   4490.    4482.    4480.    4477.    4475.    4472.    4470.    4468.
   4465.    4462.    4460.    4472.    4453.    4457.    4458.    4459.
   4455.    4458.    4459.    4460.    4459.    4456.    4451.    4447.
   4447.    4448.    4449.    4460.    4469.    4478.       0.
      0.       0.       0.       0.       0.    4620.    4560.    4520.
   4493.    4485.    4481.    4480.    4479.    4475.    4473.    4470.
   4469.    4467.    4455.    4464.    4464.    4464.    4463.    1462.
   4460.    4451.    4463.    1464.    4464.    4464.    4460.    4452.
   4449.    4447.    4449.    4459.    4460.    4476.       0.
      0.       0.       0.       0.       0.    4620.    4530.    4525.
   4495.    4489.    4485.    4484.    4481.    4480.    4478.    4475.
   4472.    4471.    1470.    4469.    4469.    4470.    4429.    4469.
   4466.    4468.    4468.    4467.    4470.    4472.    4470.    4462.
   4455.    4449.    4450.    4459.    4460.    4475.       0.
      0.       0.       0.       0.       0.    4605.    4550.    4510.
   4496.    4490.    4487.    4486.    4485.    4484.    4492.    4490.
   4478.    4477.    4476.    4473.    4474.    4475.    4475.    4474.
   4472.    4473.    4472.    4474.    4476.    4478.    4478.    4470.
   4461.    4457.    4454.    4460.    4470.    4476.       0.
      0.       0.       0.       0.       0.    4590.    4538.    4505.
   4495.    4491.    4491.    4490.    4490.    4488.    4484.    4484.
   4483.    4481.    4481.    4400.    4450.    4480.    4481.    4490.
   4478.    4478.    4477.    4470.    4490.    4481.    4482.    4480.
   4470.    4465.    4458.    4463.    4471.    4477.       0.
      0.    4805.    4765.    4710.    4640.    4575.    4528.    4500.
   4494.    4492.    4493.    4493.    4472.    4491.    4495.    4489.
   4487.    4487.    4485.    4487.    4486.    4488.    4487.    4487.
   4486.    4482.    4481.    4483.    4484.    4484.    4483.    4484.
   4480.    4475.    4464.    4467.    4472.    4478.       0.
      0.    4795.    4755.    4695.    4635.    4560.    4521.    4499.
   4495.    4495.    4495.    4495.    4494.    4493.    4493.    4492.
   4491.    4491.    4490.    4490.    4491.    4491.    4491.    4491.
   4491.    4488.    4486.    4487.    4487.    4486.    4485.    4487.
   4488.    4487.    4474.    4470.    4473.    4479.       0.
      0.    4790.    4750.    4665.    4615.    4550.    4525.    4499.
   4496.    4497.    4497.    4497.    4496.    4495.    4475.    4495.
   4494.    4493.    4493.    4493.    4495.    4494.    4494.    4493.
   4493.    4494.    4493.    4493.    4490.    4489.    4489.    4490.
   4496.    4497.    4487.    4474.    4475.    4479.       0.
      0.       0.       0.       0.    4605.    4540.    4515.    4499.
   4498.    4499.    4500.    4505.    4499.    4498.    4498.    4497.
   4497.    4495.    4495.    4494.    4497.    4497.    4495.    4495.
   4476.    4499.    4500.    4498.    4495.    4493.    4491.       0.
   4507.    4519.    4524.    4480.    4477.    4480.       0.
      0.       0.       0.       0.       0.    4525.    4515.    4560.
   4500.    4501.    4503.    4503.    4502.    4500.    4500.    4501.
   4500.    4497.    4499.    4500.    4500.    4499.    4498.    4497.
   4498.    4504.       0.       0.       0.    4476.    4497.       0.
      0.    1522.    1520.    4495.    4495.    4495.       0.
      0.       0.       0.       0.       0.    4539.    4520.    4507.
   4505.    4506.    4507.    4507.    4506.    4503.    4501.    4504.
   4501.    4500.    4500.    4505.    1505.    1502.    4500.    4500.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.    4515.    4495.    4450.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
      0.       0.       0.       0.       0.       0.       0.       0.
```

113.	0.	0.	0.	4515.	4515.	4512.	4510.	0.
114.	0.	0.	0.	0.	0.	0.	0.	0.
115.	0.	0.	0.	0.	4495.	4495.	0.	
116.	0.	0.	0.	0.	0.	0.	0.	0.
117.	0.	0.	0.	0.	0.	0.	0.	0.
118.	0.	0.	0.	0.	0.	0.	0.	0.
119.	0.	0.	0.	0.	0.	0.	0.	0.
120.	0.	0.	0.	0.	0.	4505.	0.	
121.	0.	0.	0.	0.	0.	0.	0.	0.
122.	0.	0.	0.	0.	0.	0.	0.	0.
123.	0.	0.	0.	0.	0.	0.	0.	0.
124.	0.	0.	0.	0.	0.	0.	0.	0.
125.	0.	0.	0.	0.	0.	0.	0.	
126.	1.	1	1					
127.	0.	0.	0.	0.	0.	0.	0.	0.
128.	0.	0.	0.	0.	0.	0.	0.	0.
129.	0.	0.	0.	0.	0.	0.	0.	0.
130.	0.	0.	0.	0.	0.	0.	0.	0.
131.	0.	0.	0.	0.	0.	0.	0.	
132.	0.	0.	0.	0.	0.	0.	0.	0.
133.	0.	0.	0.	0.	0.	0.	0.	0.
134.	0.	0.	0.	0.	0.	0.	0.	0.
135.	0.	0.	0.	0.	4445.	4435.	4430.	0.
136.	0.	0.	0.	0.	0.	0.	0.	
137.	0.	0.	0.	0.	0.	0.	0.	0.
138.	0.	0.	0.	0.	0.	0.	0.	0.
139.	0.	0.	0.	0.	0.	4465.	4425.	4450.
140.	4440.	4430.	4424.	4423.	4420.	4407.	4470.	0.
141.	0.	0.	0.	0.	0.	0.	0.	
142.	0.	0.	0.	0.	0.	0.	0.	0.
143.	0.	0.	0.	0.	0.	4435.	4432.	4430.
144.	4428.	4425.	4430.	4440.	4435.	4435.	4432.	4430.
145.	4428.	4422.	4416.	4413.	4420.	4407.	4480.	0.
146.	0.	0.	0.	0.	4480.	4512.	0.	
147.	0.	0.	0.	0.	0.	0.	0.	0.
148.	0.	0.	4460.	4443.	4425.	4417.	4415.	4410.
149.	4410.	4410.	4410.	4410.	4410.	4410.	4407.	4410.
150.	4413.	4407.	4407.	4407.	4407.	4425.	4475.	0.
151.	0.	0.	0.	4453.	4470.	4490.	0.	
152.	0.	0.	0.	0.	0.	0.	0.	0.
153.	0.	4470.	4440.	4420.	4419.	4415.	4412.	4410.
154.	4410.	4410.	4410.	4410.	4410.	4410.	4407.	4407.
155.	4407.	4410.	4415.	4407.	4410.	4413.	4418.	4430.
156.	4450.	4460.	4425.	4445.	4458.	4460.	0.	
157.	0.	0.	0.	0.	0.	4545.	4535.	4500.
158.	4480.	4452.	4429.	4421.	4420.	4418.	4415.	4410.
159.	4410.	4412.	4410.	4410.	4410.	4410.	4410.	4410.
160.	4415.	4419.	4420.	4407.	4417.	4410.	4410.	4415.
161.	4420.	4450.	4440.	4425.	4450.	4440.	0.	
162.	0.	0.	0.	0.	0.	4520.	4520.	4470.
163.	4460.	4437.	4430.	4430.	4435.	4425.	4419.	4415.
164.	4415.	4414.	4413.	4410.	4413.	4412.	4410.	4410.
165.	4417.	4415.	4410.	4421.	4421.	4412.	4412.	4410.
166.	4411.	4445.	4430.	4445.	4435.	4465.	0.	
167.	0.	0.	0.	0.	0.	4580.	4523.	4480.
168.	4448.	4439.	4440.	4440.	4430.	4430.	4421.	4423.
169.	4423.	4418.	4415.	4410.	4417.	4413.	4414.	4414.
170.	4419.	4410.	4415.	4425.	4425.	4425.	4414.	4413.
171.	4412.	4435.	4430.	4462.	4470.	4485.	0.	
172.	0.	0.	0.	0.	0.	4600.	4520.	4500.
173.	4470.	4457.	4455.	4445.	4439.	4433.	4427.	4427.
174.	4427.	4423.	4418.	4422.	4422.	4421.	4421.	4417.
175.	4421.	4420.	4425.	4430.	4433.	4430.	4420.	4418.
176.	4417.	4425.	4430.	4463.	4480.	4495.	0.	
177.	0.	0.	0.	0.	0.	4610.	4540.	4510.
178.	4485.	4475.	4468.	4454.	4442.	4432.	4432.	4431.
179.	4431.	4428.	4420.	4425.	4428.	4427.	4427.	4424.
180.	4424.	4425.	4426.	4415.	4424.	4420.	4430.	4430.
181.	4425.	4420.	4420.	4464.	4491.	4504.	0.	
182.	0.	0.	0.	0.	0.	4620.	4545.	4529.
183.	4492.	4484.	4480.	4470.	4452.	4440.	4437.	4435.
184.	4430.	4425.	4425.	4433.	4431.	4429.	4427.	4427.
185.	4425.	4430.	4427.	4425.	4430.	4410.	4435.	4425.
186.	4435.	4430.	4425.	4467.	4492.	4502.	0.	
187.	0.	0.	0.	0.	0.	4590.	0.	4525.
188.	4500.	4492.	4485.	4480.	4463.	4444.	4441.	4440.
189.	4434.	4432.	4430.	4437.	4436.	4432.	4430.	4429.
190.	4427.	4433.	4430.	4430.	4436.	4435.	4420.	4430.
191.	4430.	4435.	4425.	4468.	4495.	4502.	0.	
192.	0.	0.	0.	0.	0.	4664.	4650.	0.
193.	4507.	4495.	4490.	4486.	4480.	4466.	4460.	4450.
194.	4452.	4448.	4440.	4440.	4440.	4440.	4440.	4437.
195.	4437.	4437.	4432.	4438.	4450.	4450.	4440.	4445.
196.	4420.	4440.	4420.	4475.	4497.	4504.	0.	
197.	0.	4790.	4785.	4780.	4664.	4664.	4680.	0.
198.	4512.	4505.	4500.	4502.	4490.	4480.	4470.	4463.
199.	4467.	4462.	4454.	4450.	4451.	4450.	4450.	4450.
200.	4444.	4441.	4439.	4443.	4464.	4470.	4460.	4460.
201.	4440.	4442.	4425.	4480.	4498.	4504.	0.	
202.	0.	4810.	4795.	4795.	4780.	4725.	4700.	0.
203.	0.	4515.	4510.	4505.	4495.	4487.	4470.	4474.
204.	4480.	4478.	4480.	4475.	4475.	4470.	4470.	4460.
205.	4455.	4445.	4445.	4460.	4480.	4490.	4485.	4480.
206.	4465.	4462.	4430.	4465.	4496.	4500.	0.	
207.	0.	4825.	4815.	4800.	4782.	4763.	4725.	0.
208.	0.	0.	4515.	4510.	4499.	4490.	4480.	4487.
209.	4490.	4500.	4510.	4500.	4493.	4490.	4485.	4480.
210.	4467.	4451.	4455.	4476.	4490.	0.	0.	0.
211.	4485.	4475.	4460.	4440.	4485.	4499.	0.	
212.	0.	0.	0.	0.	4770.	4772.	4752.	0.
213.	0.	0.	4530.	4525.	4525.	4515.	4510.	4502.
214.	4505.	4510.	4520.	4515.	4510.	4505.	4505.	4492.
215.	4488.	4473.	4475.	4470.	0.	0.	0.	0.
216.	4510.	4495.	4485.	4455.	4450.	4460.	0.	
217.	0.	0.	0.	0.	0.	0.	0.	0.
218.	0.	0.	0.	0.	0.	0.	0.	0.
219.	0.	4530.	4525.	0.	0.	0.	0.	0.
220.	4515.	4495.	0.	0.	0.	0.	0.	0.
221.	0.	0.	0.	4475.	4480.	4475.	0.	
222.	0.	0.	0.	0.	0.	0.	0.	0.
223.	0.	0.	0.	0.	0.	0.	0.	0.
224.	0.	0.	0.	0.	0.	0.	0.	0.

225.	0.	0.	0.	0.	0.	0.	0.	0.
226.	0.	0.	0.	0.	4505.	4404.	0.	
227.	0.	0.	0.	0.	0.	0.	0.	0.
228.	0.	0.	0.	0.	0.	0.	0.	0.
229.	0.	0.	0.	0.	0.	0.	0.	0.
230.	0.	0.	0.	0.	0.	0.	0.	0.
231.	0.	0.	0.	0.	0.	4486.	0.	
232.	0.	0.	0.	0.	0.	0.	0.	0.
233.	0.	0.	0.	0.	0.	0.	0.	0.
234.	0.	0.	0.	0.	0.	0.	0.	0.
235.	0.	0.	0.	0.	0.	0.	0.	0.
236.	0.	0.	0.	0.	0.	0.	0.	
237.	0.	0.	0.	0.	0.	0.	0.	0.
238.	0.	0.	0.	0.	0.	0.	0.	0.
239.	0.	0.	0.	0.	0.	0.	0.	0.
240.	0.	0.	0.	0.	0.	0.	0.	0.
241.	0.	0.	0.	0.	0.	0.	0.	

242. 1.0E-3 1

243.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
244.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
245.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
246.	0	0	0	0	0	0	0	0	10	10	10	0	0	0	0	0	0	0	0	
247.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10
248.	10	10	10	10	10	10	10	10	10	10	10	0	0	0	0	0	0	0	0	
249.	0	0	0	0	0	0	0	0	0	0	0	11	11	11	10	10	10	10	10	10
250.	10	10	10	10	10	10	10	10	10	10	10	0	0	0	0	0	10	10	0	
251.	0	0	0	0	0	0	0	0	0	10	10	10	10	10	11	10	10	10	10	10
252.	10	10	10	10	10	10	10	10	10	10	10	10	0	0	0	10	10	10	0	
253.	0	0	0	0	0	10	0	0	10	10	10	10	10	10	10	10	10	10	10	10
254.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	0	
255.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
256.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	0	
257.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
258.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	0	
259.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
260.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	0	
261.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	15	20	15	15
262.	15	15	15	15	10	10	10	10	10	10	10	10	10	10	10	10	10	10	0	
263.	0	0	0	0	0	10	10	10	10	10	10	10	20	20	20	20	20	20	15	15
264.	15	15	15	15	15	10	10	10	10	10	10	10	10	10	10	10	10	10	0	
265.	0	0	0	0	0	10	10	15	15	15	15	15	25	25	25	30	30	10	15	15
266.	15	15	15	15	15	15	10	10	10	10	10	10	10	10	10	10	10	10	0	
267.	0	0	0	0	0	10	15	15	15	25	20	20	25	30	35	40	35	30	15	15
268.	15	15	15	15	15	15	10	10	10	10	10	10	10	10	10	10	10	10	0	
269.	0	0	0	0	0	10	15	15	15	20	20	25	30	37	40	40	35	30	15	15
270.	15	15	15	15	15	15	10	10	10	10	10	10	10	10	10	10	10	15	0	
271.	0	10	10	10	10	10	15	15	20	25	25	27	30	35	40	45	35	30	15	15
272.	15	15	15	15	14	15	10	10	10	10	10	10	10	10	10	10	10	10	0	
273.	0	10	10	10	10	10	15	15	20	30	30	30	35	35	40	40	35	10	25	20
274.	17	17	15	15	14	15	10	10	10	10	10	10	10	10	10	10	10	10	0	
275.	0	10	10	10	10	10	15	15	20	30	30	30	40	40	40	20	20	20	15	15
276.	15	15	15	20	16	10	10	10	10	10	10	10	10	10	10	10	10	10	0	
277.	0	0	0	0	10	10	15	15	20	30	30	30	20	20	20	20	20	20	15	15
278.	15	15	15	20	17	15	15	15	15	15	15	0	10	10	10	10	10	10	0	
279.	0	0	0	0	0	10	15	15	20	20	20	20	20	20	20	20	20	20	15	15
280.	15	15	15	20	20	20	0	0	0	20	20	0	0	10	10	10	10	10	0	
281.	0	0	0	0	0	10	15	15	20	20	20	20	20	20	20	20	20	20	15	15
282.	15	15	15	20	0	0	0	0	0	0	0	0	0	0	0	10	10	10	0	
283.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
284.	15	15	15	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	0	
285.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
286.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	
287.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
288.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

289. 1.0E-3 1

290.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
291.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
292.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
293.	0	0	0	0	0	0	0	0	10	10	10	0	0	0	0	0	0	0	0	
294.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10
295.	10	10	10	10	10	10	10	10	10	-10	10	0	0	0	0	0	0	0	0	
296.	0	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	10
297.	10	10	10	10	10	10	10	10	10	-10	10	0	0	0	0	0	0	0	0	
298.	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10
299.	10	10	-10	10	10	-10	-10	-10	-10	10	10	10	0	0	0	10	10	10	0	
300.	0	0	0	0	0	10	0	0	10	10	10	10	10	10	10	10	10	10	10	10
301.	10	10	-10	-10	-10	10	10	-10	10	10	10	10	10	10	10	10	10	10	0	
302.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
303.	10	10	10	10	10	10	10	-10	10	10	10	10	10	10	10	-10	10	-10	0	
304.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
305.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	-10	10	-10	10	0	
306.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
307.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	-10	10	10	10	0	
308.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
309.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	-10	10	10	10	0	
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311.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	-10	10	10	10	0	
312.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
313.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	-10	10	10	10	0	
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315.	10	10	10	10	10	10	10	10	10	10	10	10	10	-10	10	10	10	10	0	
316.	0	0	0	0	0	-10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
317.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	-10	10	10	10	0	
318.	0	10	10	10	-10	-10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
319.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	-10	10	10	10	0	
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321.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	-10	10	10	10	0	
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323.	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	-10	10	10	0	
324.	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
325.	10	10	10	10	10	10	10	10	10	10	10	0	10	10	10	10	-10	-10	0	
326.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
327.	10	10	10	10	10	10	0	0	0	10	10	0	0	10	10	10	10	10	0	
328.	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
329.	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0	10	10	10	0	
330.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10
331.	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	10	10	0	
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333.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	
334.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
335.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	

336. 1.16E-02 1 1 1 1

337.	0	0	0	0	0	0	0	0	0	0
338.	0	0	0	0	0	0	0	0	0	0
339.	0	0	0	0	0	0	0	0	0	0
340.	0	0	0	0	0	0	0	0	0	

341.	0	0	0	0	0	0	0	0	0	0
342.	0	0	0	0	0	0	0	0	0	0
343.	0	0	0	0	0	0	0	0	1500	2000
344.	2000	0	0	0	0	0	0	0	0	
345.	0	0	0	0	0	0	0	0	0	0
346.	0	0	0	0	0	0	1000	1000	1000	1000
347.	2000	1000	1000	1000	1500	1500	1500	2000	1000	2000
348.	2000	0	0	0	0	0	0	0	0	
349.	0	0	0	0	0	0	0	0	0	0
350.	0	2000	2000	1500	1500	1500	1500	1500	2000	2000
351.	2000	2000	2000	2000	1500	1500	2000	2000	4000	3000
352.	3000	0	0	0	0	0	10000	15000	0	
353.	0	0	0	0	0	0	0	0	0	2000
354.	2000	5000	5000	3000	3000	2000	3000	3000	3000	3000
355.	3000	2000	2000	2000	2000	2000	3000	3000	4000	4000
356.	3000	4000	0	0	0	5000	8000	10000	0	
357.	0	0	0	0	0	0	0	0	2000	3000
358.	3000	6000	6000	6000	6000	5000	5000	5000	6000	3000
359.	3000	3000	3000	3000	3000	5000	4000	4000	4000	4000
360.	3000	3000	4000	4000	4000	4000	6000	8000	0	
361.	0	0	0	0	0	1000	1000	2000	5000	8000
362.	10000	10000	10000	10000	10000	8000	8000	8000	8000	5000
363.	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
364.	3000	3000	3000	3000	3000	3000	5000	7000	0	
365.	0	0	0	0	0	1000	1000	2000	5000	8000
366.	10000	15000	15000	15000	15000	10000	10000	10000	10000	8000
367.	8000	8000	8000	8000	8000	8000	8000	7000	7000	7000
368.	3000	3000	2000	3000	3000	3000	4000	6000	0	
369.	0	0	0	0	0	1000	1000	2000	5000	10000
370.	20000	20000	20000	20000	20000	20000	15000	15000	15000	10000
371.	10000	10000	10000	10000	10000	9000	10000	8000	8000	8000
372.	5000	3000	2000	3000	3000	3000	4000	5000	0	
373.	0	0	0	0	0	1000	1000	2000	5000	10000
374.	20000	30000	30000	30000	30000	20000	15000	15000	10000	10000
375.	10000	10000	10000	10000	10000	10000	12000	10000	8000	10000
376.	6000	3000	2000	3000	5000	3000	3000	5000	0	
377.	0	0	0	0	0	2000	2000	2000	6000	20000
378.	30000	50000	50000	50000	40000	30000	20000	20000	15000	15000
379.	15000	12000	15000	15000	10000	10000	15000	10000	10000	15000
380.	7000	4000	2000	3000	5000	3000	3000	4000	0	
381.	0	0	0	0	0	1000	2000	2000	7000	30000
382.	50000	60000	60000	60000	60000	40000	30000	25000	20000	15000
383.	15000	15000	15000	20000	10000	10000	15000	15000	15000	20000
384.	10000	5000	3000	3000	5000	3000	3000	3000	0	
385.	0	0	0	0	0	2000	3000	4000	10000	50000
386.	80000	80000	80000	80000	70000	50000	40000	35000	25000	25000
387.	20000	20000	20000	20000	15000	15000	15000	20000	20000	40000
388.	20000	8000	4000	3000	4000	3000	3000	3000	0	
389.	0	0	0	0	0	2000	2000	8000	30000	80000
390.	100000	100000	100000	100000	80000	50000	50000	50000	30000	25000
391.	25000	25000	25000	25000	15000	15000	20000	30000	30000	50000
392.	30000	10000	5000	4000	4000	3000	4000	3000	0	
393.	0	2000	2000	2000	2000	2000	2000	10000	50000	100000
394.	100000	150000	120000	100000	80000	50000	50000	50000	40000	30000
395.	25000	25000	30000	25000	15000	15000	20000	30000	40000	100000
396.	60000	30000	6000	5000	4000	3000	5000	3000	0	
397.	0	2000	2000	2000	2000	3000	5000	30000	90000	120000
398.	100000	100000	100000	100000	80000	50000	50000	50000	50000	50000
399.	40000	30000	35000	30000	20000	20000	20000	10000	50000	150000
400.	150000	50000	7000	5000	4000	4000	5000	3000	0	
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402.	100000	100000	100000	100000	80000	60000	60000	100000	100000	60000
403.	50000	30000	40000	40000	25000	10000	30000	10000	30000	250000
404.	300000	60000	8000	6000	5000	4000	6000	4000	0	
405.	0	0	0	0	1000	3000	8000	80000	100000	80000
406.	100000	80000	80000	90000	80000	60000	60000	100000	120000	70000
407.	50000	30000	50000	50000	40000	20000	40000	50000	100000	250000
408.	300000	0	10000	7000	5000	4000	8000	5000	0	
409.	0	0	0	0	0	8000	30000	100000	100000	50000
410.	50000	50000	50000	80000	80000	60000	60000	80000	100000	30000
411.	50000	40000	50000	50000	50000	30000	0	0	0	150000
412.	150000	0	0	8000	5000	3000	10000	5000	0	
413.	0	0	0	0	0	10000	40000	50000	50000	30000
414.	30000	30000	30000	50000	50000	50000	60000	70000	90000	100000
415.	100000	50000	60000	60000	0	0	0	0	0	0
416.	0	0	0	0	0	3000	15000	6000	0	
417.	0	0	0	0	0	0	0	0	0	0
418.	0	0	0	0	0	0	0	0	0	60000
419.	60000	40000	30000	0	0	0	0	0	0	0
420.	0	0	0	0	0	0	10000	6000	0	
421.	0	0	0	0	0	0	0	0	0	0
422.	0	0	0	0	0	0	0	0	0	0
423.	0	0	0	0	0	0	0	0	0	0
424.	0	0	0	0	0	0	0	5000	0	
425.	0	0	0	0	0	0	0	0	0	0
426.	0	0	0	0	0	0	0	0	0	0
427.	0	0	0	0	0	0	0	0	0	0
428.	0	0	0	0	0	0	0	0	0	
429.					1	1				
430.	7.00E-12		1	1						

431.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
432.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
433.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
434.	0	0	0	0	0	0	0	0	100	100	100	0	0	0	0	0	0	0	0	
435.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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437.	0	0	0	0	0	0	0	0	0	0	0	0	0	100	100	100	100	100	100	100
438.	100	100	200	200	200	200	100	100	100	50	100	0	0	0	0	0	100	100	0	
439.	0	0	0	0	0	0	0	0	0	0	100	20	20	20	20	50	50	50	50	100
440.	100	100	100	100	100	50	50	50	50	100	100	0	0	0	0	100	100	100	0	
441.	0	0	0	0	0	0	0	0	0	100	50	50	20	20	50	50	50	50	50	100
442.	100	100	200	200	50	100	100	50	100	100	100	50	100	100	100	100	100	200	0	
443.	0	0	0	0	0	100	100	100	100	100	100	100	50	100	100	100	100	100	100	100
444.	100	100	100	100	100	100	100	50	100	100	100	50	100	100	100	110	100	200	0	
445.	0	0	0	0	0	100	100	100	100	100	50	100	100	100	100	100	100	100	100	100
446.	100	100	100	100	50	50	50	50	100	100	100	100	100	150	110	100	200	1	0	
447.	0	0	0	0	0	100	100	100	100	100	100	100	100	100	150	100	100	150	100	150
448.	100	100	100	50	50	50	50	50	100	100	100	100	100	100	110	1	1	1	0	
449.	0	0	0	0	0	100	100	100	100	100	100	100	200	200	300	150	150	100	100	100
450.	100	100	50	50	50	50	50	50	100	100	150	100	100	100	110	1	1	1	0	
451.	0	0	0	0	0	100	100	100	100	100	200	200	200	200	300	300	300	150	100	100
452.	100	100	50	50	50	50	50	50	100	100	100	100	100	100	110	1	1	0.5	0	
453.	0	0	0	0	0	100	100	100	100	100	300	300	150	300	300	300	300	300	150	100
454.	100	100	50	50	50	50	100	100	100	100	100	100	100	100	110	0.5	0.5	0.5	0	

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455.    0   0   0   0   0 100   0 100 100 100 100 100 300 300 300 300 300 150 150 100
456.  100  50  50  50  50  50 100 100 100 100 100 100 100 110 100 0.5 0.5 0.5   0
457.    0   0   0   0   0  10  10   0 100 100 100 100 100 100 100 150 150 150 150 100
458.  100  50  50  50  50  50 100 100 100 200 200 100 100 100 110 0.5 0.5   1   0
459.    0 200 100 100   1   1  10   0 100 100 100 100 100 100 100 100 100 100 100 100
460.  100  50  50 100 100 100 100 100 100 100 100 100 100 100 110 0.5 0.5   1   0
461.    0 100  10  10  10  10  10   0   0 100 100 100 100 100 100 100 100 100 100
462.  100 100 100 100 100 100 100 100 100 100 100 100 100 110   1   1   1   0
463.    0 100  10  10  10  10  10   0   0   0 100 100 100 100 100 100 100 100 100 100
464.  100 100 100 100 100 100 100 100 100   0   0   0 100 100 100 400   1   1   0
465.    0   0   0   0  20  20  10   0   0   0 200 200 200 200 200 200 200 200 100 100
466.  100 100 100 100 100 100 100 100   0   0   0   0 100 100 100 100 400 300   0
467.    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0 200 100   0
468.    0   0   0   0 100 100   0   0   0   0   0   0   0   0   0 100 500 100   0
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474.    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
475.    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
476.    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
477.      1.E-04          1       1
478.    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
479.    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
480.    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
481.    0   0   0   0   0   0   0   0   5   5   1   0   0   0   0   0   0   0   0
482.    0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0   0
483.    0   5  10  10  10  10  10  10  10   5   1   0   0   0   0   0   0   0   0
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619.		1.			1			1												

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4455.	4445.	4445.	4460.	4495.	4520.	4510.	4487.
4465.	4462.	4430.	4488.	4504.	4501.	0.	
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4602.	4570.	4550.	4523.	4510.	4490.	4480.	4487.
4495.	4507.	4525.	4511.	4503.	4479.	4472.	4489.
4467.	4451.	4455.	4476.	4520.	4570.	4565.	4525.
4486.	4475.	4470.	4435.	4505.	4476.	0.	
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4597.	4570.	4555.	4560.	4560.	4550.	4520.	4512.
4533.	4524.	4560.	4548.	4541.	4534.	4525.	4507.
4488.	4473.	4475.	4490.	4540.	4610.	4630.	0.
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4530.	4505.	0.	0.	0.	4650.	4780.	0.
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4580.	4633.	4600.	4760.	4780.	4680.	4620.	4650.
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0.	0.	0.	0.	0.	0.	0.	

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          4      6      6      6      8      6      6
      1329.      1
          4      4      3      3      2      2      2      2
          2      2      2      2      2      2      2      2
          2      2      2      2      3      3      4
          1
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   1 11
    1

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             1

             1      1 1     11
                           111
1                          1

             11
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   3.E-79
110 51010 2 1 1 1 1 15050 12019 7 1 1 1 1
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444044654535450044754450441254430444514435443544401430443044704460477041704470450
4460
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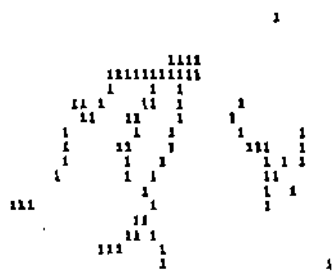

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4422441044114412442045404433442544134415441945654438443044254411444445444504 4416 4725
470546854468448544704475448544754495454645304515451545254465
     1.
4415440344034402440244184415441344114400440744054403440344024402442044054405 4465
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   5.E-10
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  -0.0080         39     0.92    0.0685      105        1.
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        1         13       23    -1.782
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1097.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1098.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1099.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1100.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1101.	9999.																			
1102.		0.			0			1												
1103.	1.20E-09				1			1												
1104.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1105.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
1106.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1107.	0	0	0	0	0	0	0	0	40	30	50	0	0	0	0	0	0	0	0	
1108.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1109.	0	40	30	30	25	20	20	25	20	0	50	0	0	0	0	0	0	0	0	
1110.	0	0	0	0	0	0	0	0	0	0	0	0	0	15	15	15	15	15	30	40
1111.	30	30	20	20	25	20	10	10	10	0	40	0	0	0	0	0	10	40	0	
1112.	0	0	0	5	0	0	0	0	0	0	100	40	30	10	10	10	10	10	0	0
1113.	0	0	0	5	5	0	0	0	0	20	20	0	0	0	0	15	10	30	0	
1114.	0	0	0	0	0	0	0	0	0	20	20	0	0	0	0	0	0	0	0	0
1115.	0	0	0	0	0	0	20	0	3	0	0	10	10	20	20	10	0	10	0	
1116.	0	0	0	0	0	50	20	40	30	10	5	5	5	5	10	5	5	10	5	0
1117.	5	5	10	5	10	25	30	0	10	10	5	3	0	15	20	0	5	0	0	
1118.	0	0	0	5	0	10	10	30	0	0	0	0	5	5	5	5	5	5	5	0
1119.	5	5	10	5	15	10	0	20	10	5	5	0	0	10	0	15	0	20	0	
1120.	0	0	0	0	0	20	20	20	0	0	0	10	0	0	5	0	5	5	5	0
1121.	5	5	10	0	15	0	10	20	20	10	5	5	7	10	0	20	20	15	0	
1122.	0	0	0	0	0	50	50	25	5	20	20	10	0	0	0	0	0	5	0	5
1123.	10	10	10	5	10	10	10	30	40	30	5	5	0	0	0	10	10	10	0	
1124.	0	0	0	0	0	60	20	15	5	10	10	0	0	0	0	0	0	0	0	5
1125.	10	10	10	5	10	10	20	10	30	0	10	30	0	0	0	10	10	20	5	
1126.	0	0	0	0	0	80	20	5	0	0	5	5	0	5	0	0	0	0	0	10
1127.	10	5	5	10	10	25	5	10	20	0	10	20	30	30	0	10	10	10	5	
1128.	0	0	0	0	0	60	0	10	5	0	0	5	0	0	0	0	0	0	0	5
1129.	5	5	5	10	5	10	5	0	10	40	20	10	10	0	5	10	10	10	0	
1130.	0	0	0	0	0	0	0	0	10	0	0	0	10	30	0	0	0	0	0	0
1131.	5	5	10	10	5	15	0	5	10	40	40	15	0	10	0	15	10	20	0	
1132.	0	100	50	30	0	0	0	0	10	10	0	20	20	50	10	0	0	0	0	0
1133.	0	5	10	10	5	0	0	0	10	30	30	20	5	5	0	10	10	20	0	
1134.	0	200	100	50	70	30	0	0	0	20	10	10	10	20	0	0	0	0	0	0
1135.	0	5	0	0	0	0	0	5	40	50	50	20	10	10	0	15	10	10	0	
1136.	0	300	230	100	30	20	0	0	0	0	10	10	10	35	10	10	10	10	20	10
1137.	10	5	2	3	0	0	5	10	50	0	0	0	10	30	20	0	20	20	0	
1138.	0	0	0	0	80	40	0	0	0	0	20	30	40	100	40	30	30	20	20	20

Appendix D

Model Output of Transient-state Calibration of

March 1969

----------CACHE VALLEY GROUND-WATER MODELING----------

NUMBER OF ROWS = 23
NUMBER OF COLUMNS = 39
NUMBER OF LAYERS = 2

MAXIMUM PERMITTED NUMBER OF ITERATIONS = 50

NUMBER OF CONSTANT HEAD NODES = 30
NUMBER OF SPRING NODES = 21
NUMBER OF RIVER NODES = 75

SIMULATION OPTIONS: DRAW HEAD MASS WATE RECH ITKR EVAP ALT DHPP MAPP

WORDS OF VECTOR Y USED = 40014

NUMBER OF PUMPING PERIODS = 4
TIME STEPS BETWEEN PRINTOUTS = 1

ERROR CRITERIA FOR CLOSURE = .1000000-001
EVAPOTRANSPIRATION RATE = .3400000-007
EFFECTIVE DEPTH OF ET = 10.00000

ON ALPHANUMERIC MAP:
MULTIPLICATION FACTOR FOR X DIMENSION = 5280.000
MULTIPLICATION FACTOR FOR Y DIMENSION = 5280.000
MAP SCALE IN UNITS OF MILES
NUMBER OF MILES PER INCH = 1.000000
MULTIPLICATION FACTOR FOR DRAWDOWN = 1.000000 PRINTED FOR LAYERS 1 2 0 0 0 0 0 0 0
MULTIPLICATION FACTOR FOR HEAD = 1.000000 PRINTED FOR LAYERS 0 0 0 0 0 0 0 0 0

STORAGE COEFFICIENT MATRIX, LAYER 1

1	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000			
2	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00010	.00010	.00010	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000			
3	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000			
4	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00011	.00011	.00011
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00000	.00000	.00000	.00000	.00000	.00010	.00010	.00000			
5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00010	.00010	.00010	.00010	.00010
	.00011	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00000	.00000	.00000	.00010	.00010	.00010	.00000			
6	.00000	.00000	.00000	.00000	.00000	.00010	.00000	.00000	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
7	.00000	.00000	.00000	.00000	.00000	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
8	.00000	.00000	.00000	.00000	.00000	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
9	.00000	.00000	.00000	.00000	.00000	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
10	.00000	.00000	.00000	.00000	.00000	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010
	.00010	.00010	.00015	.00020	.00015	.00015	.00015	.00015	.00015	.00015	.00010	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
11	.00000	.00000	.00000	.00000	.00000	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00020	.00020
	.00020	.00020	.00020	.00020	.00015	.00015	.00015	.00015	.00015	.00015	.00015	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00015	.00000			
12	.00000	.00000	.00000	.00000	.00000	.00010	.00010	.00015	.00015	.00015	.00015	.00015	.00020	.00025
	.00025	.00020	.00020	.00010	.00015	.00015	.00015	.00015	.00015	.00015	.00015	.00015	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
13	.00000	.00000	.00000	.00000	.00000	.00010	.00015	.00015	.00015	.00020	.00025	.00030	.00025	.00030
	.00035	.00040	.00025	.00020	.00015	.00015	.00015	.00015	.00015	.00015	.00015	.00015	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
14	.00000	.00000	.00000	.00000	.00000	.00010	.00015	.00015	.00015	.00020	.00020	.00025	[illegible]	[illegible]
	.00040	.00040	.00035	.00030	.00015	.00015	.00015	.00015	.00015	.00015	.00015	.00015	.00010	[illegible]
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
15	.00000	.00010	.00010	.00010	.00010	.00010	.00015	.00015	.00020	.00025	.00025	[illegible]	[illegible]	[illegible]
	.00040	.00040	.00035	.00030	.00015	.00015	.00015	.00015	.00015	.00015	.00014	.00015	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
16	.00000	.00010	.00010	.00010	.00010	.00010	.00015	.00015	.00020	.00030	.00030	.00030	[illegible]	[illegible]
	.00040	.00040	.00035	.00030	.00025	.00020	.00017	.00017	.00015	.00015	.00014	.00015	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
17	.00000	.00010	.00010	.00010	.00010	.00010	.00015	.00015	.00020	.00030	.00030	.00030	.00040	[illegible]
	.00040	.00020	.00020	.00020	.00015	.00015	.00015	.00015	.00015	.00020	.00015	.00010	.00010	.00010
	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
18	.00000	.00000	.00000	.00000	.00010	.00010	.00015	.00015	.00020	.00030	.00030	.00030	.00020	.00020
	.00020	.00020	.00020	.00020	.00015	.00015	.00015	.00015	.00015	.00020	.00017	.00015	.00015	.00015
	.00015	.00015	.00015	.00000	.00010	.00010	.00010	.00010	.00010	.00010	.00000			
19	.00000	.00000	.00000	.00000	.00000	.00010	.00015	.00015	.00020	.00020	.00020	.00020	.00020	.00020
	.00020	.00020	.00020	.00020	.00015	.00015	.00015	.00015	.00015	.00020	.00020	.00020	[illegible]	[illegible]
	.00000	.00020	.00020	.00000	.00000	.00010	.00010	.00010	.00010	.00010	.00000			
20	.00000	.00000	.00000	.00000	.00000	.00010	.00015	.00015	.00020	.00020	.00020	.00020	.00020	.00020
	.00020	.00020	.00020	.00020	.00015	.00015	.00015	.00015	.00015	.00020	.00020	[illegible]	[illegible]	[illegible]
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00010	.00010	.00010	.00000			

21	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00315	.00015	.00015	.00015	.00000	.00000	.00002	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00050	.00000	.00000	.00010	.00010	.00000			
22	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00079	.00003	.00000	.00000	.00007	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00010	.00000			
23	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000			

STORAGE COEFFICIENT MATRIX, LAYER 2

1	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000			
2	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.10000	.10000	.10000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000			
3	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	-.10000	.10000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000			
4	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	-.10000	.10000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000			
5	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	.10000	-.10000	-.10000	-.10000
	-.10000	.10000	.10000	.10000	.00000	.00000	.00000	.10000	.10000	.10000	.00000			
6	.00000	.00000	.00000	.00000	.00000	.10000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	-.10000	-.10000	.10000	.10000	-.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.00000			
7	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	-.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	-.10000	.00000			
8	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	-.10000	.10000	.00000			
9	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	.10000	.10000	.00000			
10	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	.10000	.10000	.00000			
11	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	.10000	.10000	.00000			
12	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	.10000	.10000	.00000			
13	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	.10000	.10000	.10000	.00000			
14	.00000	.00000	.00000	.00000	.00000	-.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	.10000	.10000	.00000			
15	.00000	.10000	.10000	.10000	-.10000	-.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	.10000	.10000	.00000			
16	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	.10000	.10000	.00000			
17	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	-.10000	.10000	.10000	.00000			
18	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.00000	.10000	.10000	.10000	.10000	-.10000	-.10000	.00000			
19	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.00000	.00000
	.00000	.10000	.10000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.00000			
20	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000
	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.10000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.00000			
21	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.10000	.10000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.10000	.10000	.00000			
22	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.10000	.00000			
23	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000
	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000	.00000			

DIRECTIONAL TRANSMISSIVITY MULTIPLICATION FACTORS FOR LAYER 1

X = 1.000000
Y = 1.000000
Z = .0000000

TRANSMISSIVITY = .0000000 FOR LAYER 2

DIRECTIONAL TRANSMISSIVITY MULTIPLICATION FACTORS FOR LAYER 2
X = 1.000000
Y = 1.000000
Z = .0000000

RECHARGE RATE = .0000000 FOR LAYER 1

GRID SPACING IN PROTOTYPE IN X DIRECTION

5280.	3960.	3960.	3960.	3960.	3960.	3960.	3960.	3960.	2640.	2640.	2640.
2640.	2640.	2640.	2640.	2640.	2640.	2640.	2640.	2640.	2640.	2640.	2640.
3960.	3960.	3960.	3960.	3960.	5280.	5280.	5280.	5280.	7920.	7920.	7920.
10560.	7920.	7920.									

GRID SPACING IN PROTOTYPE IN Y DIRECTION

5280.	5280.	3960.	3960.	2640.	2640.	2640.	2640.	2640.	2640.	2640.	2640.
2640.	2640.	2640.	2640.	2640.	2640.	2640.	2640.	3960.	3960.	5280.	

DELZ = 1.000000

.5000-008

1. 10. 5. 10. 10. 2. 1. 1. 1. 1. 1. 50. 50. 1. 20. 10. 7. 1. 1. 1.
1.

1.000

4440. 4465. 4535. 4500. 4475. 4450. 4425. 4430. 4445. 4435. 4435. 4440. 4430. 4440. 4470. 4460. 4770. 4470. 4490. 4500.
4440.

1.000

4420. 4408. 4408. 4407. 4407. 4421. 4420. 4418. 4416. 4413. 4412. 4410. 4408. 4408. 4407. 4407. 4425. 4413. 4410. 4470.
4460. 4430. 4418. 4415. 4414. 4407. 4450. 4440. 4427. 4423. 4415. 4408. 4505. 4425. 4420. 4409. 4421. 4525. 4441. 4427.
4422. 4410. 4411. 4412. 4420. 4540. 4433. 4425. 4413. 4415. 4419. 4565. 4438. 4430. 4425. 4414. 4445. 4450. 4416. 4725.
4705. 4685. 4468. 4485. 4470. 4475. 4485. 4475. 4495. 4544. 4530. 4515. 4515. 4575. 4465.

1.000

4415. 4403. 4403. 4402. 4402. 4418. 4415. 4413. 4411. 4408. 4407. 4405. 4403. 4403. 4402. 4402. 4420. 4408. 4405. 4465.
4455. 4425. 4413. 4410. 4409. 4402. 4445. 4435. 4422. 4418. 4410. 4403. 4500. 4420. 4415. 4404. 4416. 4520. 4436. 4424.
4417. 4405. 4406. 4407. 4415. 4535. 4428. 4420. 4408. 4410. 4414. 4560. 4433. 4425. 4420. 4409. 4440. 4445. 4411. 4720.
4700. 4680. 4463. 4480. 4463. 4470. 4480. 4470. 4490. 4541. 4525. 4510. 4510. 4520. 4460.

.5000-009

50.	100.	100.	100.	100.	300.	200.	300.	300.	300.	300.	100.	100.	100.
100.	100.	300.	200.	100.	50.	100.	100.	200.	100.	50.	100.	300.	100.
100.	200.	300.	100.	50.	100.	200.	10.	50.	20.	100.	100.	300.	100.
20.	100.	100.	50.	100.	300.	100.	50.	10.	10.	100.	100.	100.	50.
100.	100.	100.	5.	5.	5.	100.	100.	100.	100.	50.	100.	100.	50.
100.	50.	100.	100.	20.									

SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE

HMAX= .99863

5 ITERATION PARAMETERS: .0000000 .8074111+000 .7629865+000 .9958790+000 .9986300+000

PUMPING PERIOD NO. 1: 365.00 DAYS

NUMBER OF TIME STEPS= 1

DELT IN HOURS = 8760.000

MULTIPLIER FOR DELT = 1.000

485 WELLS

K	I	J	PUMPING RATE
1	12	25	-.81972
1	13	23	-1.63944
1	14	15	-.80776
1	14	19	-.67620
1	14	20	-2.80692
1	14	30	-4.35436
1	14	31	-1.84000
1	15	8	-2.22088
1	15	12	-8.15488
1	15	20	-.92000
1	15	22	-1.12700
1	15	25	-1.69004
1	15	31	-.90160
1	15	32	-1.48580
1	16	18	-2.33588
1	16	30	-3.76372
1	17	7	-4.09768
1	17	17	-4.48776
1	17	25	-4.09768
1	17	29	-3.36076
1	17	30	-9.95808
1	17	31	-7.17140
1	18	8	-.81972
1	18	9	-7.78596
1	18	18	-2.15188
1	18	19	-10.71248
1	18	21	-9.33340
1	18	28	-1.63944
1	18	29	-3.22092
1	18	30	-2.45916

1	19	15	-4.13908
1	19	18	-1.22912
1	19	21	-7.56056
1	19	30	-4.50800
1	19	34	-.59432
1	19	34	-1.20888
1	20	30	-8.54404
1	20	37	-2.86856
1	21	37	-.61456
1	2	29	.55200
1	2	30	.22700
1	2	31	.13800
1	3	17	.62100
1	3	18	.41400
1	3	19	.34500
1	3	20	.20700
1	3	21	.06900
1	3	22	.06900
1	3	23	.06900
1	3	24	.06900
1	3	25	.06900
1	3	26	.13800
1	3	27	.22700
1	3	28	.20700
1	3	31	.27600
1	4	12	.60700
1	4	13	.53800
1	4	14	.46900
1	4	15	.33100
1	4	16	.26200
1	4	31	.55200
1	4	37	.99400
1	4	38	2.41500
1	5	10	.40000
1	5	11	.40000
1	5	31	.41400
1	5	32	1.49000
1	5	36	1.32200
1	5	38	.82800
1	6	9	.29000
1	6	33	1.42100
1	6	34	1.20100
1	6	35	1.28300
1	6	38	.62100
1	7	6	.49700
1	7	7	.12800
1	7	8	.13800
1	7	38	.27600
1	8	6	.29000
1	8	38	.00700
1	9	6	.66200
1	9	38	.06900
1	10	6	.80000
1	10	38	.00700
1	11	6	1.27600
1	11	7	.34500
1	11	8	.27600
1	11	38	.00700
1	12	6	1.25400
1	12	7	.41400
1	12	8	.20700
1	12	38	.00700
1	13	6	.98000
1	13	38	.00700
1	14	6	.79400
1	14	38	.00700
1	15	2	.90000
1	15	3	.31400
1	15	4	.27600
1	15	5	.13800
1	15	38	.00700
1	16	2	.66200
1	16	38	.00700
1	17	2	.38600
1	17	32	1.73900
1	17	38	.00700
1	18	5	.13800
1	18	27	3.47800
1	18	28	2.72600
1	18	29	3.61600
1	18	33	2.22200
1	18	38	.00700
1	19	6	.38700
1	19	25	2.78800
1	19	26	3.47800
1	19	30	6.58900
1	19	31	5.87900
1	19	34	3.50500
1	19	35	3.50500
1	19	38	.06900
1	20	6	1.68400
1	20	7	1.40900
1	20	8	1.13200
1	20	9	1.13200
1	20	10	1.49000
1	20	11	2.04200
1	20	12	2.31800
1	20	13	2.31800
1	20	14	1.90400
1	20	15	1.49000
1	20	16	1.21400
1	20	17	1.07600
1	20	18	1.07600
1	20	19	1.21400
1	20	24	1.62800
1	20	36	2.53900
1	20	38	.13300
1	21	20	4.32600
1	21	21	4.25000
1	21	32	2.80100
1	21	33	2.45600
1	21	37	2.92600

1	21	38	.27600
1	22	38	.96600

-.8000-002 39 .9200 .4850-001 105 1.000

8	9	2	45.77857
8	9	2	-46.44787
8	19	2	-3.113631
15	5	1	1.194072
20	20	1	.7164294
14	7	1	.2257833
16	5	1	.1423446
12	24	1	.1246996
13	29	1	.7607473-001
17	32	1	.1220708
17	32	1	.2088043-001
17	24	1	.1598361-001
13	24	1	.1201524-001
19	26	1	.1786300-001
16	17	1	.5849699-002

TIME STEP NUMBER = 1

SIZE OF TIME STEP IN SECONDS= 31536000.00

TOTAL SIMULATION TIME IN SECONDS= 31536000.00
MINUTES= 525600.00
HOURS= 8760.00
DAYS= 365.00
YEARS= 1.00

DURATION OF CURRENT PUMPING PERIOD IN DAYS= 365.00
YEARS= 1.00

CUMULATIVE-MASS BALANCE: L**3

SOURCES:

STORAGE =	144695758.00
RECHARGE =	3584056064.00
CONSTANT FLUX =	3622918144.00
CONSTANT HEAD =	50029967.50
LEAKAGE =	.00
TOTAL SOURCES =	7401699904.00

DISCHARGES:

RIVER LEAKAGE =	1091833440.00
CONSTANT HEAD =	1392799504.00
QUANTITY PUMPED =	964359232.00
SPRING LEAKAGE =	928693880.00
EVAPOTRANSPIRATION =	3024446432.00
TOTAL DISCHARGE =	7402132352.00
DISCHARGE-SOURCES =	432448.00
PER CENT DIFFERENCE =	.01

RATES FOR THIS TIME STEP: L**3/T

STORAGE =	4.5803
RECHARGE =	113.6477
CONSTANT FLUX =	114.8820
PUMPING =	-30.5796
RIVER LEAKAGE =	-34.6218
CONSTANT HEAD:	
IN =	1.5864
OUT =	-44.1654
LEAKAGE:	
FROM PREVIOUS PUMPING PERIOD =	-95.0131
TOTAL =	-29.4487
EVAPOTRANSPIRATION =	-95.9046
SUM OF RATES =	-.9137

RATES OF COMPONENTS FOR EACH LAYER IN CFS

LAYER 1	CHOUT= .00000	CHIN= .00000	ORE= .00090	PMP=-30.524	CFLUX= 114.88	STOR=-.8042-002
	RIVER= .00000	SPRING= .00000	ET= .00090			
LAYER 2	CHOUT=-44.165	CHIN= 1.5864	ORE= 113.65	PMP=-.56000-001	CFLUX= .00090	STOR= 4.5963
	RIVER=-34.622	SPRING=-29.449	ET=-95.905			

FLOW RATES TO CONSTANT HEAD NODES:

K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)	K	I	J	RATE (L**3/T)
2	3	30	-2.150165	2	4	30	-.8430221	2	5	23	-.3595612
2	5	26	-.2541263	2	5	27	-.2319706	2	5	28	-.1425281
2	5	29	-.4548381	2	6	23	-.3128762	2	6	24	-.3631935
2	6	25	-.3380224	2	6	28	-.1720954	2	7	28	-.7384831
2	7	36	-3.183009	2	7	38	-5.089421	2	8	35	-1.370516
2	8	37	-5.052660	2	9	35	-.5773978	2	10	35	-.4208152
2	11	35	-.8996071	2	12	35	-.5111912	2	13	34	-.3260283-001
2	14	6	.9227105	2	14	35	-1.630117	2	15	5	-1.537783
2	15	6	-.9006292	2	15	35	-.8258834	2	16	35	-2.152291
2	17	36	-3.963056	2	18	37	-6.107289	2	18	38	-2.878010

FLOW TO TOP LAYER = 84.37143 FLOW TO BOTTOM LAYER = 83.57948 POSITIVE UPWARD

SPRING	5	11	-.9326651-001
SPRING	6	10	-.6572783-001
SPRING	7	6	-.2536016+000
SPRING	7	8	.2613855-002
SPRING	7	9	-.5434082-001
SPRING	8	8	-.2129653+000
SPRING	11	14	-.6698786+000
SPRING	12	14	-.6397912+000
SPRING	14	14	-.1326250+000
SPRING	14	21	-.2024142+000

SPRING	14	29	-.1015443+000
SPRING	14	30	-.7787585+000
SPRING	14	31	-.9870594+000
SPRING	15	29	-.1390471+000
SPRING	15	30	-.1315146+000
SPRING	15	31	-.2433577+000
SPRING	16	3	.2536811-001
SPRING	16	29	-.6168511-001
SPRING	18	14	.1112279+000
SPRING	18	15	.1038991+000
SPRING	19	37	-.9380280+000

TOTAL SPRING LKAGE RCHRG 2ND LAYER -.5482705+001

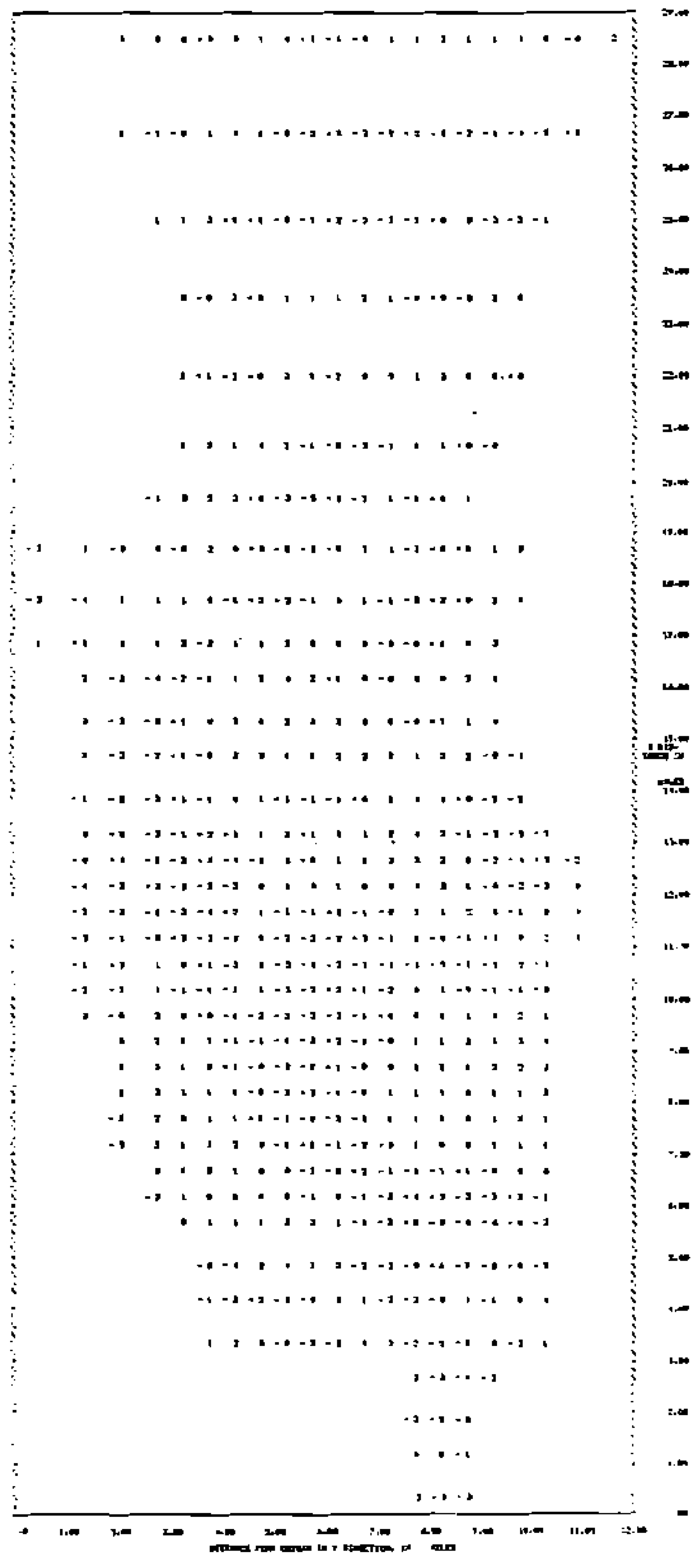
MAXIMUM HEAD CHANGE FOR EACH ITERATION:

45.7786	46.4477	3.1136	1.1941	.7184	.2258	.1423	.1247	.0761	.1221
.0209	.0160	.0120	.0179	.0058					

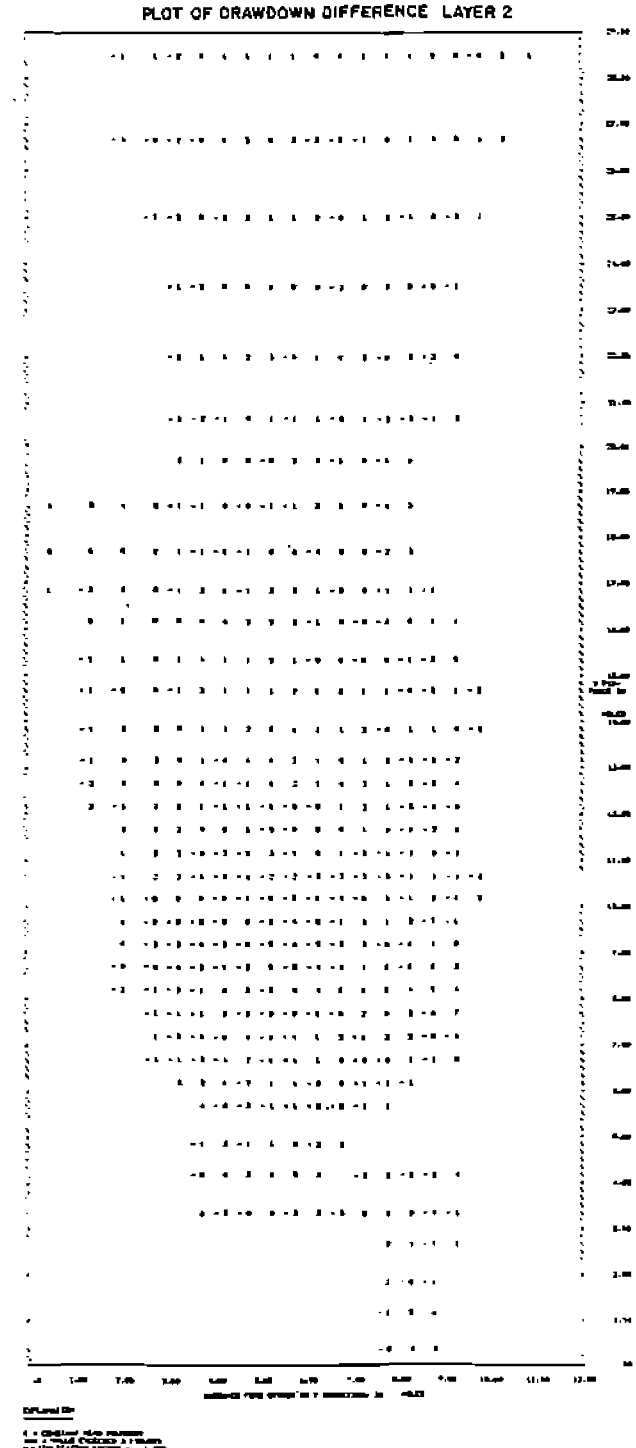
TIME STEP : 1

ITERATIONS: 14

PLOT OF DRAWDOWN DIFFERENCE LAYER 1



PLOT OF DRAWDOWN DIFFERENCE LAYER 2



DRAWDOWN, LAYER 1

1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00						
2	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.85	-3.94
	-2.74	.00	.00	.00	.00	.00	.00	.00	.00						
3	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	1.60	-3.07	-1.36	-2.76	-2.75	-3.94	-.33	.12	-.81	3.45	2.76	1.75	-.69	-1.84
	.77	.00	.00	.00	.90	.00	.00	.00	.00						
4	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-2.60	-2.71	2.09	.74
	1.77	-.16	-1.24	-2.64	-.80	-3.04	-2.33	-3.76	-5.29	-5.09	-2.70	-2.50	-1.96	1.39	.98
	-.19	.00	.00	.00	.00	.00	1.84	3.21	.00						
5	.00	.00	.00	.00	.00	.00	.00	.00	.00	-1.74	.08	2.65	1.80	1.63	2.48
	1.80	1.64	.81	.94	-1.68	-1.04	-1.82	-2.29	-2.93	-2.72	-2.12	-3.17	-4.42	.71	.67
	.28	-.80	.00	.00	.00	.52	-1.32	.49	.00						
6	.00	.00	.00	.00	.00	.00	.00	.00	.24	1.08	2.33	.76	.47	1.03	.73
	.62	.12	-.78	.03	-2.72	-2.13	-2.46	-1.77	-.93	-1.24	-1.27	-1.15	-2.31	2.19	1.28
	-.29	4.56	2.87	2.26	.07	.79	-.17	.40	.00						
7	.00	.00	.00	.00	.00	.87	-1.00	-5.23	.65	.25	2.63	1.15	.53	1.30	.12
	.60	-.35	-.54	-.99	-2.99	-4.25	-3.20	-2.70	-1.96	-.97	-.42	.47	-1.34	-1.51	.07
	1.45	5.18	2.46	-.71	-.04	2.80	1.31	-.10	.00						
8	.00	.00	.00	.00	.00	1.53	-3.02	-3.78	.54	.10	.55	2.00	.88	.63	-1.16
	-1.39	-1.27	-.57	-2.23	-1.80	-1.63	-2.98	-3.87	-1.23	.03	1.59	2.49	1.03	.85	-.87
	.44	1.74	.98	-2.72	1.54	-.38	3.13	.15	.00						
9	.00	.00	.00	.00	.00	1.99	-1.89	1.51	1.41	.41	.32	.17	-.53	-.32	-.11
	-.84	-1.98	.66	1.03	.12	.92	.25	-.88	.65	1.37	2.96	3.59	2.04	.81	-2.11
	-2.40	-.29	4.04	-.05	-.02	-.61	1.25	.78	.00						
10	.00	.00	.00	.00	.00	-.41	-1.74	3.77	2.60	.07	.27	-1.08	-.91	-1.77	-1.59
	-1.43	-1.78	-2.57	-2.35	-1.63	-1.30	.73	.33	2.02	-.45	.91	3.36	3.68	1.93	-2.55
	-4.93	-1.63	1.83	1.70	.71	-.12	-.41	.09	.00						
11	.00	.00	.00	.00	.00	-2.81	-.03	3.36	1.55	-.53	-2.74	-1.28	-.29	-2.34	-2.46
	-3.36	-1.95	-2.06	-2.52	-1.77	-.80	.08	-.36	-.82	-1.06	.66	2.17	1.08	-.43	-1.13
	-2.91	-5.02	-.84	.15	1.00	-1.38	-2.09	-1.04	.00						
12	.00	.00	.00	.00	.00	-3.01	2.11	1.98	.64	.49	-1.53	-.53	-1.59	-.69	-1.05
	-2.15	-3.14	-2.39	-2.20	-2.07	-1.02	.81	1.47	1.08	-.45	2.09	2.02	-1.05	.04	.31
	-.32	-2.22	-1.76	-1.70	.54	-2.43	-2.88	-1.48	.00						
13	.00	.00	.00	.00	.00	3.96	1.41	-3.00	-.59	-1.24	-2.42	-1.65	-.83	-.06	-.43
	-.70	-1.22	-1.24	-.79	-3.09	-1.34	.31	1.12	.92	-.06	1.62	.50	.37	.38	.75
	1.41	-1.92	-2.64	.07	1.33	-3.24	-1.92	-.30	.00						
14	.00	.00	.00	.00	.00	1.60	-1.53	-2.40	-2.71	-2.71	-.86	-.29	1.32	.07	.29
	-.20	-.15	-1.58	-.62	-.58	-.04	.45	1.94	1.74	1.13	1.92	.35	-.47	-.39	-.67
	.54	1.00	-.76	.02	.95	-2.59	-2.10	.55	.00						
15	.00	2.80	.29	-2.42	2.09	-2.27	-2.12	-5.12	-4.90	-3.83	-.96	.60	.93	1.19	1.44
	1.47	.22	.42	-1.32	1.23	.90	3.64	2.99	3.70	4.15	1.19	-.36	.24	-.34	-1.53
	-2.82	-.43	.85	1.18	-.53	-1.19	-2.22	1.14	.00						
16	.00	-2.59	.04	-4.71	-3.20	-5.14	-.35	-6.03	-5.47	-2.84	-1.15	.50	.70	.79	1.58
	1.32	.80	.75	-.46	-.35	1.29	1.94	2.15	2.45	3.46	2.59	-.51	.16	-.51	-1.88
	-2.27	-.44	.56	2.41	-.39	-.24	-2.41	1.50	.00						
17	.00	-2.54	-.78	-8.15	-3.75	-4.76	1.27	-6.53	-6.05	-2.70	-1.18	.28	.47	.37	1.04
	1.57	.91	-.28	-.70	-.67	1.53	.70	.46	-.59	-.18	2.09	1.24	2.53	.08	-.41
	-.49	.72	-.33	.14	-.49	3.01	-1.67	.81	.00						
18	.00	.00	.00	.00	-2.31	.08	-.79	-7.69	-5.70	-2.60	-.17	1.09	1.27	1.03	1.62
	1.05	1.28	-.74	-1.06	-.70	.23	-.44	-1.78	-2.99	-2.64	-.15	3.51	4.22	3.13	2.41
	.60	.00	-.01	.49	1.98	-2.12	-.89	1.17	.00						
19	.00	.00	.00	.00	.00	-3.31	.17	-8.23	-3.52	-2.96	.33	1.45	1.71	.73	1.51
	2.85	2.00	-1.14	.28	.08	-.73	-2.47	-3.59	-4.76	-4.75	-1.41	.00	.00	.00	4.02
	5.28	.00	.00	-.38	.24	-1.56	-3.92	.77	.00						
20	.00	.00	.00	.00	.00	1.12	3.76	-5.10	-2.36	-1.24	.08	.85	1.45	1.73	2.97
	3.66	1.00	-.13	-1.09	1.70	.32	-3.25	-5.06	-4.70	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	-.70	-4.72	.47	.00						
21	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	4.31	3.94	.47	-1.73	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	-1.18	-.43	.00						
22	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	2.06	.00						
23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00						

DRAWDOWN, LAYER 2

1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00						
2	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.75	.21
	5.86	.00	.00	.00	.00	.00	.00	.00	.00						
3	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	1.65	-2.05	-1.44	-1.35	-.84	-1.06	.01	-2.87	.00
	1.57	.00	.00	.00	.00	.00	.00	.00	.00						

4	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-2.11	-.35
	.29	.40	-.50	-1.33	1.09	.21	-1.48	.06	.28	.28	-.19	.99	.89	2.70	.00
	3.84	.00	.00	.00	.00	.00	-4.12	-.79	.00						
5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-.80	1.28	-.86	-.52	-.48
	-3.35	-1.72	-.42	1.52	1.54	2.40	2.60	.00	1.52	1.80	.00	.00	.00	.00	1.31
	2.30	.00	.00	.00	.00	-2.57	-.38	1.41	.00						
6	.00	.00	.00	.00	.00	.00	.00	.00	.00	4.33	-.76	-3.05	-1.08	-2.81	-3.79
	-2.97	-1.83	.02	1.61	1.75	2.44	2.82	.00	.00	.00	-1.33	.88	.00	-1.15	.90
	-1.49	1.47	-.98	-2.92	-.60	-1.61	-2.45	-2.18	.00						
7	.00	.00	.00	.00	.00	5.52	-.43	-.59	4.10	1.66	-3.07	-3.99	-1.30	-1.01	-1.67
	-4.01	-2.89	.20	-.87	-.12	.47	.80	.37	.77	1.46	2.41	4.33	.00	1.97	-1.11
	-1.16	.90	-2.14	.62	-2.70	.00	-.11	.00	.00						
8	.00	.00	.00	.00	.00	-2.92	.27	2.33	-.16	.84	-1.30	-.34	3.15	.16	-1.02
	-2.92	-.13	-.30	-.41	-3.11	.37	-.56	-1.15	-.41	1.29	.84	1.30	3.92	1.03	-.85
	.32	.18	-1.13	.68	.00	-2.19	.00	1.21	.00						
9	.00	.00	.00	.00	.00	-.47	2.02	-1.44	-2.52	-2.30	2.40	4.29	-2.54	2.24	-1.98
	-.36	.42	-.79	-1.18	-5.04	.37	-1.19	-.82	1.42	1.57	.96	.72	1.63	-1.05	-1.24
	-.41	.26	.26	2.13	.00	2.23	2.69	1.33	.00						
10	.00	.00	.00	.00	.00	.16	6.34	1.28	-1.22	.86	-.71	-.63	-4.53	-4.80	.25
	-4.79	-1.76	-.27	-1.93	2.52	-.14	-.53	1.43	1.09	1.52	.73	5.19	4.53	1.82	.04
	-1.43	-.45	.53	2.76	.00	.64	.08	.66	.00						
11	.00	.00	.00	.00	.00	-2.17	4.81	2.54	-1.33	1.10	-.68	-3.57	-.04	.43	-5.38
	-6.33	-3.32	-2.34	-2.32	-1.37	-.23	-.43	1.90	1.97	1.35	.48	.77	1.91	3.26	5.66
	-1.15	2.51	-1.30	-.40	.00	1.42	1.70	1.43	.00						
12	.00	.00	.00	.00	.00	2.21	2.86	-2.68	-1.58	-.33	.39	.58	-2.37	4.39	-4.08
	-5.10	-5.14	-1.39	-3.05	.37	.07	-.14	1.28	1.30	.66	1.47	-.25	-.69	1.31	-4.29
	2.43	4.25	1.10	.91	.00	.48	-2.05	.10	.00						
13	.00	.00	.00	.00	.00	-4.99	.00	1.54	-1.80	.44	.49	2.43	-.23	2.48	-5.51
	-3.45	-.76	-3.77	-3.26	.69	.41	1.01	.42	.49	.64	2.19	.33	.07	-.13	8.01
	.88	-1.41	-.45	.00	-1.59	-.08	-1.70	.15	.00						
14	.00	.00	.00	.00	.00	.00	-4.94	.00	-.58	-.79	-.40	-.71	2.07	6.05	4.22
	1.92	2.25	-.30	-2.66	-.06	1.44	1.74	2.57	.57	1.70	.78	-.41	-.26	.00	8.24
	9.12	.07	1.08	2.01	.00	1.34	-.82	1.07	.00						
15	.00	-8.12	-1.86	-2.08	.00	.00	5.46	.00	.71	-1.31	-.94	3.04	.41	2.70	2.35
	-.37	.91	.11	-.28	-.68	.41	.95	.73	.44	-.01	.69	.20	-2.17	-1.34	-2.05
	-.88	-.72	-3.26	-.04	.00	2.26	.31	1.24	.00						
16	.00	.39	5.38	-.38	.76	4.52	-1.96	.00	.00	-.82	1.06	1.64	1.95	4.45	-1.61
	-.22	2.33	-1.03	-.47	-1.32	-1.37	-2.93	2.01	-.89	1.29	-.01	-.67	.33	.91	2.15
	3.04	.34	-.29	1.56	.00	-.72	1.10	.84	.00						
17	.00	4.81	6.00	-1.20	-3.81	-4.14	-3.00	.00	.00	.00	-.64	-.40	-5.88	4.58	3.06
	4.27	-2.21	2.95	1.33	.08	-1.99	-1.18	-1.61	-1.13	.73	-2.11	-1.88	.64	-1.37	.00
	.00	.00	-.75	-1.69	-.25	.00	3.71	.14	.00						
18	.00	.00	.00	.00	3.21	-1.05	3.98	.00	.00	.00	.43	-3.47	6.85	3.60	2.97
	.05	-1.22	-3.86	-.79	-1.33	.63	-.29	3.53	-2.41	.31	.67	.18	.96	.00	.00
	.00	.00	2.19	.64	-.92	-1.65	.00	.00	.00						
19	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	4.97	-2.31	.00	.00	.00	.00	.00	-1.34	-2.43	.00	.00	.00	.00
	.00	.00	.00	.00	.00	1.07	5.70	-.36	.00						
20	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	1.51	1.78	.00						
21	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	1.34	.00						
22	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00						
23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00						

HEAD MATRIX, LAYER 1

1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00						
2	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	4449.15	4441.04
	4442.74	.00	.00	.00	.00	.00	.00	.00	.00						
3	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	4503.40	4493.07	4481.36	4467.76	4457.75	4453.94	4449.35	4444.88	4439.81	4436.55	4435.24	4435.25	4435.69	4433.80
	4454.23	.00	.00	.00	.00	.00	.00	.00	.00						
4	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	4492.60	4483.71	4478.09	4469.26
	4463.23	4460.16	4456.24	4452.64	4448.80	4445.04	4441.33	4437.76	4435.29	4433.09	4430.70	4430.50	4431.76	4434.61	4437.92
	4457.19	.00	.00	.00	.00	.00	4488.16	4501.79	.00						
5	.00	.00	.00	.00	.00	.00	.00	.00	.00	4484.74	4479.92	4476.35	4473.29	4468.37	4463.52
	4458.20	4454.36	4451.19	4448.06	4443.68	4440.04	4436.82	4434.29	4432.93	4432.72	4433.12	4433.17	4434.42	4436.09	4440.33
	4457.72	4478.80	.00	.00	.00	4478.48	4483.32	4496.51	.00						
6	.00	.00	.00	.00	.00	.00	.00	.00	4485.76	4478.92	4474.65	4472.24	4467.53	4465.97	4462.27
	4458.38	4454.88	4451.78	4448.97	4444.72	4441.13	4438.46	4435.77	4434.73	4436.24	4436.27	4436.15	4437.31	4437.81	4440.72
	4450.24	4465.44	4473.13	4471.74	4470.93	4471.30	4479.17	4489.60	.00						
7	.00	.00	.00	.00	.00	4574.13	4536.09	4500.23	4483.35	4476.75	4473.37	4470.85	4468.47	4465.70	4462.89
	4459.40	4456.35	4453.54	4450.79	4447.79	4445.25	4443.20	4441.70	4440.96	4440.72	4440.42	4440.53	4441.34	4441.51	4442.93
	4446.35	4454.82	4460.34	4462.71	4462.04	4464.29	4472.69	4483.10	.00						

8	.00	.00	.00	.00	.00	4578.47	4533.02	4496.78	4482.46	4476.90	4474.45	4472.00	4469.12	4467.37	4465.16
	4462.39	4459.27	4456.57	4454.23	4451.80	4449.63	4447.98	4446.87	4446.23	4445.97	4445.41	4445.51	4445.92	4446.15	4446.87
	4446.54	4448.26	4450.02	4454.72	4454.44	4461.38	4467.87	4480.85	.00						
9	.00	.00	.00	.00	.00	4598.01	4536.89	4498.49	4483.29	4478.59	4476.68	4474.83	4472.53	4470.32	4468.11
	4465.84	4462.98	4460.34	4457.97	4455.88	4454.09	4452.75	4451.88	4451.35	4450.63	4450.04	4450.41	4450.96	4451.19	4452.11
	4450.40	4447.28	4444.96	4449.03	4450.02	4460.61	4468.75	4479.22	.00						
10	.00	.00	.00	.00	.00	4615.41	4546.74	4506.23	4487.40	4481.93	4479.73	4478.08	4475.91	4473.77	4471.59
	4469.43	4466.78	4464.57	4462.35	4460.65	4459.30	4458.27	4457.67	4456.98	4455.63	4455.09	4455.64	4456.32	4457.07	4458.55
	4455.93	4450.63	4445.17	4446.30	4448.29	4460.12	4469.41	4477.91	.00						
11	.00	.00	.00	.00	.00	4622.81	4560.03	4516.64	4491.45	4485.53	4483.24	4481.28	4479.29	4477.11	4475.46
	4473.36	4470.95	4469.06	4467.52	4465.97	4464.80	4463.92	4463.36	4462.82	4461.06	4460.74	4460.83	4462.12	4463.57	4465.13
	4442.91	4457.02	4449.04	4446.85	4448.00	4460.38	4470.09	4477.04	.00						
12	.00	.00	.00	.00	.00	4623.01	4557.89	4518.02	4494.34	4488.51	4486.53	4484.53	4482.59	4480.69	4479.05
	4477.15	4475.14	4473.39	4472.20	4471.07	4470.02	4469.19	4468.53	4467.72	4466.65	4466.00	4465.98	4468.05	4469.94	4471.69
	4470.32	4464.22	4456.76	4450.70	4449.46	4461.43	4470.88	4476.48	.00						
13	.00	.00	.00	.00	.00	4601.04	4548.59	4513.00	4496.59	4491.24	4489.42	4487.65	4485.83	4484.06	4482.43
	4480.70	4479.22	4478.24	4476.98	4476.09	4475.34	4474.69	4473.88	4473.08	4472.06	4471.38	4471.50	4473.63	4475.62	4477.35
	4476.59	4471.92	4463.64	4454.93	4452.45	4463.24	4471.92	4476.30	.00						
14	.00	.00	.00	.00	.00	4588.40	4539.53	4507.40	4497.71	4493.71	4491.36	4490.29	4488.59	4487.13	4485.71
	4484.20	4483.15	4482.38	4481.62	4480.58	4480.04	4472.55	4479.06	4478.26	4476.87	4476.08	4475.65	4478.47	4480.39	4481.57
	4481.46	4479.00	4470.76	4464.98	4457.05	4465.59	4473.10	4476.45	.00						
15	.00	4802.20	4764.71	4712.42	4637.91	4577.27	4530.12	4505.12	4498.90	4495.83	4493.76	4492.32	4491.07	4489.31	4488.66
	4487.53	4486.78	4486.58	4486.32	4485.77	4485.10	4484.34	4484.01	4483.30	4481.83	4480.99	4481.36	4482.76	4484.31	4485.23
	4485.82	4484.63	4479.15	4473.82	4464.23	4468.19	4474.72	4476.84	.00						
16	.00	4797.59	4754.96	4699.71	4628.20	4565.14	4523.35	4505.03	4500.47	4497.84	4496.15	4494.50	4493.30	4492.30	4491.12
	4490.60	4490.20	4490.25	4490.46	4490.35	4489.80	4489.06	4488.85	4488.55	4487.34	4485.71	4486.51	4486.84	4487.51	4487.38
	4488.27	4487.44	4487.44	4484.59	4474.39	4470.24	4475.41	4477.50	.00						
17	.00	4792.54	4750.78	4693.15	4618.75	4554.76	4518.73	4505.53	4502.05	4499.79	4498.18	4496.72	4495.53	4494.63	4493.76
	4493.43	4493.09	4493.28	4493.70	4493.67	4493.47	4493.30	4493.54	4493.59	4493.18	4491.91	4491.76	4490.47	4489.92	4489.41
	4489.49	4489.28	4496.33	4496.86	4487.49	4470.99	4476.67	4478.19	.00						
18	.00	.00	.00	.00	4602.31	4539.92	4515.77	4506.69	4503.70	4501.60	4500.17	4498.91	4497.73	4496.97	4496.30
	4495.95	4495.72	4495.74	4496.06	4496.70	4496.77	4497.44	4497.78	4497.99	4498.64	4499.15	4496.47	4493.78	4491.87	4490.59
	4490.40	.00	4507.01	4509.51	4502.02	4482.12	4477.89	4478.83	.00						
19	.00	.00	.00	.00	.00	4528.31	4514.83	4508.23	4505.52	4503.94	4502.67	4501.55	4500.29	4499.27	4498.49
	4498.15	4498.00	4498.14	4498.72	4499.92	4500.73	4501.47	4501.59	4501.76	4502.75	4505.41	.00	.00	.00	4491.95
	4491.72	.00	.00	4522.38	4519.76	4496.56	4483.72	4484.23	.00						
20	.00	.00	.00	.00	.00	4528.88	4516.24	4510.10	4507.36	4507.24	4506.92	4506.15	4504.55	4502.27	4501.03
	4500.34	4500.00	4500.13	4501.09	4503.34	4504.68	4505.25	4505.06	4504.70	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	4515.70	4489.72	4489.53	.00						
21	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	4510.69	4511.06	4511.53	4511.73	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	4496.18	4495.43	.00						
22	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	4502.94	.00						
23	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00						

HEAD MATRIX, LAYER 2

1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00						
2	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	4444.45	4434.79
	4421.14	.00	.00	.00	.00	.00	.00	.00	.00						
3	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
	.00	.00	.00	.00	.00	.00	4463.35	4457.05	4451.44	4441.35	4430.34	4425.06	4422.99	4422.87	4407.00
	4468.43	.00	.00	.00	.00	.00	.00	.00	.00						
4	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	4432.11	4432.35
	4429.71	4427.60	4425.50	4431.33	4438.91	4434.79	4436.48	4431.94	4429.72	4427.72	4422.19	4415.01	4414.11	4417.30	4407.90
	4476.16	.00	.00	.00	.00	.00	4484.12	4512.79	.00						
5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	4460.80	4443.72	4425.86	4417.52	4415.48
	4413.35	4411.72	4410.42	4408.48	4408.44	4407.60	4407.40	4407.00	4408.48	4411.20	4407.00	4407.00	4407.00	4407.00	4423.49
	4452.70	.00	.00	.00	.00	4455.57	4470.38	4488.59	.00						
6	.00	.00	.00	.00	.00	.00	.00	.00	.00	4465.45	4440.76	4423.05	4420.08	4417.81	4415.79
	4412.97	4411.85	4409.98	4408.39	4408.25	4407.34	4407.18	4407.00	4407.00	4407.00	4411.33	4414.12	4407.00	4411.15	4412.10
	4419.49	4428.33	4450.98	4442.92	4452.60	4446.61	4460.45	4462.18	.00						
7	.00	.00	.00	.00	.00	4539.48	4535.45	4500.59	4475.90	4450.34	4432.07	4424.99	4421.30	4419.01	4416.67
	4414.01	4412.89	4411.80	4410.87	4410.12	4409.53	4409.20	4409.63	4409.23	4413.54	4416.59	4415.67	4407.00	4415.03	4411.11
	4411.16	4414.10	4422.14	4449.38	4442.70	4425.00	4450.11	4449.00	.00						
8	.00	.00	.00	.00	.00	4552.92	4519.73	4467.68	4460.16	4438.14	4431.30	4430.34	4431.85	4424.84	4420.02
	4417.92	4415.13	4414.30	4413.41	4413.11	4412.63	4410.56	4411.15	4410.41	4415.71	4414.16	4408.70	4417.08	4419.95	4412.85
	4411.68	4409.82	4412.13	4444.32	4430.00	4447.19	4435.00	4463.79	.00						
9	.00	.00	.00	.00	.00	4580.47	4520.98	4481.44	4450.52	4441.30	4437.60	4435.71	4432.56	4427.74	4422.98
	4423.36	4422.58	4418.79	4416.18	4415.04	4416.43	4414.19	4414.82	4415.58	4417.43	4409.04	4414.28	4423.37	4426.05	4421.24
	4414.41	4412.74	4411.74	4432.87	4430.00	4459.75	4447.31	4483.67	.00						
10	.00	.00	.00	.00	.00	4599.84	4513.66	4498.72	4471.22	4456.14	4455.71	4445.63	4443.53	4437.68	4436.75
	4431.75	4428.76	4423.27	4419.93	4419.48	4422.14	4421.53	4419.57	4415.91	4419.48	4419.27	4419.81	4425.47	4431.18	4429.96
	4421.43	4418.45	4416.45	4422.24	4430.00	4462.36	4479.92	4494.34	.00						
11	.00	.00	.00	.00	.00	4612.17	4535.19	4515.46	4486.35	4473.90	4468.68	4457.57	4442.04	4431.57	4437.30
	4437.33	4434.52	4426.34	4422.32	4426.37	4428.23	4427.43	4425.10	4422.03	4422.65	4424.52	4425.23	4413.09	4430.73	4414.34
	4431.15	4427.49	4426.30	4420.40	4420.00	4462.58	4489.30	4502.57	.00						

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12      .00      .00      .00      .00      .00 4617.79 4542.14 4522.68 4493.58 4484.33 4479.41 4469.42 4454.37 4435.61 4441.08
   4440.10 4435.14 4426.39 4428.05 4432.63 4432.93 4429.14 4425.72 4425.70 4424.34 4420.33 4427.25 4425.67 4428.69 4414.29
   4432.37 4420.75 4433.90 4429.09 4425.00 4466.52 4494.05 4501.90     .00

13      .00      .00      .00      .00      .00 4594.99      .00 4523.46 4501.80 4491.56 4484.51 4477.57 4463.23 4441.52 4446.51
   4443.45 4434.76 4435.77 4433.26 4436.31 4435.59 4430.99 4429.58 4428.51 4426.36 4430.81 4429.67 4439.93 4436.13 4426.99
   4419.12 4431.41 4430.45 4435.00 4476.37 4468.08 4476.70 4501.85     .00

14      .00      .00      .00      .00      .00 4664.00 4654.94      .00 4507.58 4495.99 4490.48 4486.91 4477.93 4459.75 4455.75
   4448.08 4449.75 4448.30 4442.66 4440.06 4430.56 4438.26 4437.43 4436.43 4435.10 4436.02 4432.41 4438.26 4450.90 4441.76
   4430.88 4444.93 4418.92 4437.99 4420.90 4473.66 4497.82 4502.93     .00

15      .00 4798.12 4786.86 4782.08 4664.00 4664.00 4674.54      .00 4511.29 4506.31 4500.04 4498.76 4489.59 4477.30 4462.65
   4463.37 4466.09 4461.89 4454.28 4450.68 4450.59 4449.05 4449.25 4449.56 4444.01 4440.31 4438.80 4445.17 4465.34 4472.05
   4460.88 4460.72 4443.26 4442.04 4425.00 4477.74 4497.69 4502.76     .00

16      .00 4809.61 4789.62 4795.38 4779.24 4756.48 4701.96      .00      .00 4515.82 4508.94 4503.36 4493.05 4482.55 4471.61
   4474.22 4477.67 4479.03 4480.67 4476.32 4476.37 4472.93 4467.99 4460.89 4453.71 4445.01 4445.67 4459.67 4479.09 4487.85
   4481.96 4479.64 4465.29 4460.44 4430.00 4465.72 4494.90 4499.16     .00

17      .00 4820.17 4809.00 4801.28 4785.81 4767.14 4728.00      .00      .00      .00 4515.64 4510.40 4495.88 4485.42 4476.94
   4482.73 4492.21 4497.05 4508.67 4499.92 4494.90 4491.18 4486.61 4481.13 4466.27 4453.11 4456.88 4475.36 4491.39     .00
       .00      .00 4485.75 4476.69 4460.25 4440.00 4481.27 4489.86     .00

18      .00      .00      .00      .00 4786.79 4773.05 4748.02      .00      .00      .00 4529.57 4528.67 4518.15 4511.40 4507.03
   4501.95 4506.22 4513.86 4520.79 4516.33 4509.37 4505.29 4501.47 4494.41 4487.69 4472.33 4474.82 4489.04      .00      .00
       .00      .00 4507.81 4494.96 4485.92 4456.65 4450.00 4460.00     .00

19      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
       .00      .00 4525.93 4527.31      .00      .00      .00      .00      .00 4516.34 4477.43      .00      .00      .00      .00
       .00      .00      .00      .00      .00 4473.93 4474.30 4475.36     .00

20      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
       .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
       .00      .00      .00      .00      .00      .00 4503.49 4483.22     .00

21      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
       .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
       .00      .00      .00      .00      .00      .00      .00 4484.64     .00

22      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
       .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
       .00      .00      .00      .00      .00      .00      .00      .00     .00

23      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
       .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00      .00
       .00      .00      .00      .00      .00      .00      .00      .00     .00
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RECHARGE RATE = .0000000 FOR LAYER 1

PUMPING PERIOD NO. 21 365.00 DAYS

NUMBER OF TIME STEPS= 1

DELT IN HOURS = 8760.000

MULTIPLIER FOR DELT = 1.000

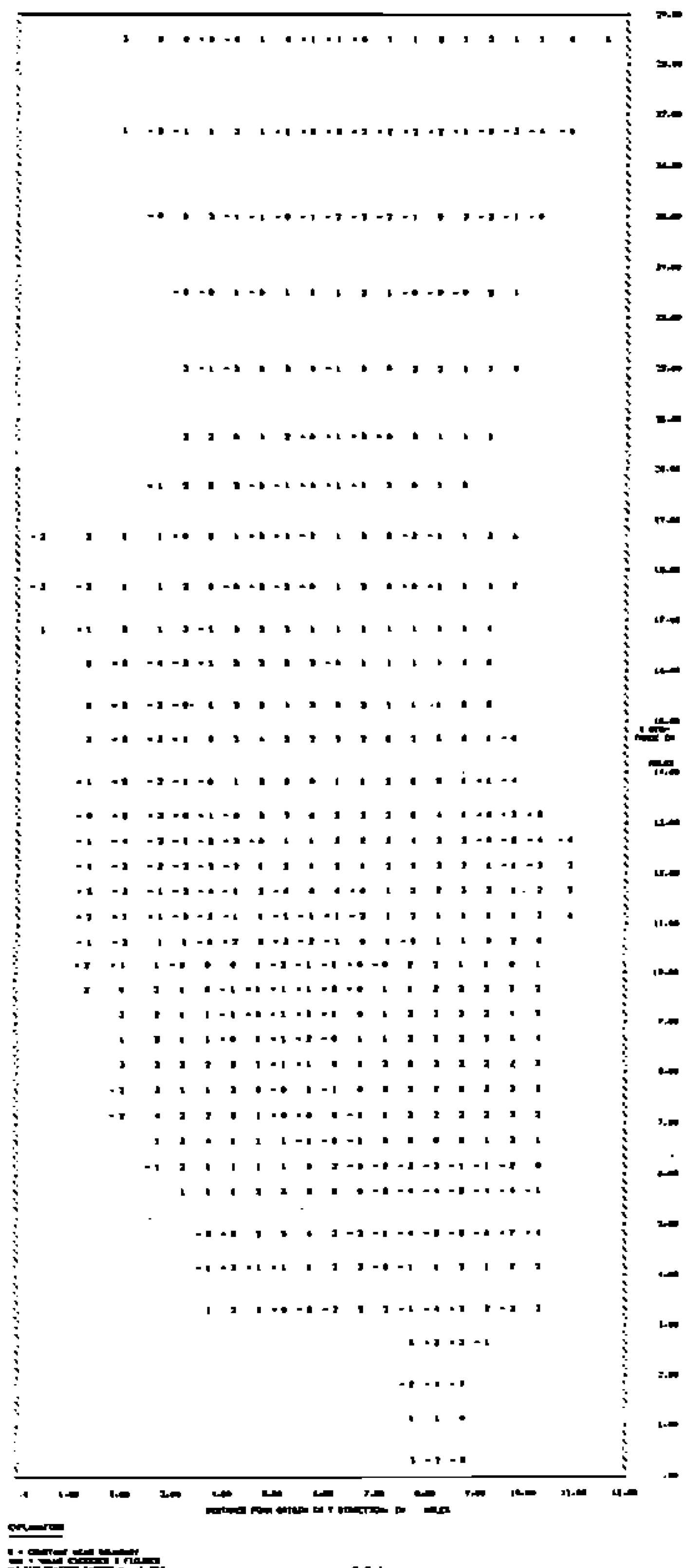
485 WELLS

K	I	J	PUMPING RATE
1	12	25	-.95070
1	13	23	-1.90139
1	14	15	-.93683
1	14	19	-.78424
1	14	20	-1.25342

Appendix E

Steady-state Drawdown Difference Map

PLOT OF DRAWDOWN DIFFERENCE LAYER I



PLOT OF DRAWDOWN DIFFERENCE LAYER 2