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User's Manual for HDR3 Computer Code

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USER'S MANUAL FOR HDR3 COMPUTER CODE

by

Connie J. Arundale

ABSTRACT

A description of the HDR3 computer code and instructions for its use are provided. HDR3 calculates space heating costs for a hot dry rock (HDR) geothermal space heating system. The code also compares these costs to those of a specific oil heating system in use at the National Aeronautics and Space Administration Flight Center at Wallops Island, Virginia. HDR3 allows many HDR system parameters to be varied so that the user may examine various reservoir management schemes and may optimize reservoir design to suit a particular set of geophysical and economic parameters.

I. INTRODUCTION

The HDR3 computer code, given various parametric values, calculates the total reservoir cost of space heating using hot dry rock geothermal resources (HDR) under various assumptions. The code presently contains no considerations for surface distribution system costs, exploration and development costs, or tax considerations, as it was developed for use in a case study of the NASA Wallops Flight Center (WFC) at Wallops Island, Virginia. A steam distribution system already existed at WFC for which alterations and extensions to the hot water system were being made. It was an advantageous choice also because previous exploration work had been done in the area, and as a government installation, tax considerations were irrelevant. Current plans include extension of the model for situations where it is necessary to consider the factors mentioned above.

Two drilling cost alternatives are used in HDR3. The first, denoted throughout as RGICOST, is based on a study by Republic Geothermal, Inc.,¹ and is best described as a step-type function dependent on the depth of drilling and other technical and geographical variables. RGICOST values are not determined in HDR3, but enter as input provided by a companion program, RGICOST, and translated to proper form by two programs, WRITEPP and FILEIT. Instructions for use of all four programs is given in Sec. III.

GEOCOST, the second drilling cost alternative, is an exponential function based on information obtained from Battelle Memorial Institute.* GEOCOST values are computed in a subroutine of HDR3 where depth of drilling is the only variable. Rock hardness determines the choice of a function, and it was assumed for this study that all permeable rock is of medium hardness and impermeable rock is hard (the choices were soft, medium, medium hard, or hard). Section II details the function and the changes required for different rock hardnesses.

The three drilling strategy options used to determine total costs with both RGICOST and GEOCOST are: (1) redrilling to the same depth, thereby restoring the original reservoir heat content, (2) redrilling to deeper depths, creating a hotter reservoir than that resulting from initial drilling, and (3) a preheat option. The preheat option compares the cost of restoring the reservoir by using (1), when temperatures therein fall below design temperature, with the cost of heating the water to design temperature using conventional fuels. The lesser of the two costs in each period is used to compute total costs for this option.

Given other parameters, HDR3 is designed to loop on various initial drilling depths, real discount rates, drilling cost increase factors, and fuel cost increase factors. The parameters include the number of fractures, required annual Btus, design temperatures, geothermal gradient, time horizon, and the difference between entrance and exit temperatures through the surface system heat exchanger. These values are all contained in the input file LOOPON, which is discussed in greater detail in Sec. III.

Given the parametric values described above, the model computes initial reservoir temperature and drilling costs. Subroutine FLOW then calculates

*This information supplied by Linda Fosbender of Battelle in a telephone conversation on June 18, 1981.

temperature drawdown in every year and compares yearly temperatures to design temperature. When the latter equals or exceeds the former, present value costs are computed under each of the drilling strategy options and the process repeats. This continues until the end of the time horizon is reached, at which time the present value of each redrilling is summed with initial drilling costs, resulting in total reservoir costs.

HDR3 also calculates benefits resulting from the use of HDR for space heat. Benefits are defined as avoided costs or the cost of using conventional fuels (and existing systems) to provide the same heat. Net benefits, total benefits minus total costs, are computed for each of the three drilling strategy options and are reported with cost results.

The following sections of this report deal with the functions used in the program, instructions for use of HDR3 and its companion programs, and an example of how the program works for a particular set of assumptions. A description of the major functions found in the program is given in Sec. II. Section III deals with the mechanics of running HDR3, RGICOST, FILEIT, and WRITEPP. It also details changes required in various input files to change parametric values. The final section, Sec. IV, includes a sample output from a run of HDR3 and explains the results. The programs and input files are contained in the Appendix.

II. MAJOR FUNCTIONS USED IN HDR3

A. Calculation of Surface System Flow Rate

The flow rate of water through the surface system is a function of the total Btus required per hour and the difference, ΔT , between the temperature that water enters a heat exchanger and the temperature at which it exits. The equation

$$\text{gal/min} = (\text{Btu/h}) / (500 \times \Delta T^{\circ\text{F}})$$

is used to compute the surface system flow rate (SMDOT). A number of conversions are necessary as SMDOT is expressed in units of kilograms per second, and our parameters include required Btu/year and ΔT in degrees centigrade. The conversions used are

$$\begin{aligned}
 1 \text{ gal H}_2\text{O} &= 3.779 \text{ kg H}_2\text{O} \\
 \Delta T^{\circ}\text{F} &= 1.8 \Delta T^{\circ}\text{C} \\
 1 \text{ min} &= 60 \text{ s} \\
 1 \text{ year} &= 8760 \text{ h.}
 \end{aligned}$$

The resulting function is

$$\text{SMDOT} = (\text{HDRBTU} * 3.779) / (\text{DELT} * 500 * 8760 * 60 * 1.8) ,$$

where

$$\begin{aligned}
 \text{HDRBTU} &= \text{required Btu/year, and} \\
 \text{DELT} &= \Delta T^{\circ}\text{C.}
 \end{aligned}$$

B. Rock Temperatures Resulting from Drilling

The temperature of the rock reached by drilling is a function of the depth of drilling (D), the geothermal temperature gradient (GR), and the temperature of the rock at the depth of basement rock (DB). In our case study of WFC, the temperature of the rock (TDB) at 9000 ft, the depth of basement, was given as 90°C. This would change for other depths of basement rock.

The temperature resulting from drilling is given then as

$$\text{TROCK} = \text{TDB} + (D - \text{DB}) * \text{GR} .$$

Should the temperature at depth of basement rock not be known, well temperatures may be approximated using the following equation:

$$\text{TROCK} = 15.0 + D * \text{GR} ,$$

where 15°C is the rock temperature at the surface (before any depth is accomplished).

C. Reservoir System Flow Rate

To obtain the flow rate necessary for the surface system and the heat extraction rate (ΔT), given a minimum water temperature (design temperature, TD) at which the heating system can operate, it is necessary to mix water from

the reservoir with water at the surface whenever reservoir temperatures exceed the design temperatures. To determine the rate of flow of water through the reservoir, the importance of which is discussed in a later section on temperature drawdown, several calculations are required. The first is the calculation of the temperature of water reinjected into the reservoir (TINJ), which is simply

$$TINJ = TD - DELT \quad .$$

This results because water flowing through the surface system is maintained at design temperature and is reinjected in the reservoir once heat has been extracted from it ($DEL T = \Delta T^{\circ}C$).

To maintain design temperature through the surface system water from the reservoir is mixed with water at reinjection temperature once it reaches the surface. In order to maintain system equilibrium, it is required that

$$SMDOT \times TD = (MDOT \times T) + (XMDOT \times TINJ)$$

and

$$SMDOT = MDOT + XMDOT \quad ,$$

where

MDOT = flow rate of water from reservoir at temperature T,

XMDOT = flow rate of water mixed at surface at temperature TINJ, and

SMDOT = flow rate of water through surface system at design temperature, TD.

To calculate the flow rate through the reservoir, the above equation is altered as follows.

$$SMDOT \times TD = (MDOT \times T) + (XMDOT \times TINJ) \quad .$$

$$SMDOT \times TD = (MDOT \times T) + (SMDOT - MDOT) \times TINJ \quad .$$

$$MDOT(T - TINJ) = SMDOT(TD - TINJ) \quad .$$

$$MDOT = SMDOT(TD - TINJ)/(T - TINJ) \quad .$$

The last equation is the form that is used in HDR3.

D. Temperature Drawdown

As water flows through the reservoir system, heat is transferred from the rock to the water. As a result, the rock gradually cools over time. The cooling process was accounted for in our model in the following way.

$$T_{t+1} = T_{inj} + (T_{rock} - T_{inj})erF(Z_t) \quad ,$$

where

- T_{t+1} = rock temperature at beginning of year $t+1$ (or end of year t),
- T_{inj} = temperature of water reinjected into the reservoir (constant),
and
- T_{rock} = rock temperature reached when drilling was completed (before any cooling resulted from water flowing through the reservoir).

$$erF(Z_t) = \text{error function of } Z_t = \frac{2}{\sqrt{\pi}} \int_0^{Z_t} e^{-x^2} dx \quad ,$$

where

$$Z_t = \sqrt{\frac{\lambda \rho C_r}{t}} \left(\frac{\pi R^2 NF}{\dot{m}_t C_w} \right) \quad ,$$

and where

- πR^2 = area of one fracture (m^2),
- NF = number of fractures,
- C_w = heat capacity of water = 4200 J/kg·K,
- C_r = heat capacity of granite = 1000 J/kg·K,
- $\dot{m}_t$ = water mass flow rate through the reservoir system in year t
(kg/s),

t' = time (seconds) = $t \times 31\,536\,000$,
 λ = thermal conductivity of granite = 3.0 W/mK, and
 ρ = rock density $\sim 2500 \text{ kg/m}^3$.

Several means of obtaining values of the function $\text{erf}(Z_t)$ were available for use in our model. One method employed the Tables of the Error Function and Its Derivative (US Department of Commerce, National Bureau of Standards Applied Mathematics Series, No. 41, October 22, 1954), which gave values accurate to fifteen decimal places. Using a power series, a second method was to compute values of the function or an asymptotic expansion for large values of Z_t . The second method was used in our analysis, although resulting values in several runs were checked against the tables to guarantee accuracy. The computational algorithms we used are detailed below.

For large values of Z_t , $\text{erf}(Z_t)$ may be advantageously computed from the following asymptotic expansion:

$$1 - \text{erf}(Z_t) \sim \frac{2}{\sqrt{\pi}} \frac{e^{-Z_t^2}}{2Z_t} \left[1 - \frac{1}{2Z_t^2} + \frac{1 \times 3}{(2Z_t^2)^2} - \frac{1 \times 3 \times 5}{(2Z_t^2)^3} + \frac{1 \times 3 \times 5 \times 7}{(2Z_t^2)^4} - \dots \right].$$

In our model when Z_t was equal to or greater than two, the following expression was used.

$$\text{erf}(Z_t) = 1 - \left\{ \frac{e^{-Z_t^2}}{Z_t \sqrt{\pi}} \left[1 - \frac{1}{2Z_t^2} + \frac{1 \times 3}{(2Z_t^2)^2} - \frac{1 \times 3 \times 5}{(2Z_t^2)^3} + \frac{1 \times 3 \times 5 \times 7}{(2Z_t^2)^4} - \frac{1 \times 3 \times 5 \times 7 \times 9}{(2Z_t^2)^5} \right] \right\}.$$

The true value of $\text{erf}(Z_t)$ lies somewhere between the value calculated above and the value that would result from adding one more term to the series. Therefore, the error in the above calculation must be less than

$$\frac{e^{-Z_t^2}}{Z_t \sqrt{\pi}} \left[\frac{1 \times 3 \times 5 \times 7 \times 9 \times 11}{(2Z_t^2)^6} \right] .$$

If $Z_t = 2$, the error would not exceed 2×10^{-4} . For values of Z_t equal to 3 and 4, the error would be less than 6.9×10^{-9} and 1.5×10^{-13} , respectively. This meant that all computations of $\text{erf}(Z_t)$ for values of $Z \geq 2$ were accurate to at least three decimal places, which was appropriate for our analysis.

For values of Z_t less than two, the calculations of $\text{erf}(Z_t)$ were made from the power series

$$\text{erf}(Z_t) = \frac{2}{\sqrt{\pi}} \left(Z - \frac{Z^3}{1.3} + \frac{Z^5}{2.5} - \frac{Z^7}{3.7} + \frac{Z^9}{4.9} - \dots \right) .$$

This series was carried as far as necessary for each Z_t in our model to guarantee accuracy to three decimal places.

This method of computing temperature drawdown in the reservoir has a major weakness that tends to overestimate the temperature loss in every year except in years when drilling occurs. This results because $\text{erf}(Z_t)$ assumes that the same flow rate through the reservoir (MDOT) occurred in all previous years as in the year in question. As reservoir temperatures decrease, reservoir system flow rates increase each year. Because these flow rates enter in the denominator of the calculation of Z_t , larger flow rates lead to smaller Z_t s and, therefore, smaller $\text{erf}(Z_t)$ s. This relationship would not present any bias if the larger flow rate used in any year had also been used in previous years, but because MDOT increases in every year (when redrilling does not occur) a bias does exist. We are currently attempting to determine a function free of such bias, but until that determination is made, the bias does exist and causes overestimation of temperature drawdown in most years.

E. GEOCOST

In HDR3 all values for GEOCOST are calculated in a subroutine of the same name. As mentioned previously, we assumed that permeable rock was of medium

hardness while impermeable rock was hard. The following functions were then used to compute costs.

$$\begin{aligned}\text{Cost (medium)} &= 116.0894471 e^{0.951723819 \times \text{Depth}} \\ \text{Cost (hard)} &= 121.9627943 e^{1.130093484 \times \text{Depth}}\end{aligned}$$

To determine total costs, using the first equation, one calculates the cost of drilling through the permeable section and adds the cost of drilling through the impermeable section, multiplies this sum by two (because the functions are for one well, and we need costs for a well pair) and then adds the cost of fracturing. The cost for the impermeable drilling is computed as follows (using the second equation): Cost to total depth - Cost to a depth which is the boundary between permeable and impermeable. Fracturing costs were given as \$70 000 times the number of fractures.

Should different rock hardnesses be assumed, the following functions may be used in place of the two above:

$$\begin{aligned}\text{Cost (medium hard)} &= 117.7297704 e^{1.057297303 \times \text{Depth}} \\ \text{Cost (soft)} &= 108.4796579 e^{0.8729852 \times \text{Depth}}\end{aligned}$$

F. Preheat Calculations

HDR3 computes the costs resulting from the preheat option in the subroutine HEAT. This subroutine calculates the number of Btus required to heat reservoir water to design temperature and the cost of doing so using conventional fuels (in our case #6 oil). This is done by first calculating required Btu/s from the following equation:

$$\text{Btu/s} = [\text{MDOT} \times 4200 \times (\text{TD} - \text{TAVG})]/1054 ,$$

where

MDOT = SMDOT = reservoir flow rate as no mixing is done,
 4200 = heat capacity of water,
 TD = design temperature,
 TAVG = reservoir temperature at the middle of the year
 = $(T_t + T_{t+1})/2$, and,
 1054 = number of Btu/J.

The resulting value is multiplied by 3.1536×10^7 to convert to Btu/year and by 1.27 to account for boiler and feed water losses. This is the total yearly Btu requirement. The number of barrels of oil required per year is calculated by dividing that requirement by $144\,000 \times 42$, where 144 000 is the Btu content of a gallon of #6 oil, and 42 is the number of gallons per barrel. To obtain present value costs, it is then only necessary to multiply by the cost of a barrel of oil and discount this value using the ratio of the fuel cost increase factor to the real discount rate.

III. INSTRUCTIONS FOR USE OF HDR3 AND COMPANION PROGRAMS

To run HDR3* it is first necessary to create a drilling cost file, WICST_, where _ denotes the number of fractures in the reservoir, that is, WICST3 is the RGICOST file for three fractures. This involves the use of three companion programs, RGICOST, WRITEPP, and FILEIT. Copies of each are contained in the Appendix, and descriptions and directions for their use are given below.

RGICOST is the program that calculates HDR drilling costs according to Republic Geothermal, Inc.'s (RGI) cost simulation procedure.¹ It performs a series of table look-ups in calculating well programs and cost components. To do this, 12 data files are called while the program is running. The first of these, PP, is a file containing all parameters relevant to the case under study. The remaining 11 files contain tables found in the RGI manual and must be present in the user's library when RGICOST is run. These tables, their allocated unit number within the program, and their relation to tables in the RGI manual are as follows.

- (1) TABLES3--opened and allocated to Unit 1 by RGICOST--contains data specified in Tables 3.1, 3.2, and 3.3 of the RGI manual.
- (2) T11P2--Unit 2, Table 11.2.
- (3) T5P3--Unit 4, Tables 5.3A and 5.3B.
- (4) T7P1--Unit 5, Table 7.1.
- (5) TGP1--Unit 7, Table G.1.
- (6) TGP2--Unit 8, Table G.2.
- (7) TGP3--Unit 9, Table G.3.
- (8) TGP4--Unit 10, Table G.4.
- (9) T4P3--Unit 14, Table 4.3.

*Program names are denoted by underscored capital letters, whereas data files are denoted simply by capitals.

- (10) T5P1--Unit 15, Table 5.1.
 (11) TGP8--Unit 16, Table G.8.

As mentioned above, the data file PP contains the site- and study-specific parameters needed for RGI cost runs. It is opened and allocated to Unit 18 by the program and is the only file the user need change to run RGICOST. The data in the file are read in free format, but must be entered on PP in the following order.

<u>Line Order</u>	<u>Line Contents</u>
1	number of parameter runs.
2	SD SDM LLP LFP LPT LRE LWS.
3	NF HF ALPHA BETA TD WWD GRAD.
4	CLASS STATE REMOTE TECH. NOTE: lines 2-4 contain parameters relevant for each parameter run. If the number of parameter runs (line 1) is greater than one, values for these parameters must be given for each run following line 1 (that is, if line 1 is 3, lines 2-10 would contain this information, where lines 2-4 correspond to the first run, 5-7 to the second, and 8-10 to the third).
5	CF1 CF2.
6	number of depth tests.
7	TEMPD P. NOTE: if the number of depth tests is greater than one, lines must be added after 7 for each depth and permeable-section depth to be tested.

Variable Names on PP

SD -- station distance between cementing company and well site (miles).
 SDM -- drilling fluid supply company distance to well (miles).
 LLP -- distance from logging and perforating company to well site (miles).
 LFP -- distance from formation packer company to well site (miles).
 LPT -- distance from pump truck yard to well (miles).
 LRE -- distance from rental equipment yard to well site (miles).
 LWS -- distance from completion contractor's yard to well (miles).
 NF -- number of fractures.
 HF -- height of fractures (diameter in feet).
 ALPHA -- downhole angles.
 BETA -- rate of angle buildup (°/ft).
 TD -- design temperature (extraneous for this version of program).
 WWD -- water well depth (feet).
 GRAD -- geothermal gradient (°C/meter).
 CLASS -- location class (001, 011, or 00111)--see Table I.
 STATE -- state identification code--see Table II.
 REMOTE -- identifier for remote wireless service area (1 = yes, 2 = no)--see Fig. 1.
 TECH -- directional drilling technique (1 = whipstock, 2 = downhole motor).

TABLE I
WELL LOCATION CLASSIFICATIONS

<u>Class</u>	<u>Terrain</u>	<u>Soil</u>	<u>Environmental Sensitivity</u>
I	Level to gently rolling	Relatively stable, no blasting or ripping required, road building material, e.g., gravel or clay, available within 20 miles	Normal
IIa.	Foothill and mountain--site selected to minimize cut and fill	Stable, some blasting or ripping required	Normal
		OR	
b.	Level to gently rolling	Relatively stable, no blasting or ripping required, road building material, e.g., gravel or clay available within 20 miles	High, requiring lined reserve pit and more stringent compaction provisions
IIIa.	Hillside location requiring extensive cut and fill	Stable, some blasting or ripping required	Normal
		OR	
b.	Foothill and mountain--site selected to minimize cut and fill	Stable, some blasting or ripping required	High, requiring lined reserve pit, more stringent drainage and compaction provisions, and noise abatement
		OR	
c.	Shallow water or very unstable location requiring built-up or boarded location	Unstable--fill material (if required) available within 20 miles	Normal

SOURCE: Schlumberger Well Services.

Fig. 1. Remote wireline service areas. Shaded areas are considered remote service areas.

TABLE II

STATE AND STATE IDENTIFICATION CODES

AL = 1	GA = 11	MD = 21	NM = 31	SD = 41
AK = 2	HI = 12	MA = 22	NY = 32	TN = 42
AZ = 3	ID = 13	MI = 23	NC = 33	TX = 43
AR = 4	IL = 14	MS = 24	ND = 34	UT = 44
CA = 5	IN = 15	MO = 25	OH = 35	VT = 45
CO = 6	IA = 16	MT = 26	OK = 36	VA = 46
CT = 7	KS = 17	NB = 27	OR = 37	WA = 47
DE = 8	KY = 18	NV = 28	PA = 38	WV = 48
DC = 9	LA = 19	NH = 29	RI = 39	WI = 49
FL = 10	ME = 20	NJ = 30	SC = 40	WY = 50

CF1 -- cost contingency factor on drilling rig time in permeable section
(decimal notation).*
CF2 -- cost contingency factor on drilling rig time in impermeable section
(decimal notation).*
TEMPD -- temperature depth** (feet).
P -- depth to basement (permeable section) (feet).

Three output files must be created to receive results from RGICOST. These are (1) TOTAL, for final cost results; (2) COST, for intermediate cost results; and (3) WELL, for well specification information. The program is currently set up to print only final costs. If more detailed information is desired, lines 553 (for well specifications) and/or 554 (for intermediate costs) in RGICOST must be changed by deleting the "c" (for comment) in column 1. This change allows the subroutines that print these results to be called. To obtain copies of any results one must then only load and list the pertinent file.

To facilitate the creation of cost files called by HDR3, two other programs were written. The first, WRITEPP, creates the parameter file PP, called by RGICOST, which was discussed above. FILEIT, the second program, takes final cost results from the file TOTAL and transforms them to proper format and location, resulting in RGI drilling cost files, WICST_ (where, again, the _ denotes the number of fractures).

WRITEPP may be used when all parameters besides number and height of fractures, drilling cost contingency factors, and depth of drilling and permeable section depth are held constant. An initial file, PARAMS, which contains the same data (in the same order) as the first four lines of the file

*The cost contingency factor on drilling rig time has been respecified since the time that the cost runs for "The Use of Hot Dry Rock Geothermal Resources for Space Heating: A Case Study," Cumming et al., Los Alamos National Laboratory, October 1981, were made.² Those runs were made using 50% for permeable sections and 15% for impermeable, but resulted in lower cost figures than results in runs using the same cost contingency factors according to the new specification. It was found that previously the factors affected only normal drilling time (then rather indirectly), and no allowance was made for time required for directional drilling.

**The temperature depth should not be equated with either vertical depth or measured depth, as it is the depth to the reservoir temperature center. RGICOST uses this depth and number and height of fractures to calculate vertical and measured depths. This was done to simplify data entry, as the depth with which we are concerned is the temperature depth, that is, the depth required at the center of the reservoir to reach a given temperature at that point, this being the average temperature of the entire reservoir.

PP must be constructed by the user. Running WRITEPP will then create the file PP by reading PARAMS, duplicating the unchanged portions, and adding any changed parameters and a series of depth tests. It is set up to take an initial depth, calculate the additional depth needed for each of a specified number of redrillings (via the deeper depth strategy), and then repeat the process for a depth equal to the initial depth plus a specified interval. One may request as many initial depths as needed, but the program automatically stops when depths greater than 23 000 ft (22 000 ft for more than four fractures) are reached, as RGICOST cannot calculate costs associated with deeper drilling.

To run WRITEPP, one must change lines 5-13 to correspond with one's desired parameters (as shown below).

```

5 HF      = _____ (number of fractures).
6 IDO     = _____ (first initial temperature depth).
7 IDB     = _____ (depth to basement).
8 NDEPTH  = _____ (number of initial depths to be tested).
9 INTVAL  = _____ (interval between initial depths).
10 NDRIL  = _____ (number of drillings for each initial depth, that is,
                        NDRIL = 10 denotes initial drilling and 9 redrillings).
11 HF      = _____ (height of fractures).
12 CF1     = _____ (drilling cost contingency factor for permeable rock).
13 CF2     = _____ (drilling cost contingency factor for impermeable rock).
14 ALPHA  = _____ (downhole angle).

```

If one wishes the first initial depth to be the minimum depth at which an HDR reservoir can be created, given the number and height of fractures, depth to basement, and downhole angle, one should enter 0 for the first initial depth on line 6. The program will then compute the minimum initial depth using the well geometry given in the RGI Manual¹ and the Los Alamos National Laboratory specification that directional drilling must not begin less than 250 ft into basement rock (Ref. 1, pp. 16-18).*

* $KOP2 = P + 250$ (from Los Alamos National Laboratory),
 $KOP2 = KOP1 + 164 \times \cos\alpha - HF$ (from RGI),
 $KOP1 = TOPI - (180/0.02\pi) \times \sin\alpha - 164 \times \cos\alpha$ (from RGI),
 $\therefore KOP2 = TOPI - (180/0.02\pi) \times \sin\alpha - HF$,
 $\therefore TOPI = KOP2 + (180/0.02\pi) \times \sin\alpha + HF$,
 $TEMPD = TOPI - 1/2 HF + \{[(NF-1) \times 164]/(2 \times \tan\alpha)\}$ (from RGI),

where

```

KOP2 = kickoff point 2,
KOP1 = kickoff point 1,
TOPI = top of production interval,
TEMPD = depth to temperature center of reservoir.

```

The program is then ready to run and the file PP will be created. It is then necessary to load and run RGICOST, resulting in output file TOTAL. This file is not in a form that can be read by HDR3, but is easily converted using the program FILEIT. Parameter changes in this program must correspond with those made for WRITEPP and are made on lines 4-6:

```

4   NDEPTH = _____
5   NDRIL  = _____
6   INTVAL = _____ .

```

It is also necessary to change line 2, which calls open the output file WICST_. If NF = 6, then the output file should be WICST6; if NF = 3, then the output file is WICST3, etc. Once these changes are made* and the program is run, a cost file WICST_ exists that may be read by HDR3.

HDR3 has two input files for each set of runs. The first is the drilling cost file, WICST_, discussed above, and the second is a parameter file, LOOPON. Data from LOOPON are read in a free format by HDR3, but must be entered in the following order

<u>Line Number</u>	<u>Content</u>
1	NR
2	R(1) R(2) ... R(NR)
3	NDCIF
4	DCIF(1) DCIF(2) ... DCIF(N)
5	NFCIF
6	FCIF(1) FCIF(2) ... FCIF(N)
7	BTUS
8	TD
9	G
10	ITH
11	DB TDB
12	DELT
13	NFRAC
14	HF
15	RP

*It may be necessary to change dimension sizes should they exceed those given in line 1:

```
1   DIMENSION RGI(X,Y),R(Y,Z),
```

where

$X \geq NDRIL$, $Y \geq NDEPTH$, and $Z \geq NDRIL + 3$.

Variable Names on LOOPON

NR = number of real discount rates.
R(X) = the Xth real discount rate.
NDCIF = number of drilling cost increase factors.
DCIF(X) = the Xth real rate of annual increase in drilling costs.
NFCIF = number of fuel cost increase factors.
FCIF(X) = the Xth real rate of annual increase in fuel costs.
BTUS = total yearly Btu requirement using conventional steam system.
TD = design temperature--lowest entrance temperature at which surface system heat exchangers will function ($^{\circ}\text{C}$).
G = geothermal gradient ($^{\circ}\text{C}/\text{km}$).
DB = depth to basement (feet).
TDB = temperature at depth to basement ($^{\circ}\text{C}$).
DELT = difference between entrance and exit temperatures in surface system heat exchangers ($\Delta T^{\circ}\text{C}$).
NFRAC = number of fractures.
HF = height of fractures (feet).
RP = retail price of oil (1980\$).

The only change generally required in HDR3 is line 32, which calls open the drilling cost file WICST_. This must be altered to correspond to the number of fractures entered on the file LOOPON. If more than three discount rates, drilling or fuel cost increase factors, more than ten initial depths, or a time horizon greater than 30 yr are used, it is necessary to change variable dimensions (lines 24-28 and line 393).

The program is then ready to run and the results are printed directly at the terminal. The general procedure for running the programs is outlined again below.

A. To create RGI drilling cost files, WICST_,

1. Type file PARAMS (lines 1-4 of PP file).
2. Load WRITEPP.
3. Make changes in WRITEPP.
 - a. Line 5 NF = _____ (number of fractures).
 - b. Line 6 IDO = _____ (1st initial temperature depth. Set equal to 0 if minimum depth is wanted).
 - c. Line 7 IDB = _____ (depth to basement).
 - d. Line 8 NDEPTH = _____ (number of initial depths to be tested).
 - e. Line 9 INTVAL = _____ (interval between initial depths).
 - f. Line 10 NDRIL = _____ (number of drillings for each initial depth).
 - g. Line 11 HF = _____ (height of fractures).

- h. Line 12 CF1 = _____ (drilling cost contingency factor--permeable).
 - i. Line 13 CF2 = _____ (drilling cost contingency factor--impermeable).
 - 4. Run WRITEPP.
 - 5. Load RGICOST.
 - 6. Run RGICOST.
 - 7. Load FILEIT.
 - 8. Make changes in FILEIT.
 - a. Line 2 WICST_____ (blank denotes number of fractures--must correspond to (a) above).
 - b. Line 4 NDEPTH = _____ (same as (d) above).
 - c. Line 5 NDRIL = _____ (same as (f) above).
 - d. Line 6 INTVAL = _____ (same as (e) above).
 - e. variable dimension sizes (if necessary).
 - 9. Run FILEIT.
- B. To get total reservoir costs of space heating using HDR,
- 1. Create file LOOPON.
 - 2. Load HDR3.
 - 3. Make changes in HDR3.
 - a. Line 32 WICST_____ = (blank denotes number of fractures--must correspond to line 13 in LOOPON).
 - b. variable dimension sizes (if necessary).
 - 4. Run HDR3.

IV. SAMPLE CASE RUNS

To illustrate how the programs work, this section presents a sample case. We assume that none of the files necessary to run HDR3 exist and must therefore be created. Referring to the general procedure outlined in the previous section, one sees that to begin one must create the file PARAMS. The following parameters will be used to create the file.

- 1. station distance between cementing company and well site (SD) = 250 mi.
- 2. drilling fluid supply company distance to well (SDM) = 250 mi.
- 3. distance from logging and perforating company to well (LLP) = 250 mi.
- 4. distance from formation packer company to well (LFP) = 250 mi.
- 5. distance from pump truck yard to well (LPT) = 250 mi.
- 6. distance from rental equipment yard to well (LRE) = 250 mi.
- 7. distance from completion contractor's yard to well (LWS) = 250 mi.
- 8. number of fractures (NF) = 3.
- 9. height of fractures (HF) = 1181 ft (360 m).
- 10. downhole angle (ALPHA) = 30°.
- 11. rate of angle buildup (BETA) = 0.02°/ft.
- 12. design temperature (extraneous for this version of RGICOST) (TD) = 74°C.
- 13. water well depth (WWD) = 300 ft.
- 14. geothermal gradient (GRAD) = 0.03°C/m.
- 15. location class (001, 011, or 111) (CLASS) = 1.

16. state identification code (46 = VA) (STATE) = 46.
17. identifier for remote wireless service area or not (1 = yes, 2 = no)
(REMOTE) = 2.
18. directional drilling technique (1 = whipstock, 2 = downhole motor)
(TECH) = 1.

With this information, the data file PARAMS is constructed as shown (note that only one parameter run is made).

Line
Number

1	1						
2	250.0	250.0	250.0	250.0	250.0	250.0	250.0
3	3.0	1181	30.0	0.02	74.0	300.0	0.03
4	1	46	2	1			

Once this file is created and saved as PARAMS, the next step is to load the program WRITEPP and make the necessary changes to conform to our case. These are as follows.

Line
Number

5	NF	= 3	(whatever is entered here will replace that entered in PARAMS).
6	ID0	= 0	(denotes that one wishes to start with the minimum allowable depth).
7	IDB	= 9000	(depth to basement = 9000 ft).
8	NDEPTH	= 10	(will test 10 initial depths).
9	INTVAL	= 1000	(each initial depth will be 1000 ft deeper than the previous one).
10	NDRIL	= 10	(number of drillings at each initial depth = 10, 1 for initial drilling and 9 redrillings).
11	HF	= 1181	(height of fracture = 1181 ft) (whatever is entered here will replace that entered in PARAMS).
12	CF1	= 0.0	{ (we assume no case contingencies for our sample case; if one assumed 50%, it would be entered as 0.5).
13	CF2	= 0.0	

(Many of these lines will remain the same for subsequent runs so fewer changes will usually be required.)

After making the changes noted above, one is ready to run WRITEPP. (Warning: an output file PP must exist in user's workspace for the program to run.) The resulting file PP (shown below) consists of five lines (1-5) of general site parameters, number of depth tests (line 6) and 63 depth tests (lines 7-69). One should note that the number of depth tests on line 6 does

not agree with the actual number of such tests. This disagreement results (as mentioned above) because the program WRITEPP deletes any tests for depths greater than those for which costs can be computed by RGICOST. Because of this disagreement, running RGICOST may result in a statement indicating that the end of input file PP was reached and computation therefore terminated. This will not alter results and should not be a source of concern should it happen.

FILE PP

```

1
250.0 250.0 250.0 250.0 250.0 250.0 250.0
3.0 1181 30.0 0.02 74.0 300.0 0.03
1 46 2 1
0.0 0.0
100
11557 9000
12738 9000
13519 9000
15100 9000
16281 9000
17462 9000
18643 9000
19824 9000
21005 9000
22186 9000
12557 9000
13738 9000
14919 9000
16100 9000
17281 9000
18462 9000
19643 9000
20824 9000
22005 9000
13557 9000
14738 9000
15919 9000
17100 9000
18281 9000
19462 9000
20643 9000
21824 9000
14557 9000
15738 9000
16919 9000
18100 9000
19281 9000
20462 9000
21643 9000
22824 9000
15557 9000
16738 9000
17919 9000
19100 9000
20281 9000
21462 9000
22643 9000
16557 9000

```


FILE PP (cont)

17738	9000
18919	9000
20100	9000
21281	9000
22462	9000
17557	9000
18738	9000
19919	9000
21100	9000
22281	9000
18557	9000
15738	9000
20919	9000
22100	9000
19557	9000
20738	9000
21919	9000
20557	9000
21738	9000
22919	9000

Again, referring to the general procedure for using the programs (Sec. III), one sees that the next step is to load and run RGICOST. Results for total costs calculated by the program are stored in the output file TOTAL, which is included here.

FILE TOTAL

TEMPC	TOTAL COST	REDRILL ODD	REDRILL EVEN
11557.00	8457000.00	4156900.00	4426500.00
12738.00	9222400.00	4505200.00	4839200.00
13919.00	10032700.0	4879200.00	5269200.00
15100.00	14668200.0	7106600.00	7716900.00
16281.00	15686300.0	7645400.00	8184500.00
17462.00	16727300.0	8152800.00	8718500.00
18643.00	17770400.0	8623100.00	9286300.00
19824.00	19401792.0	9396600.00	10218700.0
21005.00	20429792.0	9867700.00	10777400.0
22186.00	21472384.0	10337500.0	11344200.0
12557.00	9062700.00	4411300.00	4774000.00
13738.00	9854300.00	4824700.00	5191000.00
14919.00	14540400.0	7027700.00	7668800.00
16100.00	15530100.0	7568000.00	8106300.00
17281.00	16550800.0	8072700.00	8621400.00
18462.00	17625888.0	8574700.00	9191100.00
19643.00	19259488.0	9309400.00	10164100.0
20824.00	20210400.0	9754900.00	10666000.0
22005.00	21278784.0	10244800.0	11244700.0
13557.00	9767800.00	4765200.00	5125000.00
14738.00	13645600.0	6612100.00	7135100.00
15919.00	15389200.0	7452300.00	8082000.00
17100.00	16355900.0	7976300.00	8524100.00
18281.00	17410192.0	8479000.00	9071900.00
19462.00	19117392.0	9267700.00	10064700.0
20643.00	20086992.0	9686900.00	10610600.0
21824.00	21105584.0	10157800.0	11159300.0
14557.00	13480100.0	6520900.00	7061800.00
15738.00	15269000.0	7409600.00	8011600.00
16919.00	16230100.0	7899100.00	8476100.00
18100.00	17237888.0	8401700.00	8978100.00

FILE TOTAL (cont)

19281.00	18948688.0	9199300.00	9965200.00
20462.00	19944592.0	9644400.00	10510600.0
21643.00	20963488.0	10090800.0	11085000.0
22824.00	21976080.0	10576000.0	11606900.0
15557.00	15074700.0	7331600.00	7896400.00
16738.00	16057400.0	7846000.00	8392700.00
17919.00	17108192.0	8322400.00	8528300.00
19100.00	18779680.0	9132300.00	9864200.00
20281.00	19756480.0	9576300.00	10431600.0
21462.00	20841392.0	10048900.0	11005500.0
22643.00	21813184.0	10468900.0	11552200.0
16557.00	15922900.0	7749500.00	8315600.00
17738.00	16970000.0	8273700.00	8838600.00
18919.00	18662800.0	9070400.00	9809800.00
20100.00	19606992.0	9489100.00	10330400.0
21281.00	20652192.0	9960400.00	10905800.0
22462.00	21690880.0	10426700.0	11472500.0
17557.00	16795600.0	8196300.00	8742700.00
18738.00	17850400.0	8676300.00	9312800.00
19919.00	19480576.0	9417700.00	10276000.0
21100.00	20483280.0	9893500.00	10804800.0
22281.00	21522080.0	10358500.0	11373000.0
18557.00	17676688.0	8598900.00	9217400.00
19738.00	19354080.0	9375700.00	10192000.0
20919.00	20316496.0	9782100.00	10750400.0
22100.00	21332880.0	10271200.0	11272000.0
19557.00	19166096.0	9288600.00	10092200.0
20738.00	20183088.0	9754200.00	10639600.0
21919.00	21205376.0	10198800.0	11217700.0
20557.00	19993584.0	9665900.00	10538700.0
21738.00	21077776.0	10156900.0	11132400.0
22919.00	22157584.0	10658700.0	11766900.0

Should more detailed results be desired, one must load RGICOST and change lines 553 and 554 by deleting the "c" in column 1. This will allow two sub-routines to be called that determine and store well specifications in output file WELL and intermediate cost data in output file COST. Because of space limitations, when complete breakdowns are required, it is recommended that no more than twelve depth tests are made at one time. For purposes of illustration, such a run was made for only one depth test, 11 557 ft (the minimum initial depth possible for 3 fractures with 9000 ft of permeable section). The resulting files, TOTAL, WELL and COST, are shown below.

FILE TOTAL

TEMPO	TOTAL COST	REDRILL ODD	REDRILL EVEN
11557.00	8457000.00	4156900.00	4426500.00

FILE WELL

+++++ TOPI = 11863.44 P = 9000.00 WP = 4.3 1.0 CASE ASSUMPTIONS +++++
SD= 250. SDM= 250. LLP= 250. LFP= 250. LPI= 250. LRE= 250. LWS= 250.
NF= 3. HF=1181.0 ALPHA=30.00 BETA=.020 TECHNIQUE=1
CLASS= 1 STATE=46 REMOTE=2

	INJECTOR	PRODUCOR
TOPI	11863.44	11863.44
KCP	10289.00	9250.00
TMD	12691.00	11488.00
TVD	12502.00	11321.00

CASING PROGRAM

HOLE DIAMETER	CASING DIAMETER	INJECTOR TOP OF INTERVAL	INJECTOR BOTTOM OF INTERVAL	PRODUCOR TOP OF INTERVAL	PRODUCOR BOTTOM OF INTERVAL
26.0000	20.0000	0.	184.00	0.	184.00
17.5000	13.5750	0.	1840.00	0.	1840.00
12.2500	9.6250	0.	9200.00	0.	9200.00
8.5000	7.0000	9000.00	12691.00	0.	0.

LOGGING PROGRAM

INJECTOR				PRODUCOR			
#	COL. B	COL. C	COL. D	#	COL. B	COL. C	COL. D
1.	9200.00	9200.00	1840.00	1.	9200.00	9200.00	1840.00
3.	12502.00	12691.00	10239.00	3.	11321.00	11488.00	9200.00

INJECTOR					PRODUCOR				
INT	NDRT	DRT	TRIP	BIT	NDRT	DRT	TRIP	BIT	
1	43.9	31.4	1	2	43.9	31.4	1	2	
2	40.6	279.3	6	7	40.6	279.3	6	7	
3	76.9	822.3	12	13	76.9	822.3	12	13	
4	152.9	299.4	4	5	53.7	29.8	1	2	
ANGLE BUILDUP		1474.4	18	7	1418.3		18	7	
CONSTANT ANGLE		279.9	4	5	216.2		3	4	
DAYS IN PERMEABLE ROCK				47	DAYS IN PERMEABLE ROCK				47
DRILLING RIG DAYS				150	DRILLING RIG DAYS				130
VT= 2184.00		VVT= 666.47							

FILE COST

+++++++ TOPI = 11863.44 P = 9000.00 WP = 4.3 ++++++++
 1.0 CASE DRILLING ASSUMPTIONS

LOCATION COST	47000.00
MOVE COST	42200.00
RIG MOBILIZATION COST	17400.00
RIG FUEL COST	469600.00
WATER SUPPLY SETUP CHARGES	17900.00
WATER WELL COST	9500.00
CORRELATING & PERFORATING	63600.00
PACKER, BOP, & SCRAPER	13400.00
COMPLETION RIG COST	33900.00
PUMP TRUCK SERVICE	11300.00
PORTABLE DERRICK	93600.00
RENTAL EQUIP. & TRANS.	29600.00
CASING TRANSPORTATION	97500.00
DRILLING FLUID TRANSPORTATION	9600.00
ADDITIONAL TRANSPORTATION	23100.00
SUPERVISION & CO. LABOR	369600.00
INCIDENTAL COSTS	49300.00
G & A COSTS	478700.00

	INJECTOR	PRODUCER
WELLHEAD & LINER HANGERS	48600.00	62100.00
TOTAL TANGIBLE COSTS	459500.00	519000.00
TAX ON TANGIBLES	18400.00	20800.00
DRILLING RIG COST	2006400.00	1738900.00
BIT COST	400700.00	381800.00
STABILIZER COST	20300.00	18800.00
NGN-MAGNETIC COLLAR RENTAL	900.00	700.00
ANGLE BUILDUP FIXED COST	75800.00	73400.00
DRILLING FLUID COST	105300.00	105300.00
CEMENTING COST	151500.00	176600.00
LOGGING COST	45000.00	42400.00
WATER INJECTION TEST	8200.00	9700.00
FLOWMETER & TEMP SURVEY	17300.00	16500.00
MISCELLANEOUS COSTS	31700.00	24600.00
SHARE OF COMMON COSTS	1055400.00	820400.00
TOTALS	4446000.00	4011000.00

TOTAL COST TO ESTABLISH A HDR RESERVOIR 8457000.00

Because the file TOTAL is not in a form that can be read by the program HDR3, it is necessary to change this form. This is done simply by loading and running (after making necessary changes) the program FILEIT. The required changes are

Line Number		
2	... WICST3 ...	(must correspond to number of fractures, in our case -3)
4	NDEPTH = 10	(same as line 8 in <u>WRITEPP</u>)
5	NDRIL = 10	(same as line 10 in <u>WRITEPP</u>)
6	INTVAL = 1000	(same as line 9 in <u>WRITEPP</u>)

Running FILEIT results in the RGI drilling cost file, WICST3, shown below. Looking back at the file TOTAL one can see what the program FILEIT does. It takes the information for the first initial depth test (line 2), including depth, total cost, and the costs for redrilling to the same depth via same-depth drilling. Redrilling cost is given for "odd" and "even" when same-depth drilling is used. This is because the first (third, fifth, etc.) time redrilling is undertaken, a new injection well is created to replace the original one, which is closed down, while the second (fourth, sixth, etc.) time redrilling occurs, a new production well is created and the old production well is closed. These four values become the first four values (line 1) of the cost file WICST3. The rest of the values found on line 1 (WICST3) are the cost of redrilling to increasingly deeper depths. These values are taken from lines 2-10 of TOTAL. The value for "redrill even," that for creating a new production well at a deeper depth, is used for each redrilling to deeper depths. FILEIT proceeds to create one line of data in WICST3 for each initial drilling depth and all deeper drilling corresponding to that initial depth. If 10 initial depths are tested, the RGICOST file WICST3 will have 10 lines containing this information.

FILE WICST3

```

13 11257.0 8497000.0 41569000.0 4426500.0 4939200.0 5269200.0 7710900.0 8184500.0 8718500.0 9286300.0 10000000.0 10111000.0 10164100.0 10216000.0 10267000.0 10318000.0 10369000.0 10420000.0 10471000.0 10522000.0 10573000.0 10624000.0 10675000.0 10726000.0 10777000.0 10828000.0 10879000.0 10930000.0 10981000.0 11032000.0 11083000.0 11134000.0 11185000.0 11236000.0 11287000.0 11338000.0 11389000.0 11440000.0 11491000.0 11542000.0 11593000.0 11644000.0 11695000.0 11746000.0 11797000.0 11848000.0 11899000.0 11950000.0 12001000.0 12052000.0 12103000.0 12154000.0 12205000.0 12256000.0 12307000.0 12358000.0 12409000.0 12460000.0 12511000.0 12562000.0 12613000.0 12664000.0 12715000.0 12766000.0 12817000.0 12868000.0 12919000.0 12970000.0 13021000.0 13072000.0 13123000.0 13174000.0 13225000.0 13276000.0 13327000.0 13378000.0 13429000.0 13480000.0 13531000.0 13582000.0 13633000.0 13684000.0 13735000.0 13786000.0 13837000.0 13888000.0 13939000.0 13990000.0 14041000.0 14092000.0 14143000.0 14194000.0 14245000.0 14296000.0 14347000.0 14398000.0 14449000.0 14500000.0 14551000.0 14602000.0 14653000.0 14704000.0 14755000.0 14806000.0 14857000.0 14908000.0 14959000.0 15010000.0 15061000.0 15112000.0 15163000.0 15214000.0 15265000.0 15316000.0 15367000.0 15418000.0 15469000.0 15520000.0 15571000.0 15622000.0 15673000.0 15724000.0 15775000.0 15826000.0 15877000.0 15928000.0 15979000.0 16030000.0 16081000.0 16132000.0 16183000.0 16234000.0 16285000.0 16336000.0 16387000.0 16438000.0 16489000.0 16540000.0 16591000.0 16642000.0 16693000.0 16744000.0 16795000.0 16846000.0 16897000.0 16948000.0 16999000.0 17050000.0 17101000.0 17152000.0 17203000.0 17254000.0 17305000.0 17356000.0 17407000.0 17458000.0 17509000.0 17560000.0 17611000.0 17662000.0 17713000.0 17764000.0 17815000.0 17866000.0 17917000.0 17968000.0 18019000.0 18070000.0 18121000.0 18172000.0 18223000.0 18274000.0 18325000.0 18376000.0 18427000.0 18478000.0 18529000.0 18580000.0 18631000.0 18682000.0 18733000.0 18784000.0 18835000.0 18886000.0 18937000.0 18988000.0 19039000.0 19090000.0 19141000.0 19192000.0 19243000.0 19294000.0 19345000.0 19396000.0 19447000.0 19498000.0 19549000.0 19600000.0 19651000.0 19702000.0 19753000.0 19804000.0 19855000.0 19906000.0 19957000.0 20008000.0 20059000.0 20110000.0 20161000.0 20212000.0 20263000.0 20314000.0 20365000.0 20416000.0 20467000.0 20518000.0 20569000.0 20620000.0 20671000.0 20722000.0 20773000.0 20824000.0 20875000.0 20926000.0 20977000.0 21028000.0 21079000.0 21130000.0 21181000.0 21232000.0 21283000.0 21334000.0 21385000.0 21436000.0 21487000.0 21538000.0 21589000.0 21640000.0 21691000.0 21742000.0 21793000.0 21844000.0 21895000.0 21946000.0 21997000.0 22048000.0 22099000.0 22150000.0 22201000.0 22252000.0 22303000.0 22354000.0 22405000.0 22456000.0 22507000.0 22558000.0 22609000.0 22660000.0 22711000.0 22762000.0 22813000.0 22864000.0 22915000.0 22966000.0 23017000.0 23068000.0 23119000.0 23170000.0 23221000.0 23272000.0 23323000.0 23374000.0 23425000.0 23476000.0 23527000.0 23578000.0 23629000.0 23680000.0 23731000.0 23782000.0 23833000.0 23884000.0 23935000.0 23986000.0 24037000.0 24088000.0 24139000.0 24190000.0 24241000.0 24292000.0 24343000.0 24394000.0 24445000.0 24496000.0 24547000.0 24598000.0 24649000.0 24700000.0 24751000.0 24802000.0 24853000.0 24904000.0 24955000.0 25006000.0 25057000.0 25108000.0 25159000.0 25210000.0 25261000.0 25312000.0 25363000.0 25414000.0 25465000.0 25516000.0 25567000.0 25618000.0 25669000.0 25720000.0 25771000.0 25822000.0 25873000.0 25924000.0 25975000.0 26026000.0 26077000.0 26128000.0 26179000.0 26230000.0 26281000.0 26332000.0 26383000.0 26434000.0 26485000.0 26536000.0 26587000.0 26638000.0 26689000.0 26740000.0 26791000.0 26842000.0 26893000.0 26944000.0 26995000.0 27046000.0 27097000.0 27148000.0 27199000.0 27250000.0 27301000.0 27352000.0 27403000.0 27454000.0 27505000.0 27556000.0 27607000.0 27658000.0 27709000.0 27760000.0 27811000.0 27862000.0 27913000.0 27964000.0 28015000.0 28066000.0 28117000.0 28168000.0 28219000.0 28270000.0 28321000.0 28372000.0 28423000.0 28474000.0 28525000.0 28576000.0 28627000.0 28678000.0 28729000.0 28780000.0 28831000.0 28882000.0 28933000.0 28984000.0 29035000.0 29086000.0 29137000.0 29188000.0 29239000.0 29290000.0 29341000.0 29392000.0 29443000.0 29494000.0 29545000.0 29596000.0 29647000.0 29698000.0 29749000.0 29800000.0 29851000.0 29902000.0 29953000.0 30004000.0 30055000.0 30106000.0 30157000.0 30208000.0 30259000.0 30310000.0 30361000.0 30412000.0 30463000.0 30514000.0 30565000.0 30616000.0 30667000.0 30718000.0 30769000.0 30820000.0 30871000.0 30922000.0 30973000.0 31024000.0 31075000.0 31126000.0 31177000.0 31228000.0 31279000.0 31330000.0 31381000.0 31432000.0 31483000.0 31534000.0 31585000.0 31636000.0 31687000.0 31738000.0 31789000.0 31840000.0 31891000.0 31942000.0 31993000.0 32044000.0 32095000.0 32146000.0 32197000.0 32248000.0 32299000.0 32350000.0 32401000.0 32452000.0 32503000.0 32554000.0 32605000.0 32656000.0 32707000.0 32758000.0 32809000.0 32860000.0 32911000.0 32962000.0 33013000.0 33064000.0 33115000.0 33166000.0 33217000.0 33268000.0 33319000.0 33370000.0 33421000.0 33472000.0 33523000.0 33574000.0 33625000.0 33676000.0 33727000.0 33778000.0 33829000.0 33880000.0 33931000.0 33982000.0 34033000.0 34084000.0 34135000.0 34186000.0 34237000.0 34288000.0 34339000.0 34390000.0 34441000.0 34492000.0 34543000.0 34594000.0 34645000.0 34696000.0 34747000.0 34798000.0 34849000.0 34900000.0 34951000.0 35002000.0 35053000.0 35104000.0 35155000.0 35206000.0 35257000.0 35308000.0 35359000.0 35410000.0 35461000.0 35512000.0 35563000.0 35614000.0 35665000.0 35716000.0 35767000.0 35818000.0 35869000.0 35920000.0 35971000.0 36022000.0 36073000.0 36124000.0 36175000.0 36226000.0 36277000.0 36328000.0 36379000.0 36430000.0 36481000.0 36532000.0 36583000.0 36634000.0 36685000.0 36736000.0 36787000.0 36838000.0 36889000.0 36940000.0 36991000.0 37042000.0 37093000.0 37144000.0 37195000.0 37246000.0 37297000.0 37348000.0 37399000.0 37450000.0 37501000.0 37552000.0 37603000.0 37654000.0 37705000.0 37756000.0 37807000.0 37858000.0 37909000.0 37960000.0 38011000.0 38062000.0 38113000.0 38164000.0 38215000.0 38266000.0 38317000.0 38368000.0 38419000.0 38470000.0 38521000.0 38572000.0 38623000.0 38674000.0 38725000.0 38776000.0 38827000.0 38878000.0 38929000.0 38980000.0 39031000.0 39082000.0 39133000.0 39184000.0 39235000.0 39286000.0 39337000.0 39388000.0 39439000.0 39490000.0 39541000.0 39592000.0 39643000.0 39694000.0 39745000.0 39796000.0 39847000.0 39898000.0 39949000.0 39999999.0

```

Once the cost file WICST3 exists, one is ready to run the program HDR3, which determines present value costs of producing heat using HDR over a given time horizon. Again, referring to the general procedure for using the programs one sees that the file LOOPON must be created (or changed) to correspond with the parameters that one wishes to use. We assume here that no such file exists and will therefore need to make one using the following parameters.

1. number of discount rates to be used = 3
2. discount rates = 4%, 7.25%, 10%
3. number of drilling cost increase factors = 3
4. drilling cost increase factors = 3%, 4.34%, 6%
5. number of fuel cost increase factors = 3
6. fuel cost increase factors = 2%, 3%, 4%
7. yearly Btu requirement using conventional system = 161.28×10^9
8. design temperature = 74°C
9. geothermal gradient = $30^{\circ}\text{C}/\text{km}$
10. time horizon = 30 yr
11. depth to basement = 9000 ft
12. temperature at depth to basement = 90°C
13. heat extraction rate for heat exchangers (ΔT) = 11.1111°C
14. number of fractures = 3
15. height of fractures = 1181 ft
16. retail price of #6 oil = 1980\$ = 31.13

Using these parameters, the file LOOPON will be:

```

3
.C4 .C725 .10
3
.C3 .0434 .06
3
.02 .03 .C4
16128CCCC000.
74.
30.
30
9000
90
11.1111
3
1181.0
31.13

```

To facilitate understanding of the final results printed out by the program and the program (HDR3) itself, it will be helpful to examine intermediate results and the methods by which they were reached. In the following section, we take the values given as parameters in the file LOOPON and perform the same calculations as the program does. Each statement is given in the form found in the program, and program line numbers are given in parentheses. A list of all variable names follows the calculations. File results as printed by the program at the terminal, are presented here before the intermediate results are examined.

Step

1 Program reads data from file LOOPON and file WICST3 (33-35)

2 The following calculations are made.

a.
$$\begin{aligned}\text{HDRBTU} &= [\text{Btu} \times (0.32 + 0.11)] \times 1.05 & (40) \\ &= (1.6128 \times 10^{11} \times 0.43) \times 1.05 \\ &= 7.2818 \times 10^{10}\end{aligned}$$

converts total yearly Btu requirements using conventional system to total yearly Btu requirements using HDR.

b.
$$\begin{aligned}\text{BARREL} &= \text{BTUS}/(144\ 000 \times 42) & (41) \\ &= 1.6128 \times 10^{11}/6\ 048\ 000 \\ &= 26\ 666.67\end{aligned}$$

calculates barrels of oil required to meet Btu requirement using conventional system.

c.
$$\begin{aligned}\text{GR} &= \text{G}/(1000 \times 3.28084) & (42) \\ &= 30/3280.84 \\ &= 0.009144\end{aligned}$$

translates geothermal gradient ($^{\circ}\text{C}/\text{km}$) to $^{\circ}\text{C}/\text{ft}$.

d.
$$\begin{aligned}\text{SMDOT} &= (\text{HDRBTU} \times 3.779)/(\text{DELT} \times 500 \times 8760 \times 60 \times 1.8) & (43) \\ &= (7.1818 \times 10^{10} \times 3.779)/(11.1111 \times 500 \times 8760 \\ &\quad \times 60 \times 1.8) \\ &= 52.36\end{aligned}$$

determines surface system flow rate requirement.

e.
$$\begin{aligned}\text{TINJ} &= \text{TD} - \text{DELT} & (44) \\ &= 74 - 11.1111 \\ &= 62.8889\end{aligned}$$

calculates reinjection temperature.

PROGRAM RESULT

*** 3 FRACTURES ***

*** INITIAL DEPTH = 11557.00 FEET ***

INITIAL DRILLING COSTS
(1980 \$ MILLIONS)

RGI = 9.457

GEO = 11.020

TOTAL COSTS
NET BENEFITS IN PARENTHESES
(1980 \$ MILLIONS)

R	DCIF	FCIF	SAME DEPTH		DEEPER DEPTHS		PREHEAT OPTICAL	
			RGI	GEO	RGI	GEO	RGI	GEO
.0400	.0300	.0200	12.288 (6.404)	16.068 (2.604)	12.867 (5.826)	18.871 (-0.178)	9.515 (5.177)	12.078 (6.614)
.0400	.0300	.0300	12.288 (9.227)	16.088 (5.427)	12.867 (8.648)	18.871 (2.644)	9.793 (11.722)	12.356 (5.160)
.0400	.0300	.0400	12.288 (12.616)	16.088 (8.816)	12.867 (12.037)	18.871 (6.033)	10.141 (14.763)	12.704 (12.200)
.0400	.0434	.0200	13.230 (5.463)	17.334 (1.359)	13.951 (4.742)	20.800 (-2.108)	9.515 (5.177)	12.078 (6.614)
.0400	.0434	.0300	13.230 (8.286)	17.334 (4.181)	13.951 (7.564)	20.800 (0.715)	9.793 (11.722)	12.356 (5.160)
.0400	.0434	.0400	13.230 (11.674)	17.334 (7.570)	13.951 (10.953)	20.800 (4.104)	10.141 (14.763)	12.704 (12.200)
.0400	.0600	.0200	14.699 (3.994)	19.277 (-0.584)	15.642 (3.051)	23.810 (-5.118)	9.515 (5.177)	12.078 (6.614)
.0400	.0600	.0300	14.699 (6.817)	19.277 (2.238)	15.642 (5.873)	23.810 (-2.295)	9.793 (11.722)	12.356 (5.160)
.0400	.0600	.0400	14.699 (10.205)	19.277 (5.627)	15.642 (9.262)	23.810 (1.094)	10.141 (14.763)	12.704 (12.200)
.0725	.0300	.0200	10.728 (1.822)	14.024 (-1.474)	11.071 (1.479)	15.673 (-3.123)	8.969 (3.581)	11.532 (1.018)
.0725	.0300	.0300	10.728 (3.410)	14.024 (0.114)	11.071 (3.067)	15.673 (-1.536)	9.101 (5.037)	11.663 (2.474)
.0725	.0300	.0400	10.728 (5.284)	14.024 (1.988)	11.071 (4.941)	15.673 (0.338)	9.265 (6.746)	11.828 (4.183)
.0725	.0434	.0200	11.286 (1.264)	14.762 (-2.212)	11.713 (0.837)	16.816 (-4.266)	8.969 (3.581)	11.532 (1.018)
.0725	.0434	.0300	11.286 (2.852)	14.762 (-0.625)	11.713 (2.424)	16.816 (-2.679)	9.101 (5.037)	11.663 (2.474)
.0725	.0434	.0400	11.286 (4.726)	14.762 (1.249)	11.713 (4.298)	16.816 (-0.805)	9.265 (6.746)	11.828 (4.183)
.0725	.0600	.0200	12.156 (0.394)	15.914 (-3.364)	12.715 (-0.165)	18.600 (-6.050)	8.969 (3.581)	11.532 (1.018)
.0725	.0600	.0300	12.156 (1.981)	15.914 (-1.776)	12.715 (1.422)	18.600 (-4.463)	9.101 (5.037)	11.663 (2.474)
.0725	.0600	.0400	12.156 (3.855)	15.914 (0.098)	12.715 (3.296)	18.600 (-2.589)	9.265 (6.746)	11.828 (4.183)
.1000	.0300	.0200	9.933 (-0.448)	12.973 (-3.488)	10.157 (-0.671)	14.045 (-4.560)	8.741 (0.745)	11.304 (-1.818)
.1000	.0300	.0300	9.933 (0.582)	12.973 (-2.457)	10.157 (0.359)	14.045 (-3.530)	8.813 (1.703)	11.376 (-0.860)
.1000	.0300	.0400	9.933 (1.781)	12.973 (-1.259)	10.157 (1.558)	14.045 (-2.331)	8.903 (2.812)	11.466 (0.249)
.1000	.0434	.0200	10.296 (-0.811)	13.453 (-3.968)	10.574 (-1.089)	14.789 (-5.304)	8.741 (0.745)	11.304 (-1.818)
.1000	.0434	.0300	10.296 (0.219)	13.453 (-2.937)	10.574 (-0.059)	14.789 (-4.273)	8.813 (1.703)	11.376 (-0.860)
.1000	.0434	.0400	10.296 (1.418)	13.453 (-1.739)	10.574 (1.140)	14.789 (-3.075)	8.903 (2.812)	11.466 (0.249)
.1000	.0600	.0200	10.862 (-1.377)	14.202 (-4.717)	11.226 (-1.740)	15.949 (-6.464)	8.741 (0.745)	11.304 (-1.818)
.1000	.0600	.0300	10.862 (-0.347)	14.202 (-3.686)	11.226 (-0.710)	15.949 (-5.433)	8.813 (1.703)	11.376 (-0.860)
.1000	.0600	.0400	10.862 (0.852)	14.202 (-2.488)	11.226 (0.489)	15.949 (-4.235)	8.903 (2.812)	11.466 (0.249)

SURFACE SYSTEM TEMPERATURE DROP = 11.1111
ANNUAL BTU REQUIREMENTS = 72817934438.8
DESIGN TEMPERATURE = 74.00
SURFACE FLOW RATE = 52.36
GRADIENT = 30.0
DEPTH OF BASEMENT ROCK = 9000.0
TIME HORIZON = 30

FOR SAME DEPTH DRILLING, REDRILLING OCCURRED IN YEARS 18,
FOR DEEPER DEPTHS DRILLING, REDRILLING OCCURRED IN YEARS 18,

YEAR	T-SD	T-DD	MDOT	T-PT
1	113.38	113.38	11.52	113.38
2	113.38	113.38	11.52	113.38
3	113.28	113.28	11.55	113.28
4	112.76	112.76	11.66	112.76
5	111.78	111.78	11.90	111.78
6	110.37	110.37	12.25	110.37
7	108.60	108.60	12.73	108.60

RESULT (cont)

8	106.49		106.49		13.34		106.49
9	104.09		104.09		14.12		104.09
10	101.44		101.44		15.09		101.44
11	98.57		98.57		16.30		98.57
12	95.51		95.51		17.83		95.51
13	92.32		92.32		19.76		92.32
14	89.06		89.06		22.23		89.06
15	85.78		85.78		25.41		85.78
16	82.56		82.56		29.58		82.56
17	79.46		79.46		35.10		79.46
18	113.38	(76.57)	124.18	(76.57)	5.49		76.57
19	113.38	(73.94)	124.18	(73.94)	5.49		71.91
20	113.38		124.17		5.45		71.91
21	112.76		124.04		9.51		71.45
22	111.78		123.67		5.57		71.25
23	110.37		123.01		9.68		71.06
24	108.60		122.07		9.83		70.88
25	106.49		120.88		10.03		70.71
26	104.09		119.44		10.29		70.56
27	101.44		117.80		10.59		70.41
28	98.57		115.94		10.97		70.27
29	95.51		113.87		11.41		70.14
30	92.32		111.64		11.93		70.01
31	89.06		109.23		0.		69.90

*** 3 FRACTURES ***

*** INITIAL DEPTH = 12557.00 FEET ***

INITIAL DRILLING COSTS (1980 \$ MILLIONS)

RGI = 9.063

GEO = 16.392

TOTAL COSTS NET BENEFITS IN PARENTHESES (1980 \$ MILLIONS)

R	DCIF	FCIF	SAME DEPTH		DEEPER DEPTHS		PREHEAT OPTION	
			RGI	GEO	RGI	GEO	RGI	GEO
.0400	.0300	.0200	12.845	23.260	13.463	26.930	9.395	16.724
			(5.848)	(-4.567)	(5.225)	(-8.237)	(9.298)	(1.968)
.0400	.0300	.0300	12.845	23.260	13.463	26.930	9.494	16.824
			(8.670)	(-1.744)	(8.052)	(-5.414)	(12.021)	(4.691)
.0400	.0300	.0400	12.845	23.260	13.463	26.930	9.623	16.952
			(12.059)	(1.644)	(11.441)	(-2.026)	(15.281)	(7.952)
.0400	.0434	.0200	14.221	25.757	15.064	30.762	9.395	16.724
			(4.472)	(-7.065)	(3.629)	(-12.070)	(9.298)	(1.968)
.0400	.0434	.0300	14.221	25.757	15.064	30.762	9.494	16.824
			(7.294)	(-4.242)	(6.451)	(-9.247)	(12.021)	(4.691)
.0400	.0434	.0400	14.221	25.757	15.064	30.762	9.623	16.952
			(10.683)	(-0.853)	(9.840)	(-5.858)	(15.281)	(7.952)
.0400	.0600	.0200	16.596	30.070	17.828	37.380	9.395	16.724
			(2.096)	(-11.378)	(0.865)	(-18.688)	(9.298)	(1.968)
.0400	.0600	.0300	16.596	30.070	17.828	37.380	9.494	16.824
			(4.915)	(-8.555)	(3.687)	(-15.865)	(12.021)	(4.691)
.0400	.0600	.0400	16.596	30.070	17.828	37.380	9.623	16.952
			(8.308)	(-5.166)	(7.076)	(-12.476)	(15.281)	(7.952)
.0725	.0300	.0200	10.870	19.674	11.165	21.427	9.208	16.538
			(1.680)	(-7.124)	(1.385)	(-8.877)	(3.342)	(-3.988)
.0725	.0300	.0300	10.870	19.674	11.165	21.427	9.251	16.581
			(3.267)	(-5.236)	(2.972)	(-7.290)	(4.886)	(-2.444)
.0725	.0300	.0400	10.870	19.674	11.165	21.427	9.307	16.637
			(5.141)	(-3.662)	(4.846)	(-5.416)	(6.704)	(-0.626)
.0725	.0434	.0200	11.527	20.867	11.930	23.259	9.208	16.538
			(1.023)	(-8.317)	(0.620)	(-10.709)	(3.342)	(-3.988)
.0725	.0434	.0300	11.527	20.867	11.930	23.259	9.251	16.581
			(2.610)	(-6.730)	(2.207)	(-9.121)	(4.886)	(-2.444)
.0725	.0434	.0400	11.527	20.867	11.930	23.259	9.307	16.637
			(4.484)	(-4.856)	(4.081)	(-7.247)	(6.704)	(-0.626)
.0725	.0600	.0200	12.662	22.928	13.251	26.421	9.208	16.538
			(-0.112)	(-10.378)	(-0.701)	(-13.871)	(3.342)	(-3.988)
.0725	.0600	.0300	12.662	22.928	13.251	26.421	9.251	16.581
			(1.475)	(-8.791)	(0.886)	(-12.284)	(4.886)	(-2.444)
.0725	.0600	.0400	12.662	22.928	13.251	26.421	9.307	16.637
			(3.349)	(-6.917)	(2.760)	(-10.410)	(6.704)	(-0.626)
.1000	.0300	.0200	10.047	18.180	10.208	19.135	9.136	16.466
			(-0.562)	(-8.694)	(-0.722)	(-5.649)	(0.349)	(-6.981)
.1000	.0300	.0300	10.047	18.180	10.208	19.135	9.158	16.488
			(0.465)	(-7.664)	(0.308)	(-8.619)	(1.357)	(-5.972)
.1000	.0300	.0400	10.047	18.180	10.208	19.135	9.187	16.516
			(1.667)	(-6.465)	(1.507)	(-7.420)	(2.528)	(-4.802)
.1000	.0434	.0200	10.405	18.830	10.625	20.132	9.136	16.466
			(-0.920)	(-9.344)	(-1.139)	(-10.647)	(0.349)	(-6.981)
.1000	.0434	.0300	10.405	18.830	10.625	20.132	9.158	16.488
			(0.111)	(-8.314)	(-0.109)	(-9.616)	(1.357)	(-5.972)
.1000	.0434	.0400	10.405	18.830	10.625	20.132	9.187	16.516
			(1.309)	(-7.115)	(1.090)	(-8.418)	(2.528)	(-4.802)
.1000	.0600	.0200	11.023	19.952	11.344	21.854	9.136	16.466
			(-1.538)	(-10.467)	(-1.858)	(-12.369)	(0.349)	(-6.981)
.1000	.0600	.0300	11.023	19.952	11.344	21.854	9.158	16.488
			(-0.508)	(-9.436)	(-0.828)	(-11.339)	(1.357)	(-5.972)
.1000	.0600	.0400	11.023	19.952	11.344	21.854	9.187	16.516

RESULT (cont)

SURFACE SYSTEM TEMPERATURE DROP = 11.1111
 ANNUAL BTU REQUIREMENTS = 72817934438.8
 DESIGN TEMPERATURE = 74.00
 SURFACE FLOW RATE = 52.36
 GRADIENT = 30.0
 DEPTH OF BASEMENT ROCK = 9000.0
 TIME HORIZON = 30

FOR SAME DEPTH DRILLING, REDRILLING OCCURRED IN YEARS 25,
 FOR DEEPER DEPTHS DRILLING, REDRILLING OCCURRED IN YEARS 25,

YEAR	T-SD	T-DD	MOOT	T-Pt
1	122.53	122.53	9.75	122.53
2	122.53	122.53	9.75	122.53
3	122.51	122.51	9.76	122.51
4	122.35	122.35	9.78	122.35
5	121.89	121.89	9.86	121.89
6	121.16	121.16	9.98	121.16
7	120.13	120.13	10.16	120.13
8	118.80	118.80	10.40	118.80
9	117.25	117.25	10.70	117.25
10	115.47	115.47	11.06	115.47
11	113.46	113.46	11.50	113.46
12	111.26	111.26	12.02	111.26
13	108.88	108.88	12.65	108.88
14	106.33	106.33	13.39	106.33
15	103.62	103.62	14.28	103.62
16	100.77	100.77	15.36	100.77
17	97.81	97.81	16.66	97.81
18	94.77	94.77	18.25	94.77
19	91.68	91.68	20.21	91.68
20	88.58	88.58	22.64	88.58
21	85.52	85.52	25.71	85.52
22	82.54	82.54	29.60	82.54
23	79.71	79.71	34.59	79.71
24	77.05	77.05	41.07	77.05
25	122.53 (74.62)	133.32 (74.62)	8.26	74.62
26	122.53 (72.45)	133.32 (72.45)	8.26	71.55
27	122.51	133.32	8.26	71.77
28	122.35	133.29	8.26	71.61
29	121.89	133.16	8.28	71.45
30	121.16	132.86	8.31	71.31
31	120.13	132.35	0.	71.17

*** 3 FRACTURES ***

*** INITIAL DEPTH = 13557.00 FEET ***

INITIAL DRILLING COSTS
 (1980 \$ MILLIONS)

RGI = 9.768

GEO = 23.974

*** NEVER REDRILL, TOTAL COST = INITIAL CCST ***

SURFACE SYSTEM TEMPERATURE DROP = 11.1111
 ANNUAL BTU REQUIREMENTS = 72817934438.8
 DESIGN TEMPERATURE = 74.00
 SURFACE FLOW RATE = 52.36
 GRADIENT = 30.0
 DEPTH OF BASEMENT ROCK = 9000.0
 TIME HORIZON = 30

Step

- 3 Program loops on various interest rates and initial drilling depths for all calculations, but we will use only the following (for this reason, subscripts on variables are not used here).

$$R = 0.0725. \quad (45,48-50)$$

$$DCIF = 0.0434.$$

$$FCIF = 0.03.$$

$$DO = 11\ 557.$$

- 4 Calculates average temperature gained by drilling to initial depth.

$$TROCK = TDB + (DO - DB) \times GR \quad (47)$$

$$= 90 + (11\ 557 - 9000) \times 0.009144$$

$$= 113.38.$$

- 5 Calculates the present value of total benefits (avoided costs) for HDR where annual benefits are given as

$$BENFIT = (BARREL \times RP) \times (1 + FCIF)^t / (1 + R)^t \quad (53)$$

$$= (26\ 666.67 \times 31.13)(1.03)^t / (1.0715)^t.$$

Annual benefits summed over 30 yr = \$14.14 million.

- 6 Determines RGI initial drilling costs (millions)

$$a. \quad RGICD = RGICST(2) / 1\ 000\ 000 \quad (56)$$

$$= 8.457$$

(uses values read from WICST3).

- b. Calls subroutine GEOCST to calculate GEO initial drilling costs (millions) using the exponential function

$$GEOCT = 2[121.9627943[e^{1.130093434(DO \times 0.3048/1000)} \quad (57)$$

$$- e^{1.130093484(DB \times 0.3048/1000)}]$$

$$+ 116.0894471 e^{0.951723819(DB \times 0.3048/1000)}] / 1000 \quad (382-384)$$

$$= 2[121.9627943(e^{3.9808} - e^{3.1001}) + 116.0894471$$

$$e^{2.6108}] / 1000$$

$$= 10.810.$$

Step

- 6 b. Figures cost of fracturing using

$$\begin{aligned} \text{GFRAC} &= 0.07 \times \text{NFRAC} & (385) \\ &= 0.07 \times 3 \\ &= 0.21 \end{aligned}$$

and adds the two together for total cost:

$$\begin{aligned} \text{GEOCD} &= \text{GEOCT} + \text{GFRAC} & (58) \\ &= 10.81 + 0.21 \\ &= 11.02. \end{aligned}$$

- 7 Temperature drawdown is calculated for each year and resulting temperature is checked to see if it has fallen below design temperature. For the purpose of illustration, the required calculations will be made to determine drawdown in year 1 and the temperature at the beginning of year 2 [T(1) = TROCK, calculated above.]

$$\begin{aligned} \text{a. } \text{MDOT}(1) &= \text{SMDOT} \times (\text{TD} - \text{TINJ}) / [\text{T}(1) - \text{TINJ}] & (63) \\ &= 52.36(74 - 62.8889) / (113.38 - 62.8889) \\ &= 11.5224 \end{aligned}$$

Calculates flow rate through reservoir.

- b. Calls subroutine FLOW, which calculates value for Z and then for erf(Z) where

$$\begin{aligned} Z &= \sqrt{\frac{\text{LAMDA} \times \text{RO} \times \text{CR}}{\text{TIME}}} \cdot \frac{\text{PI} \times \text{R}^2 \times \text{NFRAC}}{\text{MDOT} \times \text{CW}} & (341-351) \\ &= \sqrt{\frac{3 \times 2500 \times 1000}{3.1536 \times 10^7 \times t}} \cdot \frac{3.1416 \times (180)^2 \times 3}{11.5224 \times 4200} \\ &= 3.077. \end{aligned}$$

Since $Z \geq 2$,

Step

7

b.

$$\text{erf} = 1 - \frac{e^{-Z^2}}{Z\sqrt{\pi}} \left[1 - \frac{1}{2Z^2} + \frac{1 \times 3}{(2Z^2)^2} - \frac{1 \times 3 \times 5}{(2Z^2)^3} + \frac{1 \times 3 \times 5 \times 7}{(2Z^2)^4} - \frac{1 \times 3 \times 5 \times 7 \times 9}{(2Z^2)^5} \right] \quad (354)$$

$$= 1 - \left\{ \frac{e^{-3.077^2}}{3.077\sqrt{3.1416}} \left[1 - \frac{1}{2(3.077)^2} + \frac{3}{(2 \times 3.077^2)^2} - \frac{15}{(2 \cdot 3.077^2)^3} + \frac{105}{(2 \cdot 3.077^2)^4} - \frac{945}{(2 \cdot 3.077^2)^5} \right] \right\}$$

$$= 1 - (0.0000142)(0.9538)$$

$$= 1.000.$$

Temperature in year 2 is thus

$$T(2) = T_{INJ} + (T_{ROCK} - T_{INJ}) \times \text{ERF} \quad (65)$$

$$= 62.8889 + (113.38 - 62.8889) \times 1.0$$

$$= 113.38.$$

In this example the rate of temperature drawdown was zero, so the same temperature was obtained in year 2 as in year 1. In later years, temperature drawdown increases substantially, resulting in temperatures below design temperature after year 17. To illustrate this, the above calculations will be performed for year 17. Temperature at the beginning of the year was 79.48°C, so

$$\text{MDOT}(17) = 52.36(74 - 62.8889)/(79.48 - 62.8889)$$

$$= 35.07.$$

$$Z(17) = \sqrt{\frac{3 \times 2500 \times 1000}{17 \times 3.1536 \times 10^7} \cdot \frac{3.1416 \times (180)^2 \times 3}{35.07 \times 4200}}$$

$$= 0.2452.$$

Step

7

b. Here, because $Z < 2$,

$$\begin{aligned} \text{erf} &= \frac{2}{\sqrt{\pi}} \left(Z - \frac{Z^3}{1 \times 3} + \frac{Z^5}{1 \times 2 \times 5} - \frac{Z^7}{1 \times 2 \times 3 \times 7} \right. \\ &\quad \left. + \frac{Z^9}{1 \times 2 \times 3 \times 4 \times 9} \right) \quad (356-373) \\ &= \frac{2}{\sqrt{3.1416}} \left(0.2452 - \frac{0.2452^3}{3} + \frac{0.2452^5}{10} - \frac{0.2452^7}{42} + \frac{0.2452^9}{216} \right) \\ &= 0.2712, \end{aligned}$$

and temperature at the beginning of year 18 is

$$\begin{aligned} T(18) &= \text{TINJ} + (\text{TROCK} - \text{TINJ}) \times \text{ERF} \\ &= 62.8889 + (113.38 - 62.8889)(0.2712) \\ &= 76.58. \end{aligned}$$

The temperature at the beginning of year 18 is still above design temperature (74°), but falls below design by the end of the year (73.96).

8 Because temperature at the end of year 18 (beginning of year 19) was below design temperature, the program exits from the drawdown loop (line 63) and goes on to compute redrilling and preheat costs. A check is also made to ensure that the end of the time horizon has not been reached (line 72).

9 Program initializes values to be used in calculating redrilling to same depth using RGI cost data and for the preheat option (lines 78-94). Redrilling takes place in year 18 and preheat also begins in year 18. Number of redrillings equals 1.

10 Calculates present values of redrilling in year 18 to same depth. Since this is the first redrilling, the value for "odd" redrillings is used.

$$\begin{aligned} \text{RGIODD}(18) &= [(\text{RGICST}(3) + 358.160)] \\ &\quad \times [(1 + \text{DCIF})^t - 1 / (1 + R)^{t-1}] / 1\,000\,000 \\ &= (4\,156\,900 + 358\,160) \end{aligned}$$

Step

10
$$\times [(1.0434)^{17}/(1.0725)^{17}]/1\ 000\ 000$$
$$= 2.829 \quad (95)$$

where \$358 160 is a plugging cost to shut down the old injection well when the new one is opened.

11 Determines length of time preheat will be used (lines 97-101). Normally it would be 18 years, the amount of time before redrilling would again occur, but because that extends past the time horizon, the preheat option will be used only through the end of year 30.

12 Calls subroutine HEAT, which calculates preheat option costs as follows.

a. Calls subroutine FLOW, which determines temperature drawdown during the year (uses surface flow rate as reservoir flow rate as it is assumed that one flow rate is used for an entire year, and temperature is below design temperature at some point in the year, therefore negating the possibility of mixing at the surface). (398)

b. Calculates temperature at end of year. (399)

c. Determines average yearly temperature

$$\begin{aligned} TAVG &= [TT(18) + TT(19)]/2 & (400) \\ &= (76.58 + 71.91)/2 \\ &= 74.25. \end{aligned}$$

d. Checks to see if average temperature is above design temperature (line 402). If so, computes average temperature for second half of year.

$$\begin{aligned} TTAVG &= [TAVG + TT(19)]/2 & (407) \\ &= (74.25 + 71.91)/2 \\ &= 73.08. \end{aligned}$$

e. Computes Btus required to heat HDR water to design temperature using conventional system. If $TAVG < TD$

$$HBTU = [MDOT \times 4200 \times (TD - TAVG) \times 31\ 536\ 000 \times 1.27]/1054. \quad (403)$$

If $TAVG \geq TD$

$$HBTU = [MDOT \times 4200 \times (TD - TTAVG) \times 31\ 536\ 000$$

Step

12 e. $\times 1.27]/(1054 \times 2)$ (408)

because preheating is only required for half the year. In our case,

$$\begin{aligned} \text{HBTU} &= [52.36 \times 4200 \times (74 - 73.08) \times 31\,536\,000 \\ &\quad \times 1.27]/(1054 \times 2) \\ &= 3\,843\,938\,910. \end{aligned}$$

f. Computes barrels of oil needed to supply the Btu requirement.

$$\begin{aligned} \text{BAR} &= \text{HBTU}/(144\,000 \times 42) && (404,409) \\ &= 3\,843\,938\,910/(144\,000 \times 42) \\ &= 635.57. \end{aligned}$$

g. Computes cost of oil used for preheating

If $\text{TAVG} < \text{TD}$

$$\text{CBTUR} = \text{BAR} \times \text{RP} \times [(1 + \text{FCIF})^{t-1}/(1 + R)^{t-1}]/1\,000\,000 \quad (405)$$

If $\text{TAVG} \geq \text{TD}$

$$\text{CBTUR} = \text{BAR} \times \text{RP} \times [(1 + \text{FCIF})^{t-1+1/2}/(1 + R)^{t-1+1/2}]/1\,000\,000 \quad (410)$$

(discounts to middle of year).

If $\text{TTAVG} \geq \text{TD}$

$$\text{CBTUR} = 0 \quad (411)$$

assumes that if preheating takes place for less than 1/4 of a year that the cost is zero.

In our case

$$\begin{aligned} \text{CBTUR} &= 635.57 \times 31.13 \times (1.03^{17.5}/1.0725^{17.5})/1\,000\,000 \\ &= 0.0098. \end{aligned}$$

h. Process repeats for every year that preheating is used in the period and then yearly figures are summed. Using the steps outlined above gives us

Step

<u>Year</u>	<u>T(beginning)</u>	<u>T(end)</u>	<u>TAVG</u>	<u>TTAVG</u>	<u>CBTUR</u>
18	76.58	71.91	74.25	73.08	0.0098
19	71.91	71.67	71.79	--	0.0459
20	71.67	71.45	71.56	--	0.0487
21	71.45	71.25	71.35	--	0.0508
22	71.25	71.06	71.16	--	0.0523
23	71.06	70.88	70.97	--	0.0535
24	70.88	70.71	70.80	--	0.0543
25	70.71	70.56	70.64	--	0.0548
26	70.56	70.41	70.49	--	0.0549
27	70.41	70.27	70.34	--	0.0550
28	70.27	70.14	70.21	--	0.0547
29	70.14	70.02	70.08	--	0.0543
30	70.02	69.90	69.96	--	0.0538

Total cost for preheating is \$0.6428 million for the period year 18 through year 30.

- 13 Compares total cost for preheat option to cost for redrilling (line 103). If preheating is more expensive than redrilling the program opts to redrill under the preheat option (lines 106-108).
- 14 If redrilling occurs more than once during the time horizon, steps 9-13 are repeated (using RGIODD for odd numbered redrillings and RGIEVN for even numbered redrillings).
- 15 Total cost for redrilling to same depth using RGI cost figures is added to cost for initial drilling to give total reservoir costs under that option (line 139). Total preheat costs are added to initial drilling costs to give total reservoir costs for that option (line 140).
- 16 Program initializes values to be used in calculating redrilling to same depth using GEO cost data (lines 148-151).
- 17 Calculates present value of redrilling in year 18 to same depth using GEO cost.

$$\begin{aligned}
 GEORD(18) &= (0.5 \text{ GEOCT} + GFRAC + 0.35816) \\
 &\quad \times [(1 + DCIF)^{t-1} / (1 + R)^{t-1}] \quad (154) \\
 &= [0.5(10.81) + 0.21 + 0.35816] \times (1.0434^{17} / 1.0725^{17}) \\
 &= 3.7421.
 \end{aligned}$$

Redrilling costs include plugging cost (0.35816), fracturing cost (0.21) and half the cost of initial drilling, as only one well must be drilled in order to create a new reservoir system.

Step

- 18 Preheat costs for the period (calculated in step 12 above) are compared to redrilling costs using GEO cost calculations (line 156). If preheat costs exceed redrilling costs, redrilling is undertaken using this option (line 159).
- 19 If redrilling occurs more than once, steps 16-18 are repeated.
- 20 Total cost for redrilling to same depth using GEO cost figures is added to cost for initial drilling to give total reservoir costs (Line 164). Total preheat costs are added to initial costs to give total reservoir costs for that option (line 165).
- 21 Program initializes values to be used in calculating redrilling to deeper depths using both RGI and GEO cost data (lines 170-180).
- 22 Redrilling depth is calculated
- $$D(K) = D0 + HF \times K \quad (181)$$
- $$D(1) = 11\,557 + (1181 \times 1)$$
- $$= 12\,738.$$
- 23 The temperature obtained by creating the new reservoir via the deeper-drilling redrilling option is calculated:
- $$TTROCK = TDB + [D(1) - DB] \times GR \quad (182)$$
- $$= 90 + (12\,738 - 9000) \times 0.009144$$
- $$= 124.18.$$
- 24 Calculates cost associated with drilling one well to a deeper depth and fracturing to create a new reservoir.
- a. $RGID(1) = [RGICST(5) + 358.160]$
- $$\times [(1 + DCIF)^{t-1} / (1 + R)^{t-1}] / 1\,000\,000 \quad (185)$$
- $$= (4\,839\,200 + 358.160)$$
- $$\times (1.0434^{17} / 1.0725^{17}) / 1\,000\,000$$
- $$= 3.256.$$
- b. Calls subroutine GEOCOST to compute redrilling cost as
- $$GEORRD = 2\{121.9627943[e^{1.130093484[D(1) \times 0.3048/1000]} - e^{1.130093484(DB \times 0.3048/1000)}] + 116.0894471$$
- $$\times e^{0.951723819(DB \times 0.3048/1000)}\} / 1000 \quad (384)$$

Step

24 b. = 17.369.

Present value of redrilling is then given as

$$\begin{aligned} \text{GEOD}(1) &= (0.5 \text{ GEORRD} + \text{GFRAC} + 0.35816) \\ &\quad \times [(1 + \text{DCIF})^{t-1} / (1 + R)^{t-1}] \\ &= [0.5(17.369) + 0.21 + 0.35816] \\ &\quad \times (1.0434^{17} / 1.0725^{17}) \\ &= 5.797. \end{aligned} \tag{188}$$

25 Program calculates reservoir system flow rate and calls subroutine FLOW to calculate temperature drawdown. It then computes the temperature at the beginning of the next year. The process repeats until such time as reservoir temperature falls below design temperature or the end of the time horizon is reached (lines 191-200). In our sample case, the temperature at the end of year 30 is 109.240, which is above design temperature, so redrilling does not occur again, and we go to step 26. If temperature in any year (before the end of the time horizon) had fallen below design temperature, redrilling would have occurred again, and steps 21-25 would have been repeated.

26 Total cost for redrilling to deeper depths using RGI cost data is added to initial RGI drilling cost to give total reservoir costs.

$$\begin{aligned} \text{RGITDD} &= \text{RGIDD} + \text{RGICD} \\ &= 3.198 + 8.268 \\ &= 11.466 \end{aligned} \tag{202}$$

27 Total cost for redrilling to deeper depths using GEO cost data is added to initial GEO drilling cost to give total reservoir costs.

$$\begin{aligned} \text{GEOTDD} &= \text{GEODD} + \text{GEOCD} \\ &= 5.797 + 11.02 \\ &= 16.817 \end{aligned} \tag{203}$$

28 All the steps given above are repeated for each combination of interest rates and for each initial drilling depth tested until (1) all depths are tested or (2) the initial drilling at a given depth results in a high enough temperature that the reservoir remains above design temperature throughout the time horizon. Should (2) occur, no further depths are tested.

Step

29

The program then prints all total cost figures, net benefits, and the time path of reservoir temperature under each option at the terminal.

HDR3 VARIABLE LIST

BARREL	the number of barrels of #6 oil used to produce a given amount of Btus.
BENFIT	the present value of annual benefits attributable to HDR, defined as the avoided costs of using the conventional heat source (millions 1980\$).
BTUS	the annual Btu requirement for space heating using the conventional system (steam heat generated by #6 oil).
D(L,NNN(L,K(L)))	the temperature depth to which a new well is drilled when redrilling to deeper depths (feet).
DB	depth to basement rock (feet).
DCIF(II)	the IIth real rate of annual increase in drilling costs.
DELT	difference between entrance and exit temperatures in the surface system heat exchanger ($^{\circ}\text{C}$).
DO(L)	depth to temperature center reached as a result of initial drilling (feet).
ERF(L,J)	the calculated error function used to compute temperature drawdown for initial drilling depth index L in year J.
FCIF(III)	the IIIrd real rate of annual increase in fuel costs.
G	geothermal gradient ($^{\circ}\text{C}/\text{km}$).
GEOCD(L)	the cost of creating the initial reservoir using GEOCOST for the initial depth index L (millions 1980\$).
GEOCT	the undiscounted cost of drilling a well pair to a given depth (millions of dollars).
GEOD(L,I,II,K(L))	the present value cost of redrilling to deeper depths for the kth redrilling using GEOCOST and initial drilling depth index L and interest rate indexes I and II (millions 1980\$).
GEODD(L,I,II)	the sum of the present value costs for all redrillings to deeper depths using GEOCOST, initial drilling depth index L, and interest rate indexes I and II (millions 1980\$).
GEOPH(L,I,II,III)	the present value of total reservoir costs using the preheat option and GEOCOST for initial drilling depth L and interest rate indexes I, II, and III (millions 1980\$).

GEORD(L,I,II,NN(L,NRD(L))) the present value cost of redrilling to same depth in year NN with initial depth index L and interest rate indexes I and II using GEOCOST (millions 1980\$).

GEORRD same as GEOCT, used for deeper drilling option (millions of dollars).

GEOSD(L,I,II) the sum of the present value costs of all redrillings to same depth using GEOCOST (millions 1980\$).

GEOTDD(L,I,II) the present value of total reservoir costs under the deeper depth redrilling option using GEOCOST, initial depth index L and interest rate indexes I and II (millions 1980\$).

GEOTSD(L,I,II) the present value of total reservoir drilling costs under the same depth redrilling option using GEOCOST with initial depth index L and interest rate indexes I and II (millions 1980\$).

GFRAC the undiscounted cost of fracturing (millions of dollars).

GR geothermal gradient ($^{\circ}\text{C}/\text{ft}$).

HDRBTU the annual Btu requirement for space heating using the HDR, hot water system.

HF the height of fractures (feet).

HTCST(NRD(L)) the present value cost of using the preheat option for the period associated with the NRDth redrilling (millions 1980\$).

I,II,III indexes for the discount rate, rate of drilling cost increase factor, and rate of fuel cost increase factor, respectively.

ITH the time horizon over which the system will operate (years).

K(L) the number of redrillings that have occurred under the deeper depth redrilling option for an initial depth index L.

L initial drilling depth index.

MDOT(L,J) the reservoir system flow rate in year J for the initial depth index L (kg/s).

MM a counter for years since any drilling occurred, used to compute temperature drawdown.

NDCIF the number of drilling cost increase factors to be tested.

NFCIF the number of fuel cost increase factors to be tested.

NFRAC the number of fractures in the reservoir system.

NN(L,NRD(L)) the year in which the NRDth redrilling occurs under the same depth redrilling option, for initial depth index L.

NNN(L,K(L)) the year in which the Kth redrilling occurs under the deeper depths redrilling option, for initial depth index L.

NR the number of real discount rates to be tested.

NRD(L) the number of redrillings that have occurred under the same depth redrilling option for an initial depth index L.

R(I) the Ith real rate of social discount.

RGICD(L) the cost of creating the initial reservoir using RGICOST, for the initial depth index L (millions 1980\$)

RGICST(L,N) matrix of cost data contained in the file WICST__, where L is the row and N is the column.

RGID(L,I,II,K(L)) the present value cost of redrilling to deeper depths for the Kth redrilling using RGICOST, for initial depth index L and interest rate indexes I and II (millions 1980\$).

RGIDD(L,I,II) the sum of the present value costs for all redrillings to deeper depths using RGICOST, initial depth index L, and interest rate indexes I and II (millions 1980\$).

RGIEVN(L,I,II,NN(L,NRD(L))) the present value of redrilling to same depth in year NN when a new production well is created using RGICOST, initial depth index L, and interest rate indexes I and II (millions 1980\$).

RGIODD(L,I,II,NN(L,NRD(L))) the present value of redrilling to same depth in year NN when a new injection well is created using RGICOST, initial depth index L, and interest rate indexes I and II (millions 1980\$).

RGIPH(L,I,II,III) the present value of total reservoir costs using the preheat option and RGICOST for initial depth index L and interest rate indexes I, II, and III (millions 1980\$).

RGISD(L,I,II) the sum of the present value costs of all redrillings to same depth using RGICOST for initial depth index L and interest rate indexes I and II (millions 1980\$).

RGITDD(L,I,II) the present value of total reservoir costs under the deeper depths redrilling option using RGICOST, initial depth index L and interest rate indexes I and II (millions 1980\$).

RGITSD(L,I,II)	the present value of total reservoir costs under the same depth redrilling option using RGICOST, initial depth index L, and interest rate indexes I and II (millions 1980\$).
RP	the retail price of alternative fuel source (#6 oil) (1980\$/barrel).
SMDOT	the surface system flow rate (kg/s).
T(L,J)	temperature at the beginning of year J resulting from initial drilling and redrilling to same depth for initial depth index L (°C).
TD	design temperature or minimum temperature requirement for the surface system (°C).
TDB	the temperature of the rock at a depth equal to the depth of basement (°C).
THTCST	the present value of total reservoir costs using the preheat option (millions 1980\$).
TINJ	the temperature of water that is reinjected into the HDR reservoir from the surface (°C).
TONE	the first year of the period for which preheat option costs are calculated.
TOTBEN(I,III)	the present value of total benefits (avoided costs) attributable to the use of HDR for interest rate indexes I and III (millions 1980\$).
TROCK(L)	the temperature resulting from initial drilling to the depth D0 for the initial depth index L (°C).
TT(L,J)	temperature at the beginning of year J resulting from redrilling to deeper depths for initial depth index L (°C).
TTHREE	the last year of the period for which preheat option costs are calculated when the first year of the period is TTWO.
TTROCK	the temperature resulting from redrilling to deeper depths (°C).
TTT(L,J)	temperature at the beginning of year J resulting from the use of the preheat option for initial depth index L (°C).
TTWO	the last year of the period for which preheat option costs are calculated, also the first year of the next period.
TTX(L)	the temperature that would have resulted at the beginning of the year had redrilling to the same depth not occurred in that year (°C).

TTXX(L,K(L)) the temperature that would have resulted at the beginning of the year had redrilling to deeper depths not occurred in that year ($^{\circ}\text{C}$).

TX(L) the temperature that would have resulted at the end of the year had redrilling to the same depth not occurred in that year ($^{\circ}\text{C}$).

TXX(L,K(L)) the temperature that would have resulted at the end of the year had redrilling to deeper depths not occurred in that year ($^{\circ}\text{C}$).

Z(L,J) the calculated value used to compute the error function in year J for initial drilling depth index L.

REFERENCES

1. "Industrial Assessment of Drilling Completion and Workover Costs of the Well and Fracture Subsystems of Hot Dry Rock Geothermal Systems," prepared for Los Alamos National Laboratory by Republic Geothermal, Inc., Santa Fe Springs, California (March 17, 1979).
2. R. G. Cummings, C. J. Arundale, R. L. Bivins, H. S. Burness, R. H. Drake, and R. D. Norton, "The Use of Hot, Dry Rock Geothermal Resources for Space Heating: A Case Study," Los Alamos National Laboratory report (in preparation).

APPENDIX A FILE WRITEPP

```

00001 DIMENSION P(4,7),IP(4,7)
00002 REAL HF
00003 CALL CPSYS('ALLCC','PARAMS',1)
00004 CALL CPSYS('ALLUC','PP',2)
00005 NF=3
00006 IDO=0
00007 ICB=9000
00008 NDEPTH=10
00009 INTVAL=1000
00010 NDRIL=10
00011 HF=1181
00012 CF1=0.0
00013 CF2=0.0
00014 READ(1,*)IP(1,1)
00015 WRITE(2,*)IP(1,1)
00016 READ(1,*)(P(2,K),K=1,7)
00017 WRITE(2,*)(P(2,K),K=1,7)
00018 READ(1,999)P(3,1),IP(3,2),(P(3,K),K=3,7)
00019 ALPHA=P(3,3)*3.1416/180.
00020 IF(IDO.EQ.0) IDO=(ICB+250+180*SIN(ALPHA)/(P(3,4)*3.1416)+0.5*HF+(NF-1)*164./(2*TAN(ALPHA)))+0.5
00021 P(3,1)=NF
00022 IP(3,2)=HF
00023 WRITE(2,888)P(3,1),IP(3,2),(P(3,K),K=3,7)
00024 READ(1,*)(IP(4,K),K=1,4)
00025 WRITE(2,*)(IP(4,K),K=1,4)
00026 WRITE(2,*)CF1,CF2
00027 NN=NDEPTH*NDRIL
00028 WRITE(2,*)NN
00029 IF(NF.LE.4) NTEST=23000
00030 IF(NF.GT.4) NTEST=22000
00031 CO 100 J=1,NDEPTH
00032 NN=IDO+(J-1)*INTVAL
00033 IF(NN.GT.NTEST)GO TO 100
00034 WRITE(2,*)NN,ICB
00035 CO 200 I=2,NDRIL
00036 NNN=NN+(I-1)*HF
00037 IF(NNN.GT.NTEST)GO TO 200
00038 WRITE(2,*)NNN,ICB
00039 200 CCNTINUE
00040 100 CCNTINUE
00041 888 FORMAT(1X,F4.1,2X,14,2X,F4.1,2X,F4.2,2X,F5.1,2X,F5.1,2X,F4.2)
00042 999 FORMAT(1X,F4.1,2X,14,2X,F4.1,2X,F4.2,2X,F5.1,2X,F5.1,2X,F4.2)
00043 END

```

APPENDIX B

FILEIT

```

00001 DIMENSION RGI(20,4),R(19,20)
00002 CALL OPSYS('ALLOC','WICST3',1)
00003 CALL CPSYS('ALLOC','TOTAL',2)
00004 NDEPTH=10
00005 NDRIL=10
00006 INTVAL=1000
00007 REAC(2,*)
00008 READ(2,*)(RGI(1,K),K=1,4)
00009 FIRST=RGI(1,1)
00010 LL=2
00011 DO 100 J=1,NDEPTH
00012 DO 200 I=LL,NDRIL
00013 READ(2,*)(RGI(I,K),K=1,4)
00014 IF(RGI(I,1).EQ.(FIRST+J*INTVAL))GO TO 400
00015 200 CONTINUE
00016 LL=1
00017 N=I
00018 GO TO 300
00019 400 LL=2
00020 N=I-1
00021 300 CONTINUE
00022 R(J,1)=RGI(1,1)
00023 R(J,2)=RGI(1,2)
00024 R(J,3)=RGI(1,3)
00025 R(J,4)=RGI(1,4)
00026 DO 500 I=2,N
00027 500 R(J,(I+3))=RGI(I,4)
00028 KK=N+3
00029 WRITE(1,*)KK,(R(J,K),K=1,KK)
00030 DO 600 I=1,4
00031 600 RGI(1,I)=RGI((N+1),I)
00032 100 CONTINUE
00033 END

```

APPENDIX C

RGICOST

```

00001 C *****
00002 C *****
00003 C * RGICOST -- HDK WELL COSTS *
00004 C * MULTIPLE RUN VERSION *
00005 C * VSPC VERSION *
00006 C *****
00007 C *****
00008 C *****
00009 C ***** THIS PROGRAM FOLLOWS THE COST
00010 C ***** ESTIMATION PROCEDURE DETAILED IN
00011 C ***** KUT'S "INDUSTRIAL ASSESSMENT OF
00012 C ***** DRILLING, COMPLETION AND WORKOVER
00013 C ***** COSTS." ALL VARIABLE NAMES
00014 C ***** ARE THE SAME AS USED IN THE MANUAL,
00015 C ***** UNLESS OTHERWISE SPECIFIED.
00016 C
00017 C
00018 C ***** PARAMETERS ARE TO BE STORED ON TAPE 19,
00019 C ***** FILE PP. DESIRED DEPTH AND PERMEABLE
00020 C ***** SECTION TESTS ARE TO BE STORED ON TAPE 18,
00021 C ***** FILE COMMAND.
00022 C
00023 C ***** THREE FORMS OF OUTPUT ARE PRINTED ON
00024 C ***** TAPE. TOTAL COSTS ARE PRINTED ON TAPE
00025 C ***** 17, FILE TOTAL. THE COMPLETE COST
00026 C ***** BREAKDOWNS ARE PRINTED ON TAPE 13, FILE
00027 C ***** COST. WELL DESCRIPTIONS ARE PRINTED
00028 C ***** ON TAPE 12, FILE WELL.
00029 C
00030 C INTEGER STATE,REMOTE,CLASS,TECH
00031 C REAL KCP1,NOP2,LOGG1,LOGG2,NDRT,MISC,INCDEN
00032 C REAL LLP,LFP,LPT,LRE,LWS,NF,MM,NF,MTC
00033 C DIMENSION TSP2(12,4),TSP3(23,5),TSP6(30,5),T1P2(50,2),
00034 C T4P3(9,4),TSP1(5,5),REDRI(12)
00035 C COMMON/TABLE/TSP3A(3,5,4),TSP3B(3,6),T7P1(5,6),TGP1(9,2),
00036 C TGP2(9,4),TGP3(15,3),TGP4(17,5),TSP6(10,2)
00037 C COMMON/SPEC/CASE(15,2),CASE2(5,2),LOGG1(3,4),LOGG2(3,4),
00038 C SNURT(2,5),WHLC(2),PISC(2),CT(2),B(5,2),NDRI,NDRT,
00039 C SVT,VVT,NC11,NC12,NLG1,NLG2,NP,NOP1,NOP2,NTND1,NTND2,
00040 C SNTNBL(5),SNTN32(5),NTRIP1(5),NTRIP2(5),DRT1(5),DRT2(5),NPB(2),
00041 C SNTAB1,NTAB2,DRTAB1,DRTAB2,NICAL,NTCA2,NTBCA1,NTBCA2,DRTCA1,DRTCA2
00042 C COMMON/PP/SD,SOM,LLP,LFP,LPT,LRE,LWS,NF,HF,
00043 C ALPHA,BETA,TD,CLASS,STATE,REMOTE,MMU,P,GRAC,TECH
00044 C COMMON/COSTS/CCOST(5,2),WEIGHT(5,2),CASING(2),TOTWT(2),
00045 C STANG(2),XTANG(2),RLOCAT,RIGMBL,RMVLST,RIG(2),TOTRIG,
00046 C FRMC(2),FUEL,MTRSUP,WELL,BISAB(2),BISCA(2),BTCST(5,2),SL(2),
00047 C SRCNMC(2),TOTBIT(2),FCAB(2),TOTLC(2),TLRIG(2),WIT(2),RLC(5,2),
00048 C SFTS(2),DERNIK,MTC,ATC,CTRAN,CKRPER,PBPS,RETRAN,CRCSI,TPJMP,
00049 C INCDEN,SUPCOL,SHAKE(2),WELTOT(2),GANDA,HDRCST
00050 C
00051 C ***** TABLES -- EACH OF THE FOLLOWING ARRAYS
00052 C ***** CONTAINS DATA PRESENTED IN TABULAR
00053 C ***** FORM IN THE MANUAL. ARRAY NAMES
00054 C ***** CORRESPOND TO TABLES. TSP2 = TABLE 3.2
00055 C
00056 C CALL OPSYS('ALLOC',TABLES3,1)
00057 C CALL OPSYS('ALLOC',TSP3,4)
00058 C CALL OPSYS('ALLOC',T7P1,5)
00059 C CALL OPSYS('ALLOC',T1P2,2)
00060 C CALL OPSYS('ALLOC',TGP1,7)
00061 C CALL OPSYS('ALLOC',TGP2,8)
00062 C CALL OPSYS('ALLOC',TGP3,9)
00063 C CALL OPSYS('ALLOC',TGP4,10)
00064 C CALL OPSYS('ALLOC',WELL,12)
00065 C CALL OPSYS('ALLOC',COST,13)
00066 C CALL OPSYS('ALLOC',T4P3,14)
00067 C CALL OPSYS('ALLOC',TSP1,15)
00068 C CALL OPSYS('ALLOC',TGP8,16)
00069 C CALL OPSYS('ALLOC',TOTAL,17)
00070 C CALL OPSYS('ALLOC',PP,18)
00071 C
00072 C DO 10 I=1,12
00073 C READ(1,*) (TSP2(I,J),J=1,4)
00074 C CONTINUE
00075 C DO 11 I=1,23
00076 C READ(1,*) (TSP3(I,J),J=1,5)
00077 C CONTINUE
00078 C DO 12 I=1,30
00079 C READ(1,*) (TSP6(I,J),J=1,5)
00080 C CONTINUE
00081 C DO 13 I=1,3
00082 C DO 13 J=1,5
00083 C READ(4,*) (TSP3A(I,J,K),K=1,4)
00084 C CONTINUE
00085 C DO 14 I=1,3
00086 C READ(4,*) (TSP3B(I,J),J=1,6)
00087 C CONTINUE
00088 C DO 15 I=1,5
00089 C READ(5,*) (T7P1(I,J),J=1,6)
00090 C CONTINUE
00091 C DO 16 I=1,50
00092 C READ(2,11) (T1P2(I,J),J=1,2)
00093 C CONTINUE
00094 C DO 17 I=1,9
00095 C READ(7,*) (TGP1(I,J),J=1,2)
00096 C CONTINUE
00097 C DO 18 I=1,9
00098 C READ(8,*) (TGP2(I,J),J=1,4)
00099 C CONTINUE
00100 C DO 19 I=1,15
00101 C READ(9,*) (TGP3(I,J),J=1,3)
00102 C CONTINUE
00103 C DO 20 I=1,17
00104 C READ(10,*) (TGP4(I,J),J=1,5)

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RGICOST, (cont)

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00105 20  CONTINUE
00106      DO 21 I=1,9
00107      READ(14,*) (TGP3(I,J),J=1,4)
00108 21  CONTINUE
00109      DO 22 I=1,5
00110      READ(15,*) (TSP1(I,J),J=1,5)
00111 22  CONTINUE
00112      DO 23 I=1,10
00113      READ(16,*) (TGP8(I,J),J=1,2)
00114 23  CONTINUE
00115 112  FORMAT(F3.0,1X,F7.0,1X,F7.0,1X,F7.0)
00116 111  FORMAT(F2.0,1X,F7.4)
00117 C
00118      WRITE(17,122)
00119 122  FORMAT(2X,'TEMPO',5X,'TOTAL COST',6X,'REDRILL CDU',4X,'REDRILL EVE')
00120 $N)
00121 C
00122      READ(18,*) LOOP1
00123      DO 920 NKUNS1=1,LCOP1
00124      READ(18,*) SD,SDM,LLP,LFP,LPT,LKE,LWS
00125      READ(18,*) NF,HF,ALPHA,BETA,TU,WWU,GRAC
00126      READ(18,*) CLASS,STATE,REMCTE,TECH
00127 333  FORMAT(1X,13,1X,12,1X,11,1X,11)
00128      READ(18,*) CFL,CF2
00129      READ(18,*) LOOP2
00130      DO 910 NKUNS2=1,LCOP2
00131      READ(18,*) TEMPD,P
00132 C      ***** WELL GEOMETRY
00133 C
00134      ALPHAR=(3.141592/180)*ALPHA
00135      MM=ALPHA/BETA
00136      BB=180/BETA*3.141592
00137      TUPI=TEMPD*(HF/2)-(((NF-1)*164)/(2*TAN(ALPHAR)))
00138      KOP1=FIX(TUPI-BB*SIN(ALPHAR)-164*CCS(ALPHAR))*1.0
00139      TVD1=FIX(TUPI+164*(NF-1)/TAN(ALPHAR)+82*CCS(ALPHAR))*1.0
00140      TMD1=FIX(KOP1+MM*164*(NF-1)/SIN(ALPHAR)+246)*1.0
00141      KOP2=FIX(KOP1+164*CCS(ALPHAR)-HF)*1.0
00142      TMD2=FIX(KOP2+MM*164*(NF-1)/SIN(ALPHAR)+E2)*1.0
00143      TVD2=FIX(KOP2+164*(NF-1)/TAN(ALPHAR)+82*CCS(ALPHAR)+
00144 $BB*SIN(ALPHAR))*1.0
00145      PMAX=KOP2-250
00146 330  FORMAT(1X,'TUPI =' ,F8.2,'      TVD =' ,F8.2,'      PMAX =' ,F8.2)
00147 C
00148 C      ***** DETERMINE WELL PROGRAM
00149 C
00150 400  CONTINUE
00151      CALL INITAL
00152      IF(TVD1.GE.17000)GO TO 450
00153      IF(TVD1.GE.15000)GO TO 440
00154      IF(TVD1.GE.12500)GO TO 430
00155      IF(TVD1.GE.10000)GO TO 420
00156      IF(TVD1.GE.7500)GO TO 410
00157 C      ***** DEPTH CLASS 1
00158      CALL WP1(P,TUPI,TMD1,TMD2,TVD1,TVD2,KOP1,KOP2,SD)
00159      GO TO 500
00160 410  CONTINUE
00161 C      ***** DEPTH CLASS 2
00162      CALL WP2(P,TUPI,TMD1,TMD2,TVD1,TVD2,KOP1,KOP2,SD)
00163      GO TO 500
00164 420  CONTINUE
00165 C      ***** DEPTH CLASS 3
00166      CALL WP3(P,TUPI,TMD1,TMD2,TVD1,TVD2,KOP1,KOP2,SD)
00167      GO TO 500
00168 430  CONTINUE
00169 C      ***** DEPTH CLASS 4
00170      CALL WP4(P,TUPI,TMD1,TMD2,TVD1,TVD2,KOP1,KOP2,SD)
00171      GO TO 500
00172 440  CONTINUE
00173 C      ***** DEPTH CLASS 5
00174      CALL WP5(P,TUPI,TMD1,TMD2,TVD1,TVD2,KOP1,KOP2,SD)
00175      GO TO 500
00176 450  CONTINUE
00177 C      ***** DEPTH CLASS 6
00178      CALL WP6(P,TUPI,TMD1,TMD2,TVD1,TVD2,KOP1,KOP2,SD)
00179 C
00180 C
00181 C
00182 C
00183 500  CONTINUE
00184 C      ***** CASING FOR THE INJECTION INTERVAL
00185 C
00186 C
00187      J=12
00188      IF(B(INC11,2).EQ.9.0)J=1
00189      IF(B(INC11,2).EQ.7.0)J=5
00190 510  CONTINUE
00191      IF(T3P2(J,2).GE.TVD1)GO TO 520
00192      J=J+1
00193      GO TO 510
00194 520  CONTINUE
00195      IF(CASE1(INC11,1).EQ.0.0)GO TO 522
00196      RLEN=(CASE1(INC11,2)-CASE1(INC11,1))
00197      CCOST(INC11,1)=T3P2(J,3)*RLEN/100
00198      WEIGHT(INC11,1)=T3P2(J,4)*RLEN
00199      GO TO 524
00200 522  CONTINUE
00201      RINT=T3P2(J,3)*(TMD1-KOP1)/100
00202      RINTW=T3P2(J,4)*(TMD1-KOP1)/100
00203      CALL LENGST(B(INC11,2),KOP1,KOP1,T3P3,23,WTINT,CSTINT)
00204      CCOST(INC11,1)=RINT+CSTINT
00205      WEIGHT(INC11,1)=RINTW*WTINT
00206 524  CONTINUE
00207 C
00208 C      ***** CASING ABOVE THE INJECTION INTERVAL
00209 C
00210 C
00211      NN=INC11-1
00212      DO 550 I=1,NN

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RGICOST (cont)

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00213 IF(CASE1(1,1).EQ.0.0)GO TO 530
00214 CALL LINER(B(1,2),1,CASE1(1,1),CASE1(1,2),WEIGHT(1,1),CCOST(1,1))
00215 GO TO 540
00216 530 CONTINUE
00217 CALL LINGST(B(1,2),CASE1(1,2),CASE1(1,2),T3P3,23,WEIGHT(1,1),
00218 CCCST(1,1))
00219 540 CONTINUE
00220 550 CONTINUE
00221 C
00222 C
00223 C ***** PRODUCTION WELL CASING
00224 C
00225 DO 590 I=1,NCI2
00226 IF(CASE2(1,1).EQ.0.0)GO TO 570
00227 CALL LINER(B(1,2),2,CASE2(1,1),CASE2(1,2),WEIGHT(1,2),CCOST(1,2))
00228 GO TO 580
00229 570 CONTINUE
00230 CALL LINGST(B(1,2),TVC2,CASE2(1,2),T3P6,30,WEIGHT(1,2),CCCST(1,2))
00231 580 CONTINUE
00232 590 CONTINUE
00233 C
00234 C ***** CASING CCOSTS
00235 C
00236 CASING(1)=0.
00237 TOTWT(1)=0.
00238 DO 592 I=1,NCI1
00239 CASING(1)=CASING(1)+CCCST(1,1)
00240 TOTWT(1)=TOTWT(1)+WEIGHT(1,1)
00241 592 CONTINUE
00242 CASING(2)=0.
00243 TOTWT(2)=0.
00244 DO 594 I=1,NCI2
00245 CASING(2)=CASING(2)+CCCST(1,2)
00246 TOTWT(2)=TOTWT(2)+WEIGHT(1,2)
00247 594 CONTINUE
00248 C
00249 C ***** TANGIBLES
00250 C
00251 C
00252 DO 596 I=1,50
00253 IF(TIIP2(1,1).EQ.STATE)TXRATE=TIIP2(1,2)
00254 596 CONTINUE
00255 DO 598 I=1,2
00256 TANG(I)=CASING(I)+WHLC(I)
00257 TANG(I)=TANG(I)*1.76
00258 TANG(I)=FIX(TANG(I)/100.0+0.5)*100.0
00259 TXTANG(I)=TANG(I)*TXRATE
00260 TXTANG(I)=FIX(TXTANG(I)/100.0+0.5)*100.0
00261 598 CONTINUE
00262 C
00263 C ***** LOCATION CCST
00264 C
00265 C
00266 I=1
00267 600 CONTINUE
00268 IF(CLASS.EQ.T4P3(1,1))GO TO 610
00269 I=I+1
00270 GO TO 600
00271 610 CONTINUE
00272 IF(TMD1.LT.T4P3(1,2))GO TO 620
00273 I=I+1
00274 GO TO 610
00275 620 CONTINUE
00276 NDIST=SD/100
00277 RLOCAT=T4P3(1,3)+T4P3(1,4)*NDIST
00278 C
00279 C ***** DRILLING TIME
00280 C
00281 DO 900 NCASE=1,1
00282 C
00283 C ***** INJECTOR
00284 C
00285 DTP1=0
00286 DO 830 I=1,NCI1
00287 BOTTOM=CASE1(1,2)
00288 IF(BOTTOM.GT.KOP1)BOTTOM=KOP1
00289 TOP=CASE1(1,1)
00290 II=I-1
00291 IF(II.GT.1)TOP=CASE1(II,2)
00292 CALL DRILL(B(1,1),TOP,BOTTOM,NCASE,NTNB1(1),NTRIP1(1),DRT1(1))
00293 DRT1(1)=DRT1(1)*(1.0+CF1)
00294 IF(BOTTOM.LE.(P+200))DTP1=DTP1+DRT1(1)/24
00295 830 CONTINUE
00296 NDPI=DTP1+.5
00297 CALL DRILL(B(NCI1,1),KOP1,MM,NCASE,NTAB1,FCAB(1),DRTAB1)
00298 TOP=KOP1+MM
00299 CALL DRILL(B(NCI1,1),TOP,TMD1,NCASE,NTBCA1,NTCA1,DRTCA1)
00300 DRTAB1=DRTAB1*(1.0+CF2)
00301 DRTCA1=DRTCA1*(1.0+CF2)
00302 DRC1=(DRTAB1/24+DRTCA1/24)
00303 DO 840 I=1,NCI1
00304 DRD1=DRD1+DRT1(1)/24
00305 840 CONTINUE
00306 C
00307 C ***** PRODUCOR
00308 C
00309 DTP2=0.
00310 NNCI2=NCI2+1
00311 DO 850 I=1,NNCI2
00312 BOTTOM=CASE2(1,2)
00313 IF(1.EC.NNCI2)BOTTOM=KCP2
00314 TOP=CASE2(1,1)
00315 II=I-1
00316 IF(II.GT.1)TOP=CASE2(II,2)
00317 CALL DRILL(B(1,1),TOP,BOTTOM,NCASE,NTNB2(1),NTRIP2(1),DRT2(1))
00318 DRT2(1)=DRT2(1)*(1.0+CF1)
00319 IF(BOTTOM.LE.(P+200))DTP2=DTP2+DRT2(1)/24
00320 850 CONTINUE

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RGICOST (cont)

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00321 NDP2=0.1P2+.5
00322 CALL DCRILL(B(NC11,1),KUP2,MM,NCASE,NTAB2,FCAB(2),DRTAB2)
00323 TGP=KCP2+MM
00324 CALL CRILL(B(NC11,1),TCP,TMD2,NCASE,NTBCA2,NTCA2,DRTCA2)
00325 DRTAB2=DRTAB2*(1.0+CF2)
00326 DRTCA2=DRTCA2*(1.0+CF2)
00327 DRC2=(DRTAB2/24+DRTCA2/24)
00328 DO 860 I=1,NNC12
00329 DRD2=DRD2+DRT2(I)/24
00330 E60 CONTINUE
00331 C
00332 C ***** DRILLING RIG COST
00333 C
00334 C ***** ADD NON-DRILLING RIG TIME TO DRD
00335 C
00336 DO 862 I=1,NDR1
00337 DRC1=(DRD1+NDRT(1,I)/24)
00338 E62 CONTINUE
00339 DO 864 I=1,NDR2
00340 DRC2=(DRD2+NDRT(2,I)/24)
00341 E64 CONTINUE
00342 C
00343 NTND1=DRD1+.5
00344 NDAY=NTND1/30
00345 NTND1=NTND1+NDAY
00346 NTND2=DRD2+.5
00347 NDAY=NTND2/30
00348 NTND2=NTND2+NDAY
00349 C
00350 I=1
00351 E70 CONTINUE
00352 IF(TSP1(I,1).GT.TMD1)GO TO 880
00353 I=I+1
00354 GO TO E70
00355 880 CONTINUE
00356 RMVCS=TSP1(I,3)
00357 DRATE=TSP1(I,2)
00358 NTRUCK=TSP1(I,4)
00359 FRATE=TSP1(I,5)
00360 RIGMBL=2*NTRUCK*(45.0*LRE/50.)
00361 RIG(1)=DRATE*NTND1
00362 RIG(1)=RIG(1)*1.76
00363 RIG(1)=FIX(RIG(1)/100.0+0.5)*100.0
00364 RIG(2)=DRATE*NTND2
00365 RIG(2)=RIG(2)*1.76
00366 RIG(2)=FIX(RIG(2)/100.0+0.5)*100.0
00367 TOTDAY=NTND1+NTND2
00368 TOTRIG=RIG(1)+RIG(2)
00369 C
00370 C ***** DRILLING FLUIDS, FUEL, & WATER SUPPLY COST
00371 C
00372 FUEL=FRATE*TOTDAY
00373 D=0.37*TVD1
00374 IF(D.GE.P)VVT=0.0
00375 RMC(1)=4.56*VT+3.0*VVT+1000*NDP1
00376 D=0.37*TVD2
00377 IF(D.GE.P)VVT=0.0
00378 RMC(2)=4.56*VT+3.0*VVT+1000*NDP2
00379 WTRSUP=2556.*TOTDAY/30.*815.
00380 WWELL=3824.*5.3*WHD
00381 C
00382 C ***** BIT & STABILIZER COST
00383 C
00384 C
00385 C
00386 CALL BITSTB(1,NDP1,NTAB1,NTAB1,NTBCA1,ERTCA1,KCP1,TMD1)
00387 CALL BITSTB(2,NDP2,NTAB2,NTAB2,NTBCA2,DRTCA2,KCP2,TMD2)
00388 C
00389 C ***** EVALUATION COSTS
00390 C
00391 CALL LCGING(TOP1,LCGG1,1,NG1,NC11)
00392 CALL LCGING(TOP1,LCGG2,2,NG2,NC12)
00393 DERRIK=250+150*(2*LLP-150)+450.
00394 C
00395 C ***** COMPLETION COSTS
00396 C
00397 CALL CCRPRF(LUGG1(NG1,3),LUGG1(NG1,4),NC11)
00398 C
00399 C ***** TRANSPORTATION & OTHER COSTS
00400 C
00401 NTF=(31*VT+27*VVT+620C*(NC11+NDP2))/40000+1
00402 NTA=(NTND1+NTND2)/7+1
00403 IF(STATE.EC.5)GO TO 890
00404 MTC=32C*NTF
00405 ATC=32C*NTA
00406 PPLB=5.04
00407 GU TO E92
00408 890 CONTINUE
00409 MTC=(127.5+0.7969*SDM)*NTF
00410 ATC=(127.5+0.7969*SDM)*NTA
00411 PPLB=4.89
00412 IF(LWS.GT.100)PPLB=5.25
00413 892 CONTINUE
00414 CTRAN=PPLB/100.*(TOTWT(1)+TOTWT(2))
00415 C
00416 C ***** OTHER COSTS
00417 C
00418 SUPCOL=750.*TOTDAY
00419 INCEN=100.*TOTDAY
00420 C
00421 C ***** ROUND TO HUNDREDS OF DOLLARS
00422 C
00423 RIGMBL=RIGMBL*1.76
00424 RIGMBL=FIX(RIGMBL/100.0+0.5)*100.0
00425 FUEL=FUEL*1.76
00426 FUEL=FIX(FUEL/100.0+0.5)*100.0
00427 WTRSUP=WTRSUP*1.76
00428 WTRSUP=FIX(WTRSUP/100.0+0.5)*100.0

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00429      WWELL=WWELL*1.76
00430      WWELL=IFIX(WWELL/100.0+0.5)*100.0
00431      CORPER=CORPER*1.76
00432      CORPER=IFIX(CORPER/100.0+0.5)*100.0
00433      PBPS=PBPS*1.76
00434      PBPS=IFIX(PBPS/100.0+0.5)*100.0
00435      CRCST=CRCST*1.76
00436      CRCST=IFIX(CRCST/100.0+0.5)*100.0
00437      TPUMP=TPUMP*1.76
00438      TPUMP=IFIX(TPUMP/100.0+0.5)*100.0
00439      RETRAN=RETRAN*1.76
00440      RETRAN=IFIX(RETRAN/100.0+0.5)*100.0
00441      CTRAN=CTRAN*1.76
00442      CTRAN=IFIX(CTRAN/100.0+0.5)*100.0
00443      MTC=MTC*1.76
00444      MTC=IFIX(MTC/100.0+0.5)*100.0
00445      ATC=ATC*1.76
00446      ATC=IFIX(ATC/100.0+0.5)*100.0
00447      INCEN=INCEN*1.76
00448      INCEN=IFIX(INCEN/100.0+0.5)*100.0
00449      SUPCOL=SUPCOL*1.76
00450      SUPCOL=IFIX(SUPCOL/100.0+0.5)*100.0
00451      RLOCAT=RLOCAT*1.76
00452      RLOCAT=IFIX(RLOCAT/100.0+0.5)*100.0
00453      DERRIK=DERRIK*1.76
00454      DERRIK=IFIX(DERRIK/100.0+0.5)*100.0
00455      RMVCS=RMVCS*1.76
00456      RMVCS=IFIX(RMVCS/100.0+0.5)*100.0
00457      DO 896 I=1,2
00458      WHLC(I)=WHLC(I)*1.76
00459      WHLC(I)=IFIX(WHLC(I)/100.0+0.5)*100.0
00460      MISC(I)=MISC(I)*1.76
00461      MISC(I)=IFIX(MISC(I)/100.0+0.5)*100.0
00462      TOTBIT(I)=TOTBIT(I)*1.76
00463      TOTBIT(I)=IFIX(TOTBIT(I)/100.0+0.5)*100.0
00464      SC(I)=SC(I)*1.76
00465      SC(I)=IFIX(SC(I)/100.0+0.5)*100.0
00466      RCNMC(I)=RCNMC(I)*1.76
00467      RCNMC(I)=IFIX(RCNMC(I)/100.0+0.5)*100.0
00468      FCAB(I)=FCAB(I)*1.76
00469      FCAB(I)=IFIX(FCAB(I)/100.0+0.5)*100.0
00470      RMC(I)=RMC(I)*1.76
00471      RMC(I)=IFIX(RMC(I)/100.0+0.5)*100.0
00472      CT(I)=CT(I)*1.76
00473      CT(I)=IFIX(CT(I)/100.0+0.5)*100.0
00474      TOTLC(I)=TOTLC(I)*1.76
00475      TOTLC(I)=IFIX(TOTLC(I)/100.0+0.5)*100.0
00476      WIT(I)=WIT(I)*1.76
00477      WIT(I)=IFIX(WIT(I)/100.0+0.5)*100.0
00478      FTS(I)=FTS(I)*1.76
00479      FTS(I)=IFIX(FTS(I)/100.0+0.5)*100.0
00480      896 CONTINUE
00481      C ***** TOTAL COSTS
00482      C
00483      RATIO1=NTNDL/TOTCAY
00484      RATIO2=1.0-RATIO1
00485      RATIO3=TANG(1)/(TANG(1)+TANG(2))
00486      RATIO4=1.0-RATIO3
00487      TOTAL1=FUEL+WTRSUP+WWELL+INCEN+SUPCOL
00488      TOTAL2=RLOCAT+RMVCS+RIGMBL+MTC+DERRIK+ATC
00489      SHARE(1)=RATIO1*TOTAL1+0.5*TOTAL2+RATIO3*CTRAN+CORPER+PBPS+
00490      $CRCST+TPUMP+RETRAN
00491      SHARE(1)=IFIX(SHARE(1)/100.0+0.5)*100.0
00492      SHARE(2)=RATIO2*TOTAL1+0.5*TOTAL2+RATIO4*CTRAN
00493      SHARE(2)=IFIX(SHARE(2)/100.0+0.5)*100.0
00494      DO 895 I=1,2
00495      WELTOT(I)=SHARE(I)*WHLC(I)+TANG(I)*XTANG(I)*RIG(I)+TOTBIT(I)+
00496      $SC(I)+RCNMC(I)+FCAB(I)+RMC(I)+CT(I)+TOTLC(I)+WIT(I)+FTS(I)+MISC(I)
00497      895 CONTINUE
00498      SUBTOT=WELTOT(1)+WELTOT(2)
00499      GANDA=IFIX((0.06*SUBTOT)/100.0+0.5)*100.0
00500      HDRCST=SUBTOT+GANDA
00501      WELTOT(1)=(WELTOT(1)/(SUBTOT))*GANDA+WELTOT(1)
00502      WELTOT(1)=IFIX(WELTOT(1)/100.0+0.5)*100.0
00503      WELTOT(2)=(WELTOT(2)/(SUBTOT))*GANDA+WELTOT(2)
00504      WELTOT(2)=IFIX(WELTOT(2)/100.0+0.5)*100.0
00505      SHARE(1)=WELTOT(1)-WHLC(1)-TANG(1)-XTANG(1)-RIG(1)-TOTBIT(1)-
00506      $SC(1)-RCNMC(1)-FCAB(1)-RMC(1)-CT(1)-TOTLC(1)-WIT(1)-FTS(1)-MISC(1)
00507      SHARE(2)=WELTOT(2)-WHLC(2)-TANG(2)-XTANG(2)-RIG(2)-TOTBIT(2)-
00508      $SC(2)-RCNMC(2)-FCAB(2)-RMC(2)-CT(2)-TOTLC(2)-WIT(2)-FTS(2)-MISC(2)
00509      REDRIL(1)=(RLOCAT-€300.0+RMVCS+RIGMBL+CORPER+PBPS+CRCST+TPUMP+
00510      $RETRAN+RATIO1*(FUEL+WTRSUP+SUPCOL+INCEN)+0.5*(DERRIK+MTC+ATC)+
00511      $RATIO3*CTRAN+WHLC(1)+TANG(1)+XTANG(1)+RIG(1)+TOTBIT(1)+SC(1)+
00512      $RCNMC(1)+FCAB(1)+RMC(1)+CT(1)+TOTLC(1)+WIT(1)+FTS(1)+MISC(1))
00513      REDRIL(1)=IFIX((REDRIL(1)*1.06)/100.0+0.5)*100.0
00514      REDRIL(2)=(RLOCAT-€300.0+RMVCS+RIGMBL+CORPER+PBPS+CRCST+TPUMP+
00515      $RETRAN+RATIO2*(FUEL+WTRSUP+SUPCOL+INCEN)+0.5*(DERRIK+MTC+ATC)+
00516      $RATIO4*CTRAN+WHLC(2)+TANG(2)+XTANG(2)+RIG(2)+TOTBIT(2)+SC(2)+
00517      $RCNMC(2)+FCAB(2)+RMC(2)+CT(2)+TOTLC(2)+WIT(2)+FTS(2)+MISC(2))
00518      REDRIL(2)=IFIX((REDRIL(2)*1.06)/100.0+0.5)*100.0
00519      C ***** FIXED COST OF DRILLING PERMEABLE SECTION
00520      C
00521      PDAYS=(NDP1+NDP2)
00522      PFIXED=MTC+PDAYS*FRATE+PDAYS*CRATE
00523      DO 897 J=1,2
00524      PFIXED=PFIXED+RMC(J)
00525      NN=NCI1
00526      IF(J.EQ.2)NN=NCI2
00527      DO 897 I=1,NN
00528      TEST2=CASE1(I,2)
00529      IF(J.EQ.2)TEST2=CASE2(I,2)
00530      IF(TEST2.GT.(P+200))GO TO 897
00531      PFIXED=PFIXED+(1+TXRATE)*CCUST(I,J)+BTCST(I,J)+
00532      $WEIGHT(I,J)*PLB/100.
00533      897 CONTINUE
00534      DO 898 I=1,NLGL
00535      IF(LUGL(I,2).LE.(P+200))PFIXED=PFIXED+RLC(I,1)
00536

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RGICOST (cont)

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00537 898 CCNTINLE
00538 DO 899 I=1,NLG2
00539 IF (LOGG2(I,2).LE.(P+200)) PFIXED=PFIXED+RLC(I,2)
00540 899 CCNTINLE
00541 PFIXED=IFIX(PFIXED/100.0+0.5)*100.0
00542 C
00543 C ***** PRINT CUT RESULTS
00544 C
00545 ASMP1=1.0
00546 IF (NCASE.EQ.2) ASMP1=2.0
00547 IF (NCASE.EQ.3) ASMP1=3.0
00548 WRITE(17,901) TEMPD,HORCST,KEDRIL(2),REDRIL(1)
00549 C WRITE(17,999) TEMPD,P,WP,ASMP1,WELTUT(1),WELTCT(2),HORCST,PFIXED
00550 901 FORMAT(1X,F8.2,5X,F12.2,5X,F11.2,5X,F11.2)
00551 999 FORMAT(1X,F8.2,1X,F8.2,1X,F3.1,1X,F3.1,2(1X,F10.2),1X,F12.2,
00552 $1X,F10.2)
00553 C CALL SPECIFY(ASMP1,TOPI,TMD1,TMD2,TVD1,TVD2,KCP1,KCP2)
00554 C CALL CTSUB(TOPI,ASMP1)
00555 C
00556 900 CCNTINLE
00557 910 CCNTINLE
00558 920 CCNTINLE
00559 915 CCNTINLE
00560 222 FORMAT(1X,A1)
00561 STOP
00562 END
00563 C
00564 C
00565 C *****
00566 * WELL PROGRAM SUBROUTINES *
00567 C *****
00568 C
00569 C VARRIABLE NAMES SUFFIXED BY 1
00570 C APPLY TO THE INJECTION WELL.
00571 C VARRIABLE NAMES SUFFIXED BY 2
00572 C APPLY TO THE PRODUCTION WELL.
00573 C IN ONE-DIMENSIONAL ARRAYS, POSITION
00574 C 1 CORRESPONDS TO THE INJECTION WELL,
00575 C POSITION 2 TO THE PRODUCTION.
00576 C
00577 C THE ARRAYS CASE1 & CASE2 CARRY
00578 C THE SETTING DEPTHS OF THE CASING
00579 C INTERVALS TO THE MAIN PROGRAM.
00580 C
00581 C THE ARRAYS LOGG1 & LOGG2 CARRY
00582 C THE LOGGING PROGRAMS AND LOGGING
00583 C INTERVALS TO THE MAIN PROGRAM.
00584 C THE FIRST COLUMN IN EACH ARRAY
00585 C IDENTIFIES THE APPROPRIATE LOGGING
00586 C PROGRAM, THE 2ND TO 4TH COLUMNS
00587 C CORRESPOND TO THE COLUMNS OF
00588 C TABLE 11.
00589 C
00590 C
00591 C
00592 C SUBROUTINE WPI(P,TCPI,TMD1,TMD2,TVD1,TVD2,KCP1,KCP2,SC)
00593 REAL KCP1,KCP2,LOGG1,LOGG2,NDR1,MISC
00594 COMMON/SPECS/CASE1(5,2),CASE2(5,2),LCGG1(3,4),LOGG2(3,4),
00595 $NDR1(2,5),WHLC(2),MISC(2),CT(2),B(5,2),NDR1,NDR2,
00596 $VT,VVT,NC11,NC12,NLG1,NLG2,WP,NDP1,NDP2,NTND1,NTND2
00597 NDR1=3
00598 NDR2=3
00599 IF (P.GT.2000) GO TO 100
00600 C WELL PROGRAM 1A
00601 C
00602 WP=1.1
00603 NDR1=2
00604 NLG1=2
00605 NLG2=3
00606 NC11=2
00607 NC12=2
00608 B(1,1)=17
00609 B(1,2)=13
00610 B(2,1)=12
00611 B(2,2)=9
00612 CASE1(1,2)=P+200
00613 CASE1(2,2)=TMD1
00614 CASE2(1,2)=P+200
00615 CASE2(2,2)=KCP2-50
00616 WHLC(1)=18000
00617 WHLC(2)=30980
00618 MISC(1)=8000
00619 MISC(2)=5000
00620 NDR1(1,1)=38+5*(P+200)/1000
00621 NDR1(1,2)=46+(9.1*TMD1+2*TCPI-2*(P+200))/1000
00622 NDR1(2,1)=38+5*(P+200)/1000
00623 NDR1(2,2)=37+(4.26*(KCP2-50)-0.9*(P+200))/1000
00624 NDR1(2,3)=5.4+(5.6*TMD2-1.76*KCP2)/1000
00625 VT=0.257*P+260
00626 VVT=0.0
00627 CT(1)=7462.10+6.978*P+0.1942*KCP1+2.36*TMD1+
00628 $41.24+0.015*P+0.0057*TMD1)*SD
00629 CT(2)=7574.99+6.84*P+2.21*KCP2+(18.99+0.0149*P+0.00424*KCP2)*SD
00630 LOGG1(1,1)=1
00631 LOGG1(1,2)=P+200
00632 LOGG1(1,3)=P+200
00633 LOGG1(1,4)=90
00634 LOGG1(2,1)=3
00635 LOGG1(2,2)=TVD1
00636 LOGG1(2,3)=TMD1
00637 LOGG1(2,4)=P+200
00638 LOGG2(1,1)=1
00639 LOGG2(1,2)=P+200
00640 LOGG2(1,3)=P+200
00641 LOGG2(1,4)=90
00642 LOGG2(2,1)=2
00643 LOGG2(2,2)=KCP2-50
00644 LOGG2(2,3)=KCP2-50
00645 LOGG2(2,4)=P+200

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RGICOST (cont)

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00645      LOGG2(3,1)=3
00646      LOGG2(3,2)=TVD2
00647      LOGG2(3,3)=TMD2
00648      LOGG2(3,4)=KOP2-50
00649      GO TO 200
00650 100  CONTINUE
00651 C      WELL PROGRAM 1B
00652      WP=1.2
00653      NLG1=3
00654      NLG2=3
00655      NC11=3
00656      NC12=2
00657      B(1,1)=17
00658      B(1,2)=13
00659      B(2,1)=12
00660      B(2,2)=9
00661      B(3,1)=8
00662      B(3,2)=7
00663      CASE1(1,2)=1500
00664      CASE1(2,1)=1300
00665      CASE1(2,2)=P+200
00666      CASE1(3,1)=P
00667      CASE1(3,2)=TMD1
00668      CASE2(1,2)=1500
00669      CASE2(2,1)=1300
00670      CASE2(2,2)=P+200
00671      WHLC(1)=37150.
00672      WHLC(2)=48585.
00673      MISC(1)=10000
00674      MISC(2)=7000
00675      NDRT(1,1)=45
00676      NDRT(1,2)=23+5.47*(P+200)/1000
00677      NDRT(1,3)=33+(8.9*TMD1-1.86*P+2*TOP1)/1000
00678      NDRT(2,1)=45
00679      NDRT(2,2)=23+5.41*(P+200)/1000
00680      NDRT(2,3)=5.2+(5.6*TMD2-1.76*P)/1000
00681      VT=0.15*P+775.
00682      VVT=0.0
00683      CT(1)=18578.53+1.15*P+1.25*TMD1+
00684      $(135.48+0.002*P+0.0023*TMCI)*SD
00685      CT(2)=16925.4+2.15*P+126.98+0.00424*KCP2)*SD
00686      LOGG1(1,1)=1
00687      LOGG1(1,2)=1500
00688      LOGG1(1,3)=1500
00689      LOGG1(1,4)=90
00690      LOGG1(2,1)=1
00691      LOGG1(2,2)=P+200
00692      LOGG1(2,3)=P+200
00693      LOGG1(2,4)=1500
00694      LOGG1(3,1)=3
00695      LOGG1(3,2)=TVD1
00696      LOGG1(3,3)=TMD1
00697      LOGG1(3,4)=P+200
00698      LOGG2(1,1)=1
00699      LOGG2(1,2)=1500
00700      LOGG2(1,3)=1500
00701      LOGG2(1,4)=90
00702      LOGG2(2,1)=1
00703      LOGG2(2,2)=P+200
00704      LOGG2(2,3)=P+200
00705      LOGG2(2,4)=1500
00706      LOGG2(3,1)=3
00707      LOGG2(3,2)=TVD2
00708      LOGG2(3,3)=TMD2
00709      LOGG2(3,4)=P+200
00710 200  CONTINUE
00711      RETURN
00712      END
00713 C
00714 C
00715 C
00716      SUBROUTINE WP2(P, TOP1, TMD1, TMD2, TVD1, TVD2, KCP1, KCP2, SD)
00717      REAL KCP1, KCP2, LOGG1, LOGG2, NDRT, MISC
00718      COMMON SPECS/CASE1(5,2), CASE2(5,2), LOGG1(3,4), LOGG2(3,4),
00719      $NDRT(2,5), WHLC(2), MISC(2), CT(2), B(5,2), NDR1, NDR2,
00720      $VT, VVT, NC11, NC12, NLG1, NLG2, WP, NDR1, NDR2, NTND1, NTND2
00721      NDR1=3
00722      NDR2=3
00723      IF(P.GT.3500)GO TO 200
00724      IF(P.GT.1000)GO TO 100
00725 C      WELL PROGRAM 2A
00726      WP=2.1
00727      NDR1=2
00728      NLG1=2
00729      NLG2=3
00730      NC11=2
00731      NC12=2
00732      B(1,1)=17
00733      B(1,2)=13
00734      B(2,1)=12
00735      B(2,2)=9
00736      CASE1(1,2)=P+200
00737      CASE1(2,2)=TMD1
00738      CASE2(1,2)=P+200
00739      CASE2(2,2)=KOP2-50
00740      WHLC(1)=18000
00741      WHLC(2)=30580
00742      MISC(1)=10000
00743      MISC(2)=8000
00744      NDRT(1,1)=38+5*(P+200)/1000
00745      NDRT(1,2)=46+(9.1*TMD1+2*TOP1-2*(P+200))/1000
00746      NDRT(2,1)=39+5*(P+200)/1000
00747      NDRT(2,2)=35+(3.7*(KCP2-80)-0.86*(P+200))/1000
00748      NDRT(2,3)=5.4+(5.6*TMD2-1.76*KCP2)/1000
00749      VT=0.39*P+210
00750      VVT=0.0
00751      CT(1)=7176.61+6.98*P+2.64*TMD1+
00752      $(41.23+0.3141*P+0.0056*TMD1)*SD

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00753      CT(2)=7471.66+6.93*P+2.21*KOP2+
00754      $(12.4+0.015*P+0.00424*KOP2)*SD
00755      LOGG1(1,1)=1
00756      LOGG1(1,2)=P+200
00757      LOGG1(1,3)=P+200
00758      LOGG1(1,4)=90
00759      LOGG1(2,1)=3
00760      LOGG1(2,2)=TVD1
00761      LOGG1(2,3)=TMD1
00762      LOGG1(2,4)=P+200
00763      LOGG2(1,1)=1
00764      LOGG2(1,2)=P+200
00765      LOGG2(1,3)=P+200
00766      LOGG2(1,4)=90
00767      LOGG2(2,1)=2
00768      LOGG2(2,2)=KOP2-50
00769      LOGG2(2,3)=KOP2-50
00770      LOGG2(2,4)=P+200
00771      LOGG2(3,1)=3
00772      LOGG2(3,2)=TVD2
00773      LOGG2(3,3)=TMD2
00774      LOGG2(3,4)=KOP2-50
00775      GU TU 300
00776      C100 CONTINUE
00777      C WELL PROGRAM 2B
00778      WP=2.2
00779      NLG1=3
00780      NLG2=3
00781      NC11=3
00782      NC12=2
00783      B(1,1)=17
00784      B(1,2)=13
00785      B(2,1)=12
00786      B(2,2)=9
00787      B(3,1)=8
00788      B(3,2)=7
00789      CASE1(1,2)=P+200
00790      CASE1(2,2)=KOP1-50
00791      CASE1(3,1)=KOP1-250
00792      CASE1(3,2)=TMD1
00793      CASE2(1,2)=P+200
00794      CASE2(2,2)=KOP2-50
00795      WHLC(1)=3150.
00796      WHLC(2)=4858.
00797      MISC(1)=14000.
00798      MISC(2)=11000.
00799      NDRT(1,1)=36+5*(P+200)/1000
00800      NDRT(1,2)=20+(4.2*(KOP2-50)-1.2*P)/1000
00801      NDRT(1,3)=33+(8.9*TMD1-2*KOP1+2*1001)/1000
00802      NDRT(2,1)=36+5*(P+200)/1000
00803      NDRT(2,2)=20+(4.2*(KOP2-50)-1.2*P)/1000
00804      NDRT(2,3)=5.4+(5.6*TMD2-1.76*KOP2)/1000
00805      VT=0.3*P+460
00806      VVT=0.0
00807      CT(1)=11839.12+3.35*P+1.88*KOP1+1.35*TMD1+
00808      $(50.71+0.0076*P+0.0042*KOP1+0.0023*TMD1)*SD
00809      CT(2)=5066.40+4.197*P+2.2*KOP2+
00810      $(12.4+0.015*P+0.00424*KOP2)*SD
00811      LOGG1(1,1)=1
00812      LOGG1(1,2)=P+200
00813      LOGG1(1,3)=P+200
00814      LOGG1(1,4)=90
00815      LOGG1(2,1)=2
00816      LOGG1(2,2)=KOP1-50
00817      LOGG1(2,3)=KOP1-50
00818      LOGG1(2,4)=P+200
00819      LOGG1(3,1)=3
00820      LOGG1(3,2)=TVD1
00821      LOGG1(3,3)=TMD1
00822      LOGG1(3,4)=KOP1-50
00823      LOGG2(1,1)=1
00824      LOGG2(1,2)=P+200
00825      LOGG2(1,3)=P+200
00826      LOGG2(1,4)=90
00827      LOGG2(2,1)=2
00828      LOGG2(2,2)=KOP2-50
00829      LOGG2(2,3)=KOP2-50
00830      LOGG2(2,4)=P+200
00831      LOGG2(3,1)=3
00832      LOGG2(3,2)=TVD2
00833      LOGG2(3,3)=TMD2
00834      LOGG2(3,4)=KOP2-50
00835      GU TU 300
00836      C200 CONTINUE
00837      C WELL PROGRAM 2C
00838      WP=2.3
00839      NLG1=2
00840      NLG2=3
00841      NC11=3
00842      NC12=2
00843      B(1,1)=17
00844      B(1,2)=13
00845      B(2,1)=12
00846      B(2,2)=9
00847      B(3,1)=8
00848      B(3,2)=7
00849      CASE1(1,2)=.2*(P+200)
00850      CASE1(2,2)=P+200
00851      CASE1(3,1)=P
00852      CASE1(3,2)=TMD1
00853      CASE2(1,2)=.2*(P+200)
00854      CASE2(2,2)=P+200
00855      WHLC(1)=26815.
00856      WHLC(2)=38250.
00857      MISC(1)=11000.
00858      MISC(2)=6000.
00859      NDRT(1,1)=38+0.97*(P+200)/1000
00860      NDRT(1,2)=35.5+4.55*(P+200)/1000

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RGICOST (cont)

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00861      NDRT(1,3)=33+(8.9*TMD1-1.86*P+2*1001)/1000
00862      NDRT(2,1)=38+0.97*(P+200)/1000
00863      NDRT(2,2)=35.5+4.55*(P+200)/1000
00864      NDRT(2,3)=5.2+(5.6*TMD2-1.76*P)/1000
00865      VT=0.176*P+435
00866      VVT=0.1457*(P+200-C.37*TVD1)
00867      CT(1)=5498.03+3.86*P+1.33*TMD1+
00868      $(42.35+0.0049*P+0.0023*TMD1)*SD
00869      CT(2)=7644.12+3.56*P+(15.66+0.0072*P)*SD
00870      LOGG1(1,1)=1
00871      LOGG1(1,2)=P+200
00872      LOGG1(1,3)=P+200
00873      LOGG1(1,4)=.2*(P+200)
00874      LOGG1(2,1)=3
00875      LOGG1(2,2)=TVD1
00876      LOGG1(2,3)=TMD1
00877      LOGG1(2,4)=P+200
00878      LOGG2(1,1)=1
00879      LOGG2(1,2)=P+200
00880      LOGG2(1,3)=P+200
00881      LOGG2(1,4)=.2*(P+200)
00882      LOGG2(2,1)=3
00883      LOGG2(2,2)=TVD2
00884      LOGG2(2,3)=TMD2
00885      LOGG2(2,4)=P+200
00886      300      CCNTINUE
00887      RETURN
00888      END
00889      C
00890      C
00891      C
00892      C
00893      C
00894      C
00895      C
00896      C
00897      C
00898      C
00899      C
00900      C
00901      C
00902      C
00903      C
00904      C
00905      C
00906      C
00907      C
00908      C
00909      C
00910      C
00911      C
00912      C
00913      C
00914      C
00915      C
00916      C
00917      C
00918      C
00919      C
00920      C
00921      C
00922      C
00923      C
00924      C
00925      C
00926      C
00927      C
00928      C
00929      C
00930      C
00931      C
00932      C
00933      C
00934      C
00935      C
00936      C
00937      C
00938      C
00939      C
00940      C
00941      C
00942      C
00943      C
00944      C
00945      C
00946      C
00947      C
00948      C
00949      C
00950      C
00951      C
00952      C
00953      C
00954      C
00955      C
00956      C
00957      C
00958      C
00959      C
00960      C
00961      C
00962      C
00963      C
00964      C
00965      C
00966      C
00967      C
00968      C

      ***** DEPTH CLASS 3
      SUBROUTINE WP3(P,TCPI,TMD1,TMD2,TVD1,TVD2,KCP1,KCP2,SC)
      REAL KCP,KCP2,LOGG1,LOGG2,NDRT,MISC
      COMMON/SCS/CASE1(5,2),CASE2(5,2),LOGG1(3,4),LOGG2(3,4),
      $NDRT(2,3),WHLC(2),MISC(2),CT(2),B(5,2),NDP1,NDP2,
      $VT,VVT,NCL1,NCL2,NLG1,NLG2,*P,NDP1,NDP2,NTND1,NTND2
      NLG1=3
      NDRT=3
      NDR2=3
      NLG2=3
      NCL1=3
      NCL2=2
      B(1,1)=17
      B(1,2)=13
      B(2,1)=12
      B(2,2)=9
      B(3,1)=8
      B(3,2)=7
      LOGG1(1,1)=1
      LOGG1(1,2)=P+200
      LOGG1(1,3)=P+200
      LOGG1(1,4)=90
      LOGG1(2,1)=2
      LOGG1(2,2)=KOP1-50
      LOGG1(2,3)=KOP1-50
      LOGG1(2,4)=P+200
      LOGG1(3,1)=3
      LOGG1(3,2)=TVD1
      LOGG1(3,3)=TMD1
      LOGG1(3,4)=KOP1-50
      LOGG2(1,1)=1
      LOGG2(1,2)=P+200
      LOGG2(1,3)=P+200
      LOGG2(1,4)=90
      LOGG2(2,1)=2
      LOGG2(2,2)=KOP2-50
      LOGG2(2,3)=KOP2-50
      LOGG2(2,4)=P+200
      LOGG2(3,1)=3
      LOGG2(3,2)=TVD2
      LOGG2(3,3)=TMD2
      LOGG2(3,4)=KOP2-50
      IF(P.GT.5000)GO TO 20C
      IF(P.GT.1000)GO TO 100
      WELL PROGRAM 3A
      WP=3.1
      CASE1(1,2)=P+200
      CASE1(2,2)=KOP1-50
      CASE1(3,1)=KOP1-250
      CASE1(3,2)=TMD1
      CASE2(1,2)=P+200
      CASE2(2,2)=KOP2-50
      WHLC(1)=23055.
      WHLC(2)=38250.
      MISC(1)=12000.
      MISC(2)=9000.
      NDRT(1,1)=38+5*(P+200)/1000
      NDRT(1,2)=35+(4.2*(KOP1-50)-0.86*(P+200))/1000.
      NDRT(1,3)=33+(8.9*TMD1-2*KCP1+2*1001)/1000
      NDRT(2,1)=38+5*(P+200)/1000
      NDRT(2,2)=35+(4.2*(KOP2-50)+1.2*P)/1000.
      NDRT(2,3)=5.4+(5.6*TMD2-1.76*KCP2)/1000
      VT=0.257*P+560.
      VVT=0.297*(P+200-0.37*TVD1)
      CT(1)=5609.71+6.88*P+2.01*KOP1+1.244*TMD1+
      $(44.22+0.015*P+0.002*KOP1+0.0023*TMD1)*SD
      CT(2)=7276.69+6.88*P+2.33*KCP2+(12.4+0.15*P+0.00424*KCP2)*SD
      GO TO 300
      CCNTINUE
      ***** WELL PROGRAM 3B
      WP=3.2
      WHLC(1)=37150.
      WHLC(2)=48585.
      MISC(1)=12000.
      MISC(2)=9000.
      NDRT(1,1)=38+5*(P+200)/1000.
      NDRT(2,1)=38+5*(P+200)/1000.
      VT=0.257*P+560

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RGICOST (cont)

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00569 VVT=0.297*(P+200-0.37*TVD1)
00570 CASE1(1,2)=P+200
00571 CASE1(2,1)=P
00572 IF((KUP1-50-P).LE.5500.)GO TO 110
00573 CASE1(2,2)=KOP1-50
00574 NDRT(1,2)=21+(4.2*(KOP1-50)-1.2*P)/1000.
00575 NDRT(1,3)=33+(8.9*TMD1-2*KCP1+2*ICP1)/1000.
00576 CT(1)=10210.83+4.36*P+1.19*KUP1+1.303*TMD1+
00577 $(46.03+0.0093*P+0.002*KCP1)*SD
00578 GO TO 120
00579 110 CONTINUE
00580 CASE1(2,2)=P+5500.
00581 NDRT(1,2)=23+(3.7*(P+5500)-0.76*P)/1000.
00582 NDRT(1,3)=22+(8.9*TMD1-2*P+2*ICP1)/1000.
00583 CT(1)=16754.68+5.47*P+1.303*TMD1+
00584 $(146.32+0.0118*P+0.0023*ICP1)*SD
00585 LOGG1(2,2)=P+5500.
00586 LOGG1(2,3)=P+5500.
00587 LOGG1(3,4)=P+5500.
00588 120 CONTINUE
00589 CASE1(3,1)=CASE1(2,2)-250
00590 CASE1(3,2)=TMD1
00591 CASE2(1,2)=P+200
00592 CASE2(2,1)=P
00593 IF((KUP2-50-P).LE.5500.)GO TO 130
00594 CASE2(2,2)=KUP2-50
00595 NDRT(2,2)=21+(4.2*(KUP2-50)-1.2*P)/1000.
00596 NDRT(2,3)=5.4+(5.6*TMD2-1.76*KUP2)/1000.
00597 CT(2)=7877.84+4.36*P+2.33*KUP2+
00598 $(12.4+C.00584*P+0.00424*KUP2)*SD
00599 GO TO 140
00600 130 CONTINUE
00601 CASE2(2,2)=P+5500
00602 NDRT(2,2)=23+(3.7*(P+5500)-0.76*P)/1000.
00603 NDRT(2,3)=15.6*TMD2-1.76*P)/1000.-5.17
00604 CT(2)=20788.19+6.69*P+(35.93+0.014*P)*SD
00605 LOGG2(2,2)=P+5500.
00606 LOGG2(2,3)=P+5500.
00607 LOGG2(3,4)=P+5500.
00608 140 CONTINUE
00609 GO TO 300
00610 200 CONTINUE
00611 C ***** WELL PROGRAM 3C.
00612 WP=3.3
00613 NLG1=2
00614 NLG2=2
00615 CASE1(1,2)=.2*(P+200)
00616 CASE1(2,2)=P+200
00617 CASE1(3,1)=P
00618 CASE1(3,2)=TMD1
00619 CASE2(1,2)=.2*(P+200)
00620 CASE2(2,2)=P+200
00621 WHLC(1)=18000.
00622 WHLC(2)=30980.
00623 MISC(1)=16000.
00624 MISC(2)=12000.
00625 NDRT(1,1)=36+0.97*(P+200)/1000
00626 NDRT(1,2)=35+4.55*(P+200)/1000
00627 NDRT(1,3)=33+(8.9*TMD1-1.66*P+2*ICP1)/1000
00628 NDRT(2,1)=36+0.97*(P+200)/1000
00629 NDRT(2,2)=35+4.55*(P+200)/1000
00630 NDRT(2,3)=5.2*(5.6*TMD2-1.76*P)/1000
00631 VT=0.176*P+536
00632 VVT=0.1457*(P+200-C.37*TVD)
00633 CT(1)=8533.86+2.51*P+1.303*TMD+
00634 $(42.35+0.0049*P+0.0023*TMD)*SD
00635 CT(2)=6484.55+3.87*P+(11.08+0.0122*P)*SD
00636 LOGG1(1,4)=.2*(P+200)
00637 LOGG1(2,1)=3
00638 LOGG1(2,2)=TVD1
00639 LOGG1(2,3)=TMD1
00640 LOGG1(2,4)=P+200
00641 LOGG2(1,4)=.2*(P+200)
00642 LOGG2(2,1)=3
00643 LOGG2(2,2)=TVD2
00644 LOGG2(2,3)=TMD2
00645 LOGG2(2,4)=P+200
00646 300 CONTINUE
00647 RETURN
00648 END
00649 C ***** DEPTH CLASS 4
00650 C
00651 C
00652 SUBROUTINE WP4(P,ICP1,TMD1,TMD2,TVD1,TVD2,KCP1,KUP2,SL)
00653 REAL KCP1,KUP2,LOGG1,LOGG2,NDRT,MISC
00654 COMMON/SPCLS/CASE1(5,2),CASE2(5,2),LOGG1(3,4),LOGG2(3,4),
00655 $NDRT(2,5),WHLC(2),MISC(2),CT(2),B(5,2),NDP1,NDP2,
00656 $VT,VVT,NCI1,NCI2,NLG1,NLG2,WP,NDP1,NDP2,NTND1,NTND2
00657 NDR1=4
00658 NDR2=4
00659 B(1,1)=26
00660 B(1,2)=20
00661 B(2,1)=17
00662 B(2,2)=13
00663 B(3,1)=12
00664 B(3,2)=9
00665 B(4,1)=8
00666 B(4,2)=7
00667 LOGG1(1,1)=1
00668 LOGG1(1,2)=P+200
00669 LOGG1(1,3)=P+200
00670 LOGG1(1,4)=90
00671 LOGG1(2,1)=2
00672 LOGG1(2,2)=1500
00673 LOGG1(2,3)=1500
00674 LOGG1(2,4)=P+200
00675 LOGG1(3,1)=3
00676 LOGG1(3,2)=TVD1

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RGICOST (cont)

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01C77 LOGG1(2,3)=TMD1
01C78 LOGG1(2,4)=1500
01C79 LOGG2(1,1)=1
01C80 LOGG2(1,2)=P+200
01C81 LOGG2(1,3)=P+200
01C82 LOGG2(1,4)=90
01C83 LOGG2(2,1)=2
01C84 LOGG2(2,2)=KOP2-50
01C85 LOGG2(2,3)=KOP2-50
01C86 LOGG2(2,4)=1500
01C87 LOGG2(3,1)=3
01C88 LOGG2(3,2)=TVD2
01C89 LOGG2(3,3)=TMD2
01C90 LOGG2(3,4)=KOP2-50
01C91 IF(P.GT.7000)GO TO 200
01C92 IF(P.GT.1000)GC TC 100
01C93 C WELL PROGRAM 4A
01C94 WP=4.1
01C95 NLG1=3
01C96 NLG2=3
01C97 NLG3=3
01C98 NC11=3
01C99 NC12=3
01100 CASE1(1,2)=P+200
01101 CASE1(2,2)=1500
01102 CASE1(3,2)=TMD1
01103 CASE2(1,2)=P+200
01104 CASE2(2,2)=1500
01105 CASE2(3,2)=KOP2-50
01106 WHLC(1)=2250.
01107 WHLC(2)=3520.
01108 MISC(1)=1700.
01109 MISC(2)=1500.
01110 NDRT(1,1)=18+6.27*(P+200)/1000
01111 NDRT(1,2)=44+.86*(P+200)/1000
01112 NDRT(1,3)=43.4+(7.6*TMD1+2*TUP1)/1000
01113 NDRT(2,1)=18+6.27*(P+200)/1000
01114 NDRT(2,2)=40.
01115 NDRT(2,3)=34+4.21*(KOP2-50)/1000
01116 NDRT(2,4)=2.87+(5.6*TMD2-1.76*KOP2)/1000
01117 VT=0.656*P+431
01118 VVT=0.1457*(P+200-C.37*TVD1)
01119 CT(1)=20645.77+14.44*P+1.84*KCP1+0.835*TMC1+
01120 $(88.38+0.35*P+0.0056*KCP1)*SD
01121 CT(2)=20380.73+15.28*P+2.33*KOP2+(29.22+0.35*P+0.00424*KOP2)*SD
01122 GO TO 300
01123 100 CONTINUE
01124 C ***** WELL PROGRAM 4B
01125 WP=4.2
01126 NLG1=3
01127 NLG2=3
01128 NC11=4
01129 NC12=3
01130 WHLC(1)=37150.
01131 WHLC(2)=48585.
01132 MISC(1)=1900.
01133 MISC(2)=1500.
01134 NDRT(1,1)=35+.485*(P+200)/1000
01135 NDRT(1,2)=38+5.054*(P+200)/1000
01136 NDRT(2,1)=35+.485*(P+200)/1000
01137 NDRT(2,2)=38+5.054*(P+200)/1000
01138 VT=0.333*P+567
01139 VVT=0.297*(P+200-0.37*TVD1)
01140 CASE1(1,2)=0.1*(P+200)
01141 CASE1(2,2)=P+200
01142 CASE1(3,1)=P
01143 CASE1(4,2)=TMD1
01144 CASE2(1,2)=0.1*(P+200)
01145 CASE2(2,2)=P+200
01146 CASE2(3,1)=P
01147 LOGG1(1,4)=0.1*(P+200)
01148 LOGG2(1,4)=0.1*(P+200)
01149 IF((KCP1-50-P).LE.7500.)GC TO 110
01150 CASE1(3,2)=P+7500
01151 NDRT(1,3)=23+(3.8*(P+7500)-0.76*P)/1000
01152 NDRT(1,4)=18+(8.9*TMD1-1.76*P)/1000
01153 CT(1)=22051.01+7.16*P+1.373*TMD1+
01154 $(178.37+0.01546*P+0.0023*TMD1)*SD
01155 LOGG1(2,2)=P+7500
01156 LOGG1(2,3)=P+7500
01157 LOGG1(3,4)=P+7500
01158 GO TO 120
01159 110 CONTINUE
01160 CASE1(3,2)=KOP1-50
01161 NDRT(1,3)=19+(4.21*(KCP1-50)-1.2*P)/1000
01162 NDRT(1,4)=33+(8.9*TMD1-2*KCP1+2*LCPI)/1000
01163 CT(1)=13031.62+5.96*P+1.2*KOP1+1.37*TMD1+
01164 $(43.18+0.0136*P+0.002*KCP1+0.0023*TMC1)*SC
01165 LOGG1(2,2)=KOP1-50
01166 LOGG1(2,3)=KOP1-50
01167 LOGG1(3,4)=KOP1-50
01168 120 CONTINUE
01169 CASE1(4,1)=CASE1(3,2)-200
01170 CASE2(1,2)=0.1*(P+200)
01171 CASE2(2,2)=P+200
01172 CASE2(3,1)=P
01173 IF((KOP2-50-P).LE.7500.)GC TO 130
01174 CASE2(3,2)=P+7500
01175 NDRT(2,3)=23+(3.7*(P+7500)-0.76*P)/1000
01176 NDRT(2,4)=15.6*TMD2-1.76*P/1000-.8.0
01177 CT(2)=28268.65+8.25*P+(42.83+0.018*P)*SD
01178 LOGG2(2,2)=P+7500
01179 LOGG2(2,3)=P+7500
01180 LOGG2(3,4)=P+7500
01181 GO TO 140
01182 130 CONTINUE
01183 CASE2(3,2)=KOP2-50
01184 NDRT(2,3)=19+(4.21*(KCP2-50)-1.2*P)/1000

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RGICOST (cont)

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01185 NDRT(2,4)=5.4+(5.6*TMD2-1.76*P)/1000
01186 CT(2)=10698.51+1.395*P+2.33*KGP2+(10.8+0.014*P+0.00424*KUP2)*SD
01187 LOGG2(2,2)=KOP2-50
01188 LOGG2(2,3)=KUP2-50
01189 LOGG2(3,4)=KOP2-50
01190 140 CONTINUE
01191 GO TO 300
01192 200 CONTINUE
01193 C ***** WELL PROGRAM 4C
01194 WP=4.3
01195 NLG1=2
01196 NLG2=2
01197 NC11=4
01198 NC12=3
01199 CASE1(1,2)=0.02*(P+200)
01200 CASE1(2,2)=.2*(P+200)
01201 CASE1(3,2)=P+200
01202 CASE1(4,1)=P
01203 CASE1(4,2)=TMD1
01204 CASE2(1,2)=0.02*(P+200)
01205 CASE2(2,2)=.2*(P+200)
01206 CASE2(3,2)=P+200
01207 WHLC(1)=27605.
01208 WHLC(2)=35280.
01209 MISC(1)=18000.
01210 MISC(2)=14000.
01211 NDRT(1,1)=35+0.97*(P+200)/1000
01212 NDRT(1,2)=35+0.609*(P+200)/1000.
01213 NDRT(1,3)=35+4.55*(P+200)/1000
01214 NDRT(1,4)=35+(8.9*TMD1-1.66*P+2*TMD1)/1000
01215 NDRT(2,1)=35+0.97*(P+200)/1000
01216 NDRT(2,2)=35+0.609*(P+200)/1000.
01217 NDRT(2,3)=35+4.55*(P+200)/1000
01218 NDRT(2,4)=5.2+(5.6*TMD2-1.76*P)/1000
01219 VT=0.183*P+537
01220 VVT=0.1457*(P+200)-0.37*TVD1)
01221 CT(1)=13062.22+2.915*P+1.373*TMD1+(36.89+0.0057*P+0.0023*TMD1)*SD
01222 CT(2)=18055.31+7.02*P+(8.82+0.00752*P)*SD
01223 LOGG1(1,4)=.2*(P+200)
01224 LOGG1(2,1)=3
01225 LOGG1(2,2)=TVD1
01226 LOGG1(2,3)=TMD1
01227 LOGG1(4,4)=KOP1-50
01228 LOGG2(1,4)=.2*(P+200)
01229 LOGG2(2,1)=3
01230 LOGG2(2,2)=TVD2
01231 LOGG2(2,3)=TMD2
01232 LOGG2(2,4)=P+200
01233 300 CONTINUE
01234 RETURN
01235 END
01236 C ***** DEPTH CLASS 5
01237 C
01238 SUBROUTINE WP5(P,TCPI,TMD1,TMD2,TVD1,TVD2,KOP1,KUP2,SD)
01239 REAL KCP1,KOP2,LOGG1,LOGG2,NDRT,MISC
01240 COMMON/SPECS/CASE1(5,2),CASE2(5,2),LOGG1(3,4),LOGG2(3,4),
01241 NDRT(2,5),WHLC(2),MISC(2),CT(2),B(5,2),NDRT1,NDRT2,
01242 SVT,VVT,NC11,NC12,NLG1,NLG2,WP,NOP1,NCP2,NTND1,NTND2
01243
01244 NDRT1=4
01245 NDRT2=4
01246 B(1,1)=26
01247 B(1,2)=20
01248 B(2,1)=17
01249 B(2,2)=13
01250 B(3,1)=12
01251 B(3,2)=9
01252 B(4,1)=8
01253 B(4,2)=7
01254 LOGG1(1,1)=1
01255 LOGG1(1,2)=P+200
01256 LOGG1(1,3)=P+200
01257 LOGG1(1,4)=90
01258 LOGG1(2,1)=2
01259 LOGG1(2,2)=KOP1-50
01260 LOGG1(2,3)=KOP1-50
01261 LOGG1(2,4)=1500
01262 LOGG1(3,1)=3
01263 LOGG1(3,2)=TVD1
01264 LOGG1(3,3)=TMD1
01265 LOGG1(3,4)=KOP1-50
01266 LOGG2(1,1)=1
01267 LOGG2(1,2)=P+200
01268 LOGG2(1,3)=P+200
01269 LOGG2(1,4)=90
01270 LOGG2(2,1)=2
01271 LOGG2(2,2)=KOP2-50
01272 LOGG2(2,3)=KOP2-50
01273 LOGG2(2,4)=1500
01274 LOGG2(3,1)=3
01275 LOGG2(3,2)=TVD2
01276 LOGG2(3,3)=TMD2
01277 LOGG2(3,4)=KOP2-50
01278 IF(P.GT.9000)GO TO 300
01279 IF(P.GT.2500)GO TO 200
01280 IF(P.GT.1000)GO TO 100
01281 C ***** WELL PROGRAM 5A
01282 WP=5.1
01283 NLG1=3
01284 NLG2=3
01285 NC11=4
01286 NC12=3
01287 CASE1(1,2)=P+200
01288 CASE1(2,2)=1500
01289 CASE1(3,2)=KOP1-50
01290 CASE1(4,1)=KOP1-250
01291 CASE1(4,2)=TMD1
01292 CASE2(1,2)=P+200

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RGICOST (cont)

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01293 CASE2(2,2)=1500
01294 CASE2(3,2)=KOP2-50
01295 WHLC(1)=27605.
01296 WHLC(2)=35280.
01297 MISC(1)=20000.
01298 MISC(2)=16000.
01299 NDRT(1,1)=38+6.273*(P+200)/1000
01300 NDRT(1,2)=40.
01301 NDRT(1,3)=33+4.21*(KOP1-50)/1000.
01302 NDRT(1,4)=38+(8.9*IMD1-2*KCP1+2*TOP1)/1000.
01303 NDRT(2,1)=38+6.273*(P+200)/1000
01304 NDRT(2,2)=40.
01305 NDRT(2,3)=33+4.21*(KOP2-50)/1000.
01306 NDRT(2,4)=5.4+(5.6*IMD2-1.76*P)/1000
01307 VT=0.656*P+531
01308 VVT=0.0
01309 CT(1)=21662.82+16.19*P+1.25*KCP1+1.637*IMD1+
01310 $(93.86+0.0373*P+0.002*KOP1+0.0023*IMD1)*SD
01311 CT(2)=23432.8+16.19*P+2.38*KCP2+(36.69+0.037*P+0.00424*KOP2)*SD
01312 GU TO 500
01313 C 100 CONTINUE
01314 C ***** WELL PROGRAM 5B
01315 WP=5.2
01316 NLG1=3
01317 NLG2=3
01318 NC11=4
01319 NC12=3
01320 CASE1(1,2)=0.1*(P+200)
01321 CASE1(2,2)=P+200
01322 CASE1(3,2)=KOP1-50
01323 CASE1(4,1)=KOP1-250
01324 CASE1(4,2)=IMD1
01325 CASE2(1,2)=J.1*(P+200)
01326 CASE2(2,2)=P+200
01327 CASE2(3,2)=KOP2-50
01328 WHLC(1)=27605.
01329 WHLC(2)=35280.
01330 MISC(1)=20000.
01331 MISC(2)=16000.
01332 NDRT(1,1)=35+0.485*(P+200)/1000
01333 NDRT(1,2)=38+5*(P+200)/1000.
01334 NDRT(1,3)=33+(4.21*(KCP1-50)-0.6*(P+200))/1000.
01335 NDRT(1,4)=38+(8.9*IMD1-2*KCP1+2*TOP1)/1000.
01336 NDRT(2,1)=35+0.485*(P+200)/1000
01337 NDRT(2,2)=38+5*(P+200)/1000.
01338 NDRT(2,3)=33+4.21*(KOP2-50)/1000.
01339 NDRT(2,4)=5.4+(5.6*IMD2-1.76*P)/1000
01340 VT=0.333*P+467
01341 VVT=0.0
01342 CT(1)=8882.20+7.01*P+1.25*KOP1+1.673*IMD1+
01343 $(38.8+0.0157*P+0.002*KOP1+0.0023*IMD1)*SD
01344 CT(2)=10634.19+8.12*P+2.38*KOP2+(10.8+0.0185*P+0.00424*KOP2)*SD
01345 LOGG1(1,4)=0.1*(P+200)
01346 LOGG2(1,4)=0.1*(P+200)
01347 GU TO 500
01348 C 200 CONTINUE
01349 C ***** WELL PROGRAM 5C
01350 WP=5.3
01351 NLG1=3
01352 NLG2=3
01353 NC11=4
01354 NC12=3
01355 WHLC(1)=37150.
01356 WHLC(2)=48585.
01357 MISC(1)=21000.
01358 MISC(2)=17000.
01359 NDRT(1,1)=35+0.485*(P+200)/1000.
01360 NDRT(1,2)=38+5*(P+200)/1000.
01361 NDRT(2,1)=35+0.485*(P+200)/1000.
01362 NDRT(2,2)=38+5*(P+200)/1000.
01363 VT=0.333*P+817
01364 VVT=0.297*(P+200-0.37*IMD1)
01365 CASE1(1,2)=0.1*(P+200)
01366 CASE1(2,2)=P+200
01367 CASE1(3,1)=P
01368 CASE1(4,2)=IMD1
01369 CASE2(1,2)=0.1*(P+200)
01370 CASE2(2,2)=P+200
01371 CASE2(3,1)=P
01372 LOGG1(1,4)=0.1*(P+200)
01373 LOGG2(1,4)=0.1*(P+200)
01374 IF((KOP1-50-P).LE.7500.IGC TO 110
01375 CASE1(3,2)=P+7500
01376 NDRT(1,3)=23+(3.7*(P+7500)-0.76*P)/1000.
01377 NDRT(1,4)=18+(8.9*IMD1-1.76*P)/1000.
01378 CT(1)=18142.90+7.19*P+1.673*IMD1+
01379 $(178.33+0.0156*P+0.0023*IMD1)*SD
01380 LOGG1(2,2)=P+7500
01381 LOGG1(2,3)=P+7500
01382 LOGG1(3,4)=P+7500
01383 GU TO 120
01384 C 110 CONTINUE
01385 CASE1(3,2)=KOP1-50
01386 NDRT(1,3)=19+(4.21*(KCP1-50)-1.2*P)/1000.
01387 NDRT(1,4)=33+(8.9*IMD1-2*KOP1+2*TOP1)/1000.
01388 CT(1)=5340.32+5.96*P+1.25*KOP1+1.673*IMD1+
01389 $(43.16+0.0136*P+0.002*KOP1+0.0023*IMD1)*SD
01390 LOGG1(2,4)=P+200
01391 C 120 CONTINUE
01392 CASE1(4,1)=CASE1(3,2)-200
01393 CASE2(1,2)=0.1*(P+200)
01394 CASE2(2,2)=P+200
01395 CASE2(3,1)=P
01396 IF((KOP2-50-P).LE.7500.IGC TO 130
01397 CASE2(3,2)=P+7500
01398 NDRT(2,3)=23+(3.7*(P+7500)-0.76*P)/1000.
01399 NDRT(2,4)=15.6*IMD2-1.76*P)/1000.-8.0
01400 CT(2)=28451.76+8.31*P+(42.83+0.018*P)*SD

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01401 LOGG2(1,4)=0.1*(P+200)
01402 LOGG2(2,2)=P+7500
01403 LOGG2(2,3)=P+7500
01404 LOGG2(3,4)=P+7500
01405 GO TO 140
01406 130 CONTINUE
01407 CASE2(3,2)=KOP2-50
01408 NDRT(2,3)=19+(4.21*(KCP2-50)-1.2*P)/1000.
01409 NDRT(2,4)=5.4+(5.6*TMD2-1.76*P)/1000
01410 CT(2)=10654.79+5.56*P+2.37*KUP2+(10.8+0.014*P+0.00424*KOP2)*SD
01411 LOGG2(1,4)=0.1*(P+200)
01412 LOGG2(2,2)=KOP2-50
01413 LOGG2(2,3)=KOP2-50
01414 140 CONTINUE
01415 GO TO 500
01416 300 CONTINUE
01417 C ***** WELL PROGRAM 50
01418 WP=5.4
01419 NDR1=4
01420 NDR2=4
01421 NLG1=2
01422 NLG2=2
01423 NC11=4
01424 NC12=3
01425 CASE1(1,2)=0.02*(P+200)
01426 CASE1(2,2)=2*(P+200)
01427 CASE1(2,3)=P+200
01428 CASE1(4,1)=P
01429 CASE1(4,2)=TMD1
01430 CASE2(1,2)=0.02*(P+200)
01431 CASE2(2,2)=2*(P+200)
01432 CASE2(3,2)=P+200
01433 WHLC(1)=27605.
01434 WHLC(2)=35280.
01435 MISC(1)=21000.
01436 MISC(2)=17000.
01437 NDRT(1,1)=35+0.97*(P+200)/1000
01438 NDRT(1,2)=35+0.609*(P+200)/1000.
01439 NDRT(1,3)=35+4.55*(P+200)/1000
01440 NDRT(1,4)=35+(8.9*TMD1-1.86*P+2*UPI)/1000
01441 NDRT(2,1)=35+0.97*(P+200)/1000
01442 NDRT(2,2)=35+0.609*(P+200)/1000.
01443 NDRT(2,3)=35+4.55*(P+200)/1000
01444 NDRT(2,4)=5.2+(5.6*TMD2-1.76*P)/1000
01445 VT=0.183*P+881
01446 VVT=0.297*(P+200)-0.37*TVD1)
01447 CT(1)=7884.23+2.82*P+1.673*TMD1+(36.85+0.0057*P+0.0023*TMD1)*SC
01448 CT(2)=5674.49+3.98*P+(8.85+0.007*P)*SD
01449 LOGG1(1,4)=2*(P+200)
01450 LOGG1(2,1)=3
01451 LOGG1(2,2)=TVD1
01452 LOGG1(2,3)=TMD1
01453 LOGG1(2,4)=P+200
01454 LOGG2(1,4)=2*(P+200)
01455 LOGG2(2,1)=3
01456 LOGG2(2,2)=TVD2
01457 LOGG2(2,3)=TMD2
01458 LOGG2(2,4)=P+200
01459 500 CONTINUE
01460 RETURN
01461 END
01462 C
01463 C ***** DEPTH CLASS 6
01464 C
01465 SUBROUTINE WPOIP,TCPI,TMD1,TMD2,TVD1,TVD2,KOP1,KOP2,SD)
01466 REAL KCP1,KOP2,LOGG1,LOGG2,NDRT,MISC
01467 COMMON/SPCS/CASE1(5,2),CASE2(5,2),LOGG1(3,4),LOGG2(3,4),
01468 $NDRT(2,5),WHLC(2),MISC(2),CT(2),U(5,2),NDR1,NDR2,
01469 $VT,VVT,NC11,NC12,NLG1,NLG2,WP,NUP1,NUP2,NTAD1,NTAD2
01470 NDR1=4
01471 NDR2=4
01472 B(1,1)=26
01473 B(1,2)=20
01474 B(2,1)=17
01475 B(2,2)=13
01476 B(3,1)=12
01477 B(3,2)=9
01478 B(4,1)=8
01479 B(4,2)=7
01480 B(5,1)=6
01481 B(5,2)=5
01482 LOGG1(1,1)=1
01483 LOGG1(1,2)=P+200
01484 LOGG1(1,3)=P+200
01485 LOGG1(1,4)=0.2*(P+200)
01486 LOGG1(2,1)=2
01487 LOGG1(2,2)=KOP1-50
01488 LOGG1(2,3)=KOP1-50
01489 LOGG1(2,4)=P+200
01490 LOGG1(3,1)=3
01491 LOGG1(3,2)=TVD1
01492 LOGG1(3,3)=TMD1
01493 LOGG1(3,4)=KOP1-50
01494 LOGG2(1,1)=1
01495 LOGG2(1,2)=P+200
01496 LOGG2(1,3)=P+200
01497 LOGG2(1,4)=0.2*(P+200)
01498 LOGG2(2,1)=2
01499 LOGG2(2,2)=KOP2-50
01500 LOGG2(2,3)=KOP2-50
01501 LOGG2(2,4)=P+200
01502 LOGG2(3,1)=3
01503 LOGG2(3,2)=TVD2
01504 LOGG2(3,3)=TMD2
01505 LOGG2(3,4)=KOP2-50
01506 NC11=4
01507 NC12=3
01508 NLG1=3

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01509 NLG2=3
01510 VVT=0.0
01511 IF(P.GT.16500) GC TO 500
01512 IF(P.GT.13000) GC TO 400
01513 IF(P.GT.9000) GC TO 300
01514 IF(P.GT.6000) GC TO 200
01515 IF(P.GT.1000) GC TO 100
01516 C ***** WELL PROGRAM 6A
01517 WP=6.1
01518 CASE1(1,2)=P+200
01519 CASE1(2,2)=1500
01520 CASE1(4,2)=TMD1
01521 CASE2(1,2)=P+200
01522 CASE2(2,2)=1500
01523 WHLC(1)=27605.
01524 WHLC(2)=35280.
01525 MISC(1)=25000.
01526 MISC(2)=21000.
01527 NDRT(1,1)=18+6.27*(P+200)/1000
01528 NDRT(1,2)=40.
01529 NDRT(2,1)=18+6.27*(P+200)/1000
01530 NDRT(2,2)=40.
01531 VT=0.656*P+531
01532 LOGG1(1,4)=9.0
01533 LOGG2(1,4)=9.0
01534 LOGG1(2,4)=15000
01535 LOGG2(2,4)=15000
01536 IF(KUP1.LT.17000) GC TO 10
01537 CASE1(3,2)=17000
01538 NDRT(1,3)=105
01539 NDRT(1,4)=(8.9*TMD1+2*TUP1)/1000.-9
01540 CT(1)=41371.56+16.19*P+0.271*KUP1+1.693*TMD1+
01541 $(174.71+0.0373*P+0.0007*KUP1+0.0023*TMD1)*SD
01542 GO TO 20
01543 C
01544 10 CONTINUE
01545 CASE1(3,2)=KUP1-50
01546 NDRT(1,3)=33+4.21*(KUP1-50)/1000.
01547 NDRT(1,4)=33+(8.9*TMD1-2*KUP1+2*TUP1)/1000.
01548 CT(1)=20045.56+16.19*P+1.293*KUP1+1.693*TMD1+
01549 $(93.81+0.0373*P+0.002*KUP1+0.0023*TMD1)*SD
01550 20 CONTINUE
01551 LOGG1(2,2)=CASE1(3,2)
01552 LOGG1(2,3)=CASE1(3,2)
01553 LOGG1(3,4)=CASE1(3,2)
01554 CASE1(4,1)=CASE1(3,2)-200
01555 IF(KUP2.LT.17000) GC TO 30
01556 CASE2(3,2)=17000
01557 NDRT(2,3)=105
01558 NDRT(2,4)=5.6*TMD2/1000.-24.41
01559 CT(2)=44129.24+16.19*P+0.271*KUP2+
01560 $(107.98+0.037*P+0.00068*KUP2)*SD
01561 GO TO 40
01562 30 CONTINUE
01563 CASE2(3,2)=KUP2-50
01564 NDRT(2,3)=33+4.21*(KUP2-50)/1000.
01565 NDRT(2,4)=5.4+(5.6*TMD2-1.76*KUP2)/1000.
01566 CT(2)=23220.57+16.19*P+2.42*KUP2+
01567 $(36.69+0.37*P+0.00424*KUP2)*SD
01568 40 CONTINUE
01569 LOGG2(2,2)=CASE2(3,2)
01570 LOGG2(2,3)=CASE2(3,2)
01571 LOGG2(3,4)=CASE2(3,2)
01572 GO TO 60
01573 100 CONTINUE
01574 C ***** WELL PROGRAM 6B
01575 WP=6.2
01576 CASE1(1,2)=0.1*(P+200)
01577 CASE1(2,2)=P+200
01578 CASE1(4,2)=TMD1
01579 CASE2(1,2)=0.1*(P+200)
01580 CASE2(2,2)=P+200
01581 WHLC(1)=27605.
01582 WHLC(2)=35280.
01583 MISC(1)=23000.
01584 MISC(2)=23000.
01585 NDRT(1,1)=35+1.21*(P+200)/1000
01586 NDRT(1,2)=38+5*(P+200)/1000.
01587 NDRT(2,1)=35+1.21*(P+200)/1000
01588 NDRT(2,2)=38+5*(P+200)/1000.
01589 VT=0.333*P+467
01590 IF(KUP1.LT.17000) GC TO 110
01591 CASE1(3,2)=17000
01592 NDRT(1,3)=107-86*(P+200)/1000.
01593 NDRT(1,4)=(8.9*TMD1+2*TUP1)/1000.-9
01594 CT(1)=34375.66+9.72*P+0.271*KUP1+1.133*TMD1+
01595 $(73.87+0.0215*P+0.0007*KUP1+0.0023*TMD1)*SD
01596 GO TO 120
01597 110 CONTINUE
01598 CASE1(3,2)=KUP1-50
01599 NDRT(1,3)=35+(4.424*(KUP1-50)-0.86*(P+200))/1000.
01600 NDRT(1,4)=33+(8.9*TMD1-2*KUP1+2*TUP1)/1000.
01601 CT(1)=2381.76+9.99*P+1.293*KUP1+1.693*TMD1+
01602 $(40.1+C.022*P+0.002*KUP1+0.0023*TMD1)*SD
01603 120 CONTINUE
01604 LOGG1(2,2)=CASE1(3,2)
01605 LOGG1(2,3)=CASE1(3,2)
01606 LOGG1(3,4)=CASE1(3,2)
01607 CASE1(4,1)=CASE1(3,2)-200
01608 IF(KUP2.LT.17000) GC TO 130
01609 CASE2(3,2)=17000
01610 NDRT(2,3)=107-0.86*(P+200)/1000.
01611 NDRT(2,4)=5.6*TMD2/1000.-28.41
01612 CT(2)=15358.30+9.72*P+0.271*KUP2+(83.71+0.022*P+0.00068*KUP2)*SD
01613 GO TO 140
01614 130 CONTINUE
01615 CASE2(3,2)=KUP2-50
01616 NDRT(2,3)=35+(4.42*(KUP2-50)-0.86*(P+200))/1000.
01617 NDRT(2,4)=5.4+(5.6*TMD2-1.76*KUP2)/1000.

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01617 CT(2)=10150.28+10.18*P+2.23*KLP2+(12.0+0.26*P)*S)
01618 140 CONTINUE
01619 LOGG2(2,2)=CASE2(3,2)
01620 LOGG2(2,3)=CASE2(3,2)
01621 LOGG2(3,4)=CASE2(3,2)
01622 GU TO 600
01623 200 CONTINUE
01624 C ***** WELL PROGRAM 6C
01625 WP=6.3
01626 WHLC(1)=37150.
01627 WHLC(2)=48585.
01628 MISC(1)=25000.
01629 MISC(2)=19000.
01630 NDRT(1,1)=35+.485*(P+200)/1000.
01631 NDRT(1,2)=38+5*(P+200)/1000.
01632 NDRT(2,1)=35+.485*(P+200)/1000.
01633 NDRT(2,2)=38+5*(P+200)/1000.
01634 VT=0.323*P+817
01635 VVT=0.297*(P+200-0.37*TVD1)
01636 CASE1(1,2)=0.1*(P+200)
01637 CASE1(2,2)=P+200
01638 CASE1(3,1)=P
01639 CASE1(4,2)=TMD1
01640 CASE2(1,2)=0.1*(P+200)
01641 CASE2(2,2)=P+200
01642 CASE2(3,1)=P
01643 LOGG1(1,4)=0.1*(P+200)
01644 LOGG2(1,4)=0.1*(P+200)
01645 IF (KCP1-50-P).GT.7500.160 TO 210
01646 CASE1(3,2)=KOP1-50
01647 NDRT(1,3)=19+(4.21*(KCP1-50)-1.2*P)/1000.
01648 NDRT(1,4)=33+(8.9*TMD1-2*KCP1+2*TUP1)/1000.
01649 CT(1)=3037.81+5.656*P+0.07*KOP1+1.653*TMD1+
01650 $(43.16+0.0136*P+0.002*KCP1+0.0023*TMD1)*SD
01651 GU TO 220
01652 210 CONTINUE
01653 CASE1(3,2)=P+7500
01654 NDRT(1,3)=23+(3.7*(P+7500)-0.76*P)/1000.
01655 NDRT(1,4)=18+(8.9*TMD1-1.76*P)/1000.
01656 CT(1)=10402.26+7.46*P+1.653*TMD1+
01657 $(178.33+0.0156*P+0.0023*TMD1)*SD
01658 220 CONTINUE
01659 CASE1(4,1)=CASE1(3,2)-200
01660 LOGG1(2,2)=CASE1(3,2)
01661 LOGG1(2,3)=CASE1(3,2)
01662 LOGG1(3,4)=CASE1(3,2)
01663 IF (KUP2-50-P).GT.7500.160 TO 230
01664 CASE2(2,2)=KUP2-50
01665 NDRT(2,3)=19+(4.21*(KUP2-50)-1.2*P)/1000.
01666 NDRT(2,4)=5.4+(5.6*TMD2-1.76*KCP2)/1000
01667 CT(2)=10767.34+5.945*P+2.37*KUP2+(85.71+0.022*P+0.00068*KUP2)*SD
01668 GU TO 240
01669 230 CONTINUE
01670 CASE2(3,2)=P+7500
01671 NDRT(2,3)=23+(3.7*(P+7500)-0.76*P)/1000.
01672 NDRT(2,4)=5.6*TMD2-1.76*KUP2)/1000.-E.0
01673 CT(2)=20749.66+8.61*P+(42.83+0.018*P)*SD
01674 240 CONTINUE
01675 LOGG2(2,2)=CASE2(3,2)
01676 LOGG2(2,3)=CASE2(3,2)
01677 LOGG2(3,4)=CASE2(3,2)
01678 GU TO 600
01679 300 CONTINUE
01680 C ***** WELL PROGRAM 6C
01681 WP=6.4
01682 NDR1=5
01683 NDR2=5
01684 NC1=5
01685 NC2=4
01686 CASE1(1,2)=0.02*(P+200)
01687 CASE1(2,2)=.2*(P+200)
01688 CASE1(3,2)=P+200
01689 CASE1(4,1)=P
01690 CASE1(4,2)=KUP1-50
01691 CASE1(5,1)=KOP1-250
01692 CASE1(5,2)=TMD1
01693 CASE2(1,2)=0.02*(P+200)
01694 CASE2(2,2)=.2*(P+200)
01695 CASE2(3,2)=P+200
01696 CASE2(4,1)=P
01697 CASE2(4,2)=KUP2-50
01698 WHLC(1)=31560.
01699 WHLC(2)=40335.
01700 MISC(1)=27000.
01701 MISC(2)=24000.
01702 NDRT(1,1)=35+0.97*(P+200)/1000
01703 NDRT(1,2)=35+0.609*(P+200)/1000.
01704 NDRT(1,3)=35+4.55*(P+200)/1000
01705 NDRT(1,4)=20+(3.97*(KOP1-50)-0.97*P)/1000.
01706 NDRT(1,5)=33+(8.9*TMD1-2*KCP1+2*TUP1)/1000
01707 NDRT(2,1)=35+0.97*(P+200)/1000
01708 NDRT(2,2)=35+0.609*(P+200)/1000.
01709 NDRT(2,3)=35+4.55*(P+200)/1000
01710 NDRT(2,4)=20+(3.97*(KUP2-50)-0.97*P)/1000.
01711 NDRT(2,5)=5.4+(5.6*TMD2-1.76*KUP2)/1000
01712 VT=0.1629*P+817
01713 VVT=0.1657*(P+200-0.37*TVD1)+0.247*(0.2*(P+200)-0.37*TVD2)
01714 CT(1)=13936.23+2.93*P+0.51*KUP1+1.1292*TMD1+
01715 $(38.07+0.0062*P+0.0004*KOP1+0.0014*TMD1)*SD
01716 CT(2)=10853.39+3.0*P+1.25*KUP2+(9.04+0.0062*P+0.0012*KCP2)*SD
01717 GU TO 600
01718 400 CONTINUE
01719 C ***** WELL PROGRAM 6E
01720 WP=6.5
01721 NLG1=2
01722 NLG2=2
01723 CASE1(1,2)=0.02*(P+200)
01724 CASE1(2,2)=.2*(P+200)

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01725 CASE1(3,2)=P+200
01726 CASE1(4,1)=P
01727 CASE1(4,2)=TVD1
01728 CASE2(1,2)=0.02*(P+200)
01729 CASE2(2,2)=.2*(P+200)
01730 CASE2(3,2)=P+200
01731 WHLC(1)=27605.
01732 WHLC(2)=35280.
01733 MISC(1)=25000.
01734 MISC(2)=19000.
01735 NDRT(1,1)=35+0.97*(P+200)/1000
01736 NDRT(1,2)=35+0.609*(P+200)/1000.
01737 NDRT(1,3)=35+4.55*(P+200)/1000
01738 NDRT(1,4)=33+(8.9*TMD1-1.86*P+2*TUP1)/1000
01739 NDRT(2,1)=35+0.97*(P+200)/1000
01740 NDRT(2,2)=35+0.609*(P+200)/1000.
01741 NDRT(2,3)=35+4.55*(P+200)/1000
01742 NDRT(2,4)=5.2+(5.6*TMD2-1.76*P)/1000
01743 VT=0.1829*P+817
01744 VVI=0.1457*(P+200-C.37*TVD1)
01745 CT(1)=7951.97+3.155*P+1.432*TMD1+(30.38+0.0057*P+0.0023*TMD1)*SD
01746 CT(2)=5801.97+4.29*P+(8.85+0.008*P)*SC
01747 LOGG1(2,1)=3
01748 LOGG1(2,2)=TVD1
01749 LOGG1(2,3)=TMD1
01750 LOGG1(2,4)=P+200
01751 LOGG2(2,1)=3
01752 LOGG2(2,2)=TVD2
01753 LOGG2(2,3)=TMD2
01754 LOGG2(2,4)=P+200
01755 GO TO 600
01756 CONTINUE
500 ***** WELL PROGRAM EF
01757 NP=6.0
01758 NDK1=2
01759 NDK2=5
01760 NC11=2
01761 NC12=4
01762 CASE1(1,2)=0.02*(P+200)
01763 CASE1(2,2)=.2*(P+200)
01764 CASE1(3,2)=15000
01765 CASE1(4,1)=14800
01766 CASE1(4,2)=P+200
01767 CASE1(5,1)=P
01768 CASE1(5,2)=TVD1
01769 CASE2(1,2)=0.02*(P+200)
01770 CASE2(2,2)=.2*(P+200)
01771 CASE2(3,2)=15000
01772 CASE2(4,1)=14800
01773 CASE2(4,2)=P+200
01774 WHLC(1)=31560.
01775 WHLC(2)=40335.
01776 MISC(1)=25000.
01777 MISC(2)=23000.
01778 NDRT(1,1)=35+0.97*(P+200)/1000
01779 NDRT(1,2)=35+0.609*(P+200)/1000.
01780 NDRT(1,3)=104
01781 NDRT(1,4)=5.2*(P+200)/1000.-8
01782 NDRT(1,5)=33+(8.9*TMD1-1.86*P+2*TUP1)/1000
01783 NDRT(2,1)=35+0.97*(P+200)/1000
01784 NDRT(2,2)=35+0.609*(P+200)/1000.
01785 NDRT(2,3)=104
01786 NDRT(2,4)=5.2*(P+200)/1000.-8
01787 NDRT(2,5)=5.2+(5.6*TMD2-1.76*KCP2)/1000
01788 VT=0.1673*P+1911
01789 VVI=0.1457*(15000-0.37*TVCI)+0.0701*(P+200)
01790 CT(1)=33970.43+3.21*P+1.201*TMD1+(85.83+0.0017*P+0.0014*TMD1)*SD
01791 CT(2)=32410.12+2.97*P+(46.80+0.0054*P)*SD
01792 LOGG1(1,2)=15000
01793 LOGG1(1,3)=15000
01794 LOGG1(1,4)=15000
01795 LOGG1(2,2)=P+200
01796 LOGG1(2,3)=P+200
01797 LOGG1(3,4)=P+200
01798 LOGG2(1,2)=15000
01799 LOGG2(1,3)=15000
01800 LOGG2(2,4)=15000
01801 LOGG2(2,2)=P+200
01802 LOGG2(2,3)=P+200
01803 LOGG2(3,4)=P+200
01804 LOGG2(3,2)=P+200
600 CONTINUE
01805 RETURN
01806 END
01807
01808 C
01809 C
01810 C
01811 C *****
01812 C * WELL SPECIFICATIONS SUBROUTINE *
01813 C *****
01814 C
01815 C THIS SUBROUTINE STORES THE WELL
01816 C SPECIFICATIONS IDENTIFIED BY THE
01817 C WELL TYPE IN READABLE FORM ON
01818 C TAPE 12, FILE WELL
01819 C
01820 C SUBROUTINE SPECIFY(ASMP,TOP1,TMD1,TMD2,TVD1,TVD2,KCP1,KCP2)
01821 C INTEGER CLASS,STATE,REMOTE,TECH
01822 C REAL KCP1,KCP2,LOGG1,LOGG2,NDRT,MISC
01823 C REAL LLP,LFP,LPT,LRE,LWS,HF,MM,NF,MT
01824 C COMMON/SPES/ CASE1(5,2),CASE2(5,2),LOGG1(3,4),LOGG2(3,4),
01825 C $NDRT(2,5),WHLC(2),MISC(2),CT(2),B(5,2),NDF1,NDRT2,
01826 C $VT,VVI,NC11,NC12,NLG1,NLG2,NP,NOP1,NOP2,NTND1,NTND2,
01827 C $NTAB1(5),NTAB2(5),NRIPI(5),NTIIP2(5),DRT1(5),DRT2(5),NPB(2),
01828 C $NTAB1,NTAB2,DRTAB2,NTICAI,NTICAI,NTBCA1,NTBCA2,URTCAL,DRTCA2
01829 C $CCMMON/PP/SD,SDM,LLP,LFP,LPT,LRE,LWS,NF,HF,
01830 C $ALPHA,BETA,TD,CLASS,STATE,REMOTE,WD,P,GRAC,TECH
01831 C DIMENSION BIT(5,2)
01832 C DO 5 I=1,NC11
01833 C DO 5 J=1,2

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RGICOST (cont)

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01833 IF(B(I,J).EQ.20.)BIT(I,J)=20.0
01834 IF(B(I,J).EQ.26.)BIT(I,J)=26.0
01835 IF(B(I,J).EQ.17.)BIT(I,J)=17.5
01836 IF(B(I,J).EQ.13.)BIT(I,J)=13.575
01837 IF(B(I,J).EQ.12.)BIT(I,J)=12.25
01838 IF(B(I,J).EQ.9.)BIT(I,J)=9.625
01839 IF(B(I,J).EQ.8.)BIT(I,J)=8.5
01840 IF(B(I,J).EQ.7.)BIT(I,J)=7.0
01841 IF(B(I,J).EQ.6.)BIT(I,J)=6.25
01842 IF(B(I,J).EQ.5.)BIT(I,J)=5.0
01843 5 CONTINUE
01844 WRITE(12,51)TOP1,P,WP,ASMP1
01845 51 FORMAT(1X,'+++++ TCPI =',F9.2,' P =',F8.2,' WP =',F3.1,
01846 $2X,F3.1,' CASE ASSUMPTIONS +++++')
01847 WRITE(12,150)SD,SDP,LLP,LFP,LPI,LKE,LWS
01848 150 FORMAT(1X,'SD=',F5.0,' SDP=',F5.0,' LLP=',F5.0,' LFP=',F5.0,
01849 $' LPI=',F5.0,' LKE=',F5.0,' LWS=',F5.0)
01850 WRITE(12,160)NF,HF,ALPHA,BETA,TECH
01851 160 FORMAT(1X,'NF=',F3.0,' HF=',F6.1,' ALPHA=',F5.2,' BETA=',F4.3,
01852 $' TECHNIQUE=',I1)
01853 WRITE(12,170)CLASS,STATE,REMOTE
01854 170 FORMAT(1X,'CLASS=',I3,' STATE=',I2,' REMOTE=',I1/)
01855 WRITE(12,601)
01856 WRITE(12,601)TOP1,TCPI
01857 WRITE(12,701)KOP1,KOP2
01858 WRITE(12,801)TMD1,TMD2
01859 WRITE(12,901)TVD1,TVD2
01860 WRITE(12,1001)
01861 WRITE(12,500)
01862 DO 10 I=1,NCL1
01863 WRITE(12,300)BIT(I,1),BIT(I,2),CASE1(I,1),CASE1(I,2),
01864 $CASE2(I,1),CASE2(I,2)
01865 10 CONTINUE
01866 WRITE(12,100)
01867 WRITE(12,600)
01868 N=NLG1
01869 IF(NLG2.GT.NLG1)N=NLG2
01870 DO 20 I=1,N
01871 WRITE(12,310)(LOGG1(I,J),J=1,4),(LOGG2(I,J),J=1,4)
01872 20 CONTINUE
01873 WRITE(12,100)
01874 WRITE(12,700)
01875 NN=NDR1
01876 IF(NDR2.GT.NDR1)NN=NDR2
01877 DO 30 I=1,NN
01878 WRITE(12,210)I,NDR1(I,1),NDR1(I,2),NDR1(I,3),NDR1(I,4),
01879 $NDR2(I,1),NDR2(I,2),NDR2(I,3),NDR2(I,4)
01880 30 CONTINUE
01881 WRITE(12,710)DRTAB1,NTAB1,NPB(1),DRTAB2,NTAB2,NPB(2)
01882 WRITE(12,720)DRTCA1,NTCA1,NTBCA1,DRTCA2,NTCA2,NTBCA2
01883 WRITE(12,100)
01884 WRITE(12,200)NDP1,NDP2
01885 200 FORMAT(1X,'DAYS IN PERMEABLE ROCK',5X,14,10X,14)
01886 WRITE(12,205)NTND1,NTND2
01887 205 FORMAT(1X,'DRILLING RIG DAYS',5X,14,10X,14/)
01888 WRITE(12,220)VT,VVT
01889 50 FORMAT(1X,' INJECTOR PRODUCTION')
01890 60 FORMAT(1X,'TOP1',F8.2,2X,F8.2)
01891 70 FORMAT(1X,'KUP',F8.2,2X,F8.2)
01892 80 FORMAT(1X,'TAD',F8.2,2X,F8.2)
01893 90 FORMAT(1X,'TVD',F8.2,2X,F8.2)
01894 100 FORMAT(1X,' ')
01895 210 FORMAT(1X,12,4X,2(1X,F6.1,1X,F6.1,1X,13,1X,13,5X))
01896 220 FORMAT(1X,1X,'VT=',F8.2,4X,'VVT=',F8.2/)
01897 300 FORMAT(1X,1X,F8.4,1X,F8.4,4(1X,F8.2))
01898 310 FORMAT(1X,2(1X,F2.0,1X,F8.2,1X,F8.2,1X,F8.2,3X))
01899 400 FORMAT(1X,1X,A2,1X,12/)
01900 500 FORMAT(1X,' CASING PROGRAM',/
01901 $,23X,' INJECTOR',10X,' PRODUCTION',/
01902 $, ' HOLE CASING TOP CF BOTTOM OF'
01903 $, ' TOP CF BOTTOM CF',/
01904 $, ' DIAMETER DIAMETER INTERVAL INTERVAL '
01905 $, ' INTERVAL INTERVAL',/
01906 600 FORMAT(1X,' LOGGING PROGRAM',/
01907 $,11X,' INJECTOR',22X,' PRODUCTION',/
01908 $,21X,' # COL. B CCL. C CUL. D',/
01909 $, ' INT NDR1 INTRIP BIT NDR1 LKT INTRIP BIT')
01910 700 FORMAT(1X,' ANGLE BUILDUP',2(1X,F8.1,1X,13,1X,13,12X))
01911 710 FORMAT(1X,' CONSTANT ANGLE',2(1X,F8.1,1X,13,1X,13,13X))
01912 720 FORMAT(1X,' CONSTANT ANGLE',2(1X,F8.1,1X,13,1X,13,13X))
01913 RETURN
01914 END
01915 C
01916 C
01917 C *****
01918 C * CASING COST SUBROUTINES *
01919 C *****
01920 C
01921 SUBROUTINE LINER(BIT,N,TOP,BOTTOM,TLTWT,COST)
01922 LENGTH=BOTTOM-TOP
01923 IF(BIT.EQ.9.)GO TC 10
01924 WEIGHT=23
01925 PRICE=1185.80
01926 GO TO 20
01927 10 CONTINUE
01928 WEIGHT=40
01929 PRICE=186.00
01930 IF(N.EQ.2)PRICE=2036.84
01931 20 CONTINUE
01932 COST=PRICE*LENGTH/100
01933 TOTWT=WEIGHT*LENGTH
01934 RETURN
01935 END
01936 SUBROUTINE LONGST(BIT,TEST1,TEST2,TABLE,N1,TCTWT,COST)
01937 DIMENSION TABLE(N1,5),LENGTH(10),PRICE(10),WEIGHT(10)
01938 COST=0.0
01939 TOTWT=0.0
01940 J=2

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RGICOST (cont)

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01941 5  CCNTINLE
01942 IF(BIT.EQ.TABLE(J,1))GO TO 10
01943 J=J+1
01944 GO TO 5
01945 10  CCNTINLE
01946 20  CCNTINLE
01947 IF(TABLE(J,2).GE.TEST1)GO TO 30
01948 J=J+1
01949 GO TO 20
01950 30  CCNTINLE
01951 K=1
01952 JJ=J-1
01953 40  CCNTINLE
01954 TOP=TABLE(JJ,3)
01955 IF(K.EQ.1)TOP=0.0
01956 WEIGHT(K)=TABLE(J,5)
01957 PRICE(K)=TABLE(J,4)
01958 LENGTH(K)=TABLE(J,3)-TOP
01959 IF(TABLE(J,3).GE.TEST2)GO TO 50
01960 J=J+1
01961 JJ=JJ+1
01962 K=K+1
01963 GO TO 40
01964 50  CCNTINLE
01965 LENGTH(K)=TEST2-TOP
01966 DO 60 J=1,K
01967 COST=CCST*LENGTH(M)/100*PRICE(M)
01968 TOTWT=TOTWT+LENGTH(M)*WEIGHT(M)
01969 60  CCNTINLE
01970 RETURN
01971 END
01972 C
01973 C *****
01974 C * DRILLING TIME SUBROUTINES
01975 C *****
01976 C
01977 SUBROUTINE DRILL(BIT,TCP,BCTOM,L,NINB,NTFIP,DRT)
01978 COMMON/TABLE/TSP3A(3,5,4),TSP3B(3,6),T7P1(5,6),TGP1(9,2),
01979 $TGP2(9,4),TGP3(15,3),TGP4(17,5),TGP8(10,2)
01980 COMMON/PP/SD,SDM,LLP,LFP,LPI,LKE,LWS,AF,HF,
01981 $ALPHA,BETA,TD,CLASS,STATE,REMOTE,WWO,P,GRAD,TECH
01982 NSUM=0
01983 C1=TSP3B(L,3)
01984 C2=TSP3B(L,4)
01985 J=1
01986 10  CCNTINLE
01987 IF(BIT.EQ.TSP3A(L,J,1))GO TO 20
01988 J=J+1
01989 GO TO 10
01990 20  CCNTINLE
01991 NN=2
01992 IF(BOTTOM.LE.(P+200))NN=1
01993 VNN=NN+2
01994 F=TSP3E(L,NN)
01995 PK=TSP3A(L,J,NNN)
01996 BL=TSP3A(L,J,2)
01997 K=PR*BL
01998 NTRIP=(BOTTOM-TOP)/K+.5
01999 IF(NTRIP.EQ.0)NTRIP=1
02000 NTNB=NTRIP+1
02001 DO 30 I=1,NTRIP
02002 NSUM=NSUM+1
02003 30  CCNTINLE
02004 DRT=(1+F)*(NTRIP*(TOP*C1+C2)+K*C1*NSUM)+(BOTTOM-TOP)/PK
02005 RETURN
02006 END
02007 C
02008 C ***** DIRECTIONAL DRILLING
02009 C
02010 SUBROUTINE DRILL(BIT,RKOP,AB,L,NT,FC,DRT)
02011 INTEGER CLASS,STATE,REMOTE,TECH
02012 COMMON/TABLE/TSP3A(3,5,4),TSP3B(3,6),T7P1(5,6),TGP1(9,2),
02013 $TGP2(9,4),TGP3(15,3),TGP4(17,5),TGP8(10,2)
02014 COMMON/PP/SD,SDM,LLP,LFP,LPI,LKE,LWS,AF,HF,
02015 $ALPHA,BETA,TD,CLASS,STATE,REMOTE,WWO,P,GRAD,TECH
02016 C1=TSP3B(L,3)
02017 C2=TSP3B(L,4)
02018 J=1
02019 10  CCNTINLE
02020 IF(BIT.EQ.TSP3A(L,J,1))GO TO 20
02021 J=J+1
02022 GO TO 10
02023 20  CCNTINLE
02024 PR=TSP3A(L,J,4)
02025 IF(TECH.EQ.1)GO TO 30
02026 NT=AB/TSP3B(L,6)+2
02027 DRT=NT*(C1*(RKOP+.5*AB)+C2)+AB/PR+Y*NT
02028 FC=535*DRT/24+AB/PR*TSP3B(L,6)
02029 GO TO 40
02030 30  CCNTINLE
02031 NT=AB/TSP3B(L,5)+3
02032 DRT=2*NT*(C1*(RKOP+.5*AB)+C2)+C1*(AB+C2)+AB/PR+26*NT
02033 FC=6342+558*DRT/24
02034 40  CCNTINLE
02035 RETURN
02036 END
02037 C
02038 C *****
02039 C * BIT & STABILIZER CGST SUBROUTINE *
02040 C *****
02041 C
02042 C SUBROUTINE BITSTB(N,NA,NB,NT,NBCA,DRT,RKCF,TMC)
02043 INTEGER CLASS,STATE,REMOTE,TECH
02044 DIMENSION NB(5)
02045 COMMON/TABLE/TSP3A(3,5,4),TSP3B(3,6),T7P1(5,6),TGP1(9,2),
02046 $TGP2(9,4),TGP3(15,3),TGP4(17,5),TGP8(10,2)
02047 COMMON/SPECS/CASE1(5,2),CASE2(5,2),LEGG1(3,4),LEGG2(3,4),
02048

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RGICOST (cont)

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02049 $NDRT(2,5),WHLC(2),MISC(2),CT(2),B(5,2),NDR1,NDR2,
02050 $VT,VV1,NC11,NC12,ALG1,ALG2,WP,NDP1,NCP2,NTNC1,NTND2,
02051 $NTNB(1,5),NTNB2(1,5),NTRIP1(1,5),NTRIP2(1,5),DRT1(1,5),DRT2(1,5),NPB(2),
02052 $NTAB1,NTAB2,DRTAB1,DRTAB2,NTCAL,NTCA2,NTBCA1,NTBCA2,DRICA1,DRICA2
02053 COMMON/PP/SO,SOM,LFP,LPT,LKE,LWS,NF,HF,
02054 $ALPHA,BETA,TD,CLASS,STATE,REMUTE,WWO,P,GRAD,TECH
02055 COMMON/CCSIS/CCOST(5,2),WEIGHT(5,2),CASINC(2),TOTWT(2),
02056 $TANG(2),TXTANG(2),RLOCAT,RIGMBL,RMVCST,RIG(2),TOTRIG,
02057 $RMC(2),FUEL,WTRSUP,WWELL,ETSAB(2),BTSCA(2),BTCST(5,2),SC(2),
02058 $RCNMC(2),TOTBIT(2),FCAB(2),TOTLC(2),TLRIG(2),WIT(2),RLC(5,2),
02059 $FTS(2),DERRIK,MCT,ATC,CTRAN,CORPER,PBPS,RETRAN,CRCSST,TPUMP
02060 I=1
02061 J=1
02062 10 CONTINUE
02063 IF(B(I,1).EQ.T7P1(J,1))GO TO 20
02064 J=J+1
02065 GO TO 10
02066 20 CONTINUE
02067 BTCST(I,N)=NB(I)*T7P1(J,2)
02068 IF(I.EQ.NN)GO TO 30
02069 I=I+1
02070 GO TO 10
02071 30 CONTINUE
02072 IF(TECT.EQ.1)GO TO 40
02073 NRSB=NT-1
02074 NPB(N)=0.0
02075 GO TO 50
02076 40 CONTINUE
02077 NRSB=NT
02078 NPB(N)=NT/3+1
02079 50 CONTINUE
02080 BITS=NRSB*T7P1(J,2)
02081 PILUT=NPB(N)*T7P1(J,3)
02082 BTSCA(N)=PILUT+BITS
02083 BTSCA(N)=NB(CA)*T7P1(J,2)
02084 NSTB=KKUP/1000+2
02085 NSTBCA=(TMD-(RKOP+PM))/1000+3
02086 SC(N)=NSTB*100.+NSTBCA*T7P1(J,5)
02087 RCNMC(N)=CRI/24*T7P1(J,4)
02088 TOTBIT(N)=BTSCA(N)+BITSAB(N)
02089 DO 60 I=1,NN
02090 TOTBIT(N)=TOTBIT(N)+BTCST(I,N)
02091 60 CONTINUE
02092 RETURN
02093 END
C
02094 *****
02095 * EVALUATION & COMPLETION COSTS *
02096 *****
C
02097 SUBROUTINE LOGING(TOPI,AA,N,NN,NNN)
02098 REAL LRIG(4,2)
02099 REAL LLP,LFP,LPT,LFE,LWS,FF,MM,NF
02100 DIMENSION AA(3,4)
02101 DIMENSION CD(4,2),ACC(4,2),TP(4,2),HT(4,2)
02102 COMMON/TABLE/T5P3A(3,5,4),T5P3B(3,6),T7P1(5,6),TGPI(4,2),
02103 $TGP2(9,4),TGP3(15,3),TGP4(17,5),TGP6(10,2)
02104 COMMON/SPECS/CASE1(5,2),CASE2(5,2),LCCG1(3,4),LCCG2(3,4),
02105 $NDRT(2,5),WHLC(2),MISC(2),CT(2),B(5,2),NDR1,NDR2,
02106 $VT,VV1,NC11,NC12,ALG1,ALG2,WP,NDP1,NCP2,NTNC1,NTND2,
02107 $NTNB(1,5),NTNB2(1,5),NTRIP1(1,5),NTRIP2(1,5),DRT1(1,5),DRT2(1,5),NPB(2),
02108 $NTAB1,NTAB2,DRTAB1,DRTAB2,NTCAL,NTCA2,NTBCA1,NTBCA2,DRICA1,DRICA2
02109 COMMON/PP/SO,SOM,LFP,LPT,LKE,LWS,NF,HF,
02110 $ALPHA,BETA,TD,CLASS,STATE,REMUTE,WWO,P,GRAD,TECH
02111 COMMON/CCSIS/CCOST(5,2),WEIGHT(5,2),CASINC(2),TOTWT(2),
02112 $TANG(2),TXTANG(2),RLOCAT,RIGMBL,RMVCST,RIG(2),TOTRIG,
02113 $RMC(2),FUEL,WTRSUP,WWELL,ETSAB(2),BTSCA(2),BTCST(5,2),SC(2),
02114 $RCNMC(2),TOTBIT(2),FCAB(2),TOTLC(2),TLRIG(2),WIT(2),RLC(5,2),
02115 $FTS(2),DERRIK,MCT,ATC,CTRAN,CORPER,PBPS,RETRAN,CRCSST,TPUMP
02116 DATA CC/8*0.0/,TP/8*0.0/,ACD/8*0.0/,
02117 $ECT/0.0/,SPCL/0.0/
02118 DO 5 KK=1,5
02119 DO 5 JJ=1,2
02120 RLC(KK,JJ)=0.0
02121 5 CONTINUE
02122 TLRIG(N)=0.0
02123 TOTLC(N)=0.0
02124 L=1
02125 10 CONTINUE
02126 IF((2*LLP).LT.TGPI(L,1))GO TO 20
02127 L=L+1
02128 GO TO 10
02129 20 CONTINUE
02130 SERV=TGP1(L,2)
02131 DO 100 I=1,NN
02132 J=AA(I,1)
02133 II=J-2
02134 R3=AA(I,3)
02135 R4=AA(I,4)
02136 R2=R3-R4
02137 IF(II)30,40,50
02138 30 CONTINUE
02139 TP(J,N)=40
02140 LRIG(J,N)=R2/2000.+2.5+R2/6000.
02141 CD(J,N)=900.
02142 IF(R3.GT.2000.)CD(J,N)=0.23*R3+440.
02143 IF(R2.LE.2000.)CD(J,N)=0.45*R3-0.22*R4
02144 GO TO 60
02145 40 CONTINUE
02146 TP(J,N)=120.
02147 LRIG(J,N)=R2/1000.+4.0+K2/18000.+R2/2500.
02148 CD(J,N)=2840.
02149 IF(R3.GT.2000.)CD(J,N)=0.72*R3+1400
02150 IF(R2.LE.2000.)CD(J,N)=1.42*R3-0.7*K4
02151 GO TO 60
02152 50 CONTINUE
02153 TP(J,N)=160
02154 LRIG(J,N)=5.5+R2/5000.+R2/1800.+K2/2500.+R2/3000.+R2/1500.
02155
02156

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RGICOST (cont)

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02157 CD(J,N)=3800
02158 IF(R3.GT.2000)CD(J,N)=1.09*R3+1700.
02159 IF(R2.GE.2000)C(J,N)=1.94*R3-0.85*R4
02160 60 CONTINUE
02161 T=72.+GRAD*AA(I,2)
02162 K=1
02163 70 CONTINUE
02164 IF(R3.LT.TGP2(K,1))GO TC 80
02165 K=K+1
02166 GO TO 70
02167 80 CONTINUE
02168 ADD(J,N)=TGP2(K,4)
02169 IF(T.LE.450.)ADD(J,N)=TGP2(K,3)
02170 IF(T.LE.400.)ADD(J,N)=TGP2(K,2)
02171 IF(T.LE.300.)ADD(J,N)=0.0
02172 HT(J,N)=J*ADD(J,N)
02173 IF(REMCITE.EQ.1)CD(J,N)=1.1*CD(J,N)
02174 RLC(J,N)=C(J,N)+T*F(J,N)+HT(J,N)+SERV
02175 TOTLC(N)=TOTLC(N)+RLC(J,N)
02176 TLRIG(N)=TLRIG(N)+RLC(J,N)
02177 100 CONTINUE
02178 I=1
02179 110 CONTINUE
02180 IF(B(NAN,1).EQ.T7P1(I,1))GO TO 120
02181 I=I+1
02182 GO TO 110
02183 120 CONTINUE
02184 BASE=T7P1(1,5)
02185 NTIME=(LFP/40.+48+(12+TOP1/500.))/24+1
02186 NDEPTH=(TOP1-4000)/1000
02187 IF(TOP1.GT.4000.)ETC=50.*(2+2*NDEPTH)
02188 IF(TOP1.GT.4000.)ACD(4,N)=39*NDEPTH
02189 IF(B(NAN,1).EQ.6.)ETC=39.*(2+2*NDEPTH)
02190 IF(LFP.GT.200.)SPCL=224.*NTIME
02191 TRANS=2*LFP*0.65
02192 WIT(N)=BASE+ADD(4,N)+ETC*SPCL+TRANS
02193 CD(4,N)=0.37*R3+1100.
02194 IF(REMCITE.EQ.1)CD(4,N)=CD(4,N)*1.1
02195 HT(4,N)=HT(3,N)
02196 FIS(N)=SERV+CD(4,N)+HT(4,N)
02197 LKIG(4,N)=2*R3/10000.+R2/6000.+R2/3000.
02198 TLRIG(N)=TLRIG(N)+LKIG(4,N)
02199 RETURN
02200 END
C
C
C *****
C * CORRELATION & PERFORATING COSTS *
C *****
C
02201
02202
02203
02204
02205
02206
02207 SUBROUTINE CORPRF(R3,R4,NAN)
02208 REAL LLP,LFP,LPT,LRE,LWS,FF,NF
02209 COMMON/1ABLE/15P3A(3,5,4),15P3B(3,6),17P1(5,6),19P1(9,2),
02210 19P2(9,4),19P3(15,3),19P4(17,5),19P8(10,2)
02211 COMMON/SPECS/CASE1(5,2),CASE2(5,2),LOGG1(3,4),LOGG2(3,4),
02212 $NDK1(2,5),WHLC(2),MLSC(2),CT(2),B(5,2),NDK1,NCR2,
02213 $VT,VVT,NC1,NC2,NLG1,NLG2,WP,NUP1,NUP2,NIND1,NTNU2,
02214 $NTAB1(5),NTAB2(5),NTRIP1(5),NTRIP2(5),DRT1(5),DRT2(5),NPB(2),
02215 $NTAB1,NTAB2,DRTAB1,DRTAB2,NTCA1,NTCA2,NTBCA1,NTBCA2,DRTCA1,DRTCA2
02216 COMMON/PP/SD,SDM,LLP,LFP,LPT,LRE,LWS,NF,FF,
02217 $ALPHA,BETA,TD,CLASS,STATE,REMCITE,mw,P,GRAD,TECH
02218 COMMON/CUSTS/CCOST(5,2),WEIGHT(5,2),CASING(2),TOTRIG(2),
02219 $TANG(2),TXTANG(2),FLOCAT,RIGMBL,RMVLST,RIG(2),TOTRIG,
02220 $RMC(2),FUEL,WTRSUP,WELL,BTSAB(2),BTSCA(2),BTGST(5,2),SC(2),
02221 $RCRMC(2),TOTBIT(2),FCAB(2),TOTLC(2),TLRIG(2),WIT(2),RLC(5,2),
02222 $FIS(2),DEKRK,MT,ATC,CTRAN,CLPLR,PBPS,RETRAN,CTRST,TPUMP
02223 CD=0.13*R3+280
02224 IF(R2.GE.2000)CD=0.27*R3-0.14*R4
02225 K=1
02226 130 CONTINUE
02227 IF(R3.LT.TGP3(K,1))GO TC 140
02228 K=K+1
02229 GO TO 130
02230 140 CONTINUE
02231 SHOTS=TGP3(J,2)
02232 R5=(R2+R3)/2
02233 K=1
02234 150 CONTINUE
02235 IF(R5.LT.TGP3(K,1))GO TO 160
02236 K=K+1
02237 GO TO 150
02238 160 CONTINUE
02239 SHOTS=SHOTS+10*((NF-1)*TGP3(K,2))
02240 SFA=60*NF
02241 TT=72+GRAD*R5
02242 K=1
02243 170 CONTINUE
02244 IF(R5.LT.TGP2(K,1))GO TC 180
02245 K=K+1
02246 GO TO 170
02247 180 CONTINUE
02248 CHARGE=TGP2(K,4)
02249 IF(TT.LE.450)CHARGE=TGP2(K,3)
02250 IF(TT.LE.400)CHARGE=TGP2(K,2)
02251 IF(TT.LE.300)CHARGE=0.0
02252 HT=(1+NF)/4.*CHARGE
02253 IF(TT.LE.350)GO TO 190
02254 IF(TT.GE.470)GO TO 190
02255 HT=HT+280*NF
02256 190 CONTINUE
02257 IF(REMCITE.EQ.2)GO TO 200
02258 REMCHG=4000
02259 IF(1.1*CD).GT.4000.)REMCHG=.1*CD
02260 200 CONTINUE
02261 CORPER=CD+SERV+SHOTS+HT+REMCHG+SFA
02262 ETJ=2.0*R2/1800+R5/10000+R5/20000*NF/4+0.145*NF
02263 CRT=22+LWS/20+NF*(14.5+R4/2000)+R3*(7+NF)/2000
02264 CRD=CRT/24

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RGICOST (cont)

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02265      CRGST=116.98*CRT+4.15*CRD
02266      IF(LWS.GT.50)CRGST=CRGST+420*CRD
02267      IF(B(NAN,1).EQ.7)GO TO 210
02268      SCRAPE=247.0
02269      IF(R3.GE.12500)SCRAPE=370.0
02270      GO TO 220
02271  210  CONTINUE
02272      SCRAPE=259.0
02273      IF(R3.GE.12500)SCRAPE=388.0
02274  220  CONTINUE
02275      K=1
02276  230  CONTINUE
02277      IF(R3.LE.TGP4(K,1))GO TO 240
02278      K=K+1
02279      GO TO 230
02280  240  CONTINUE
02281      BASIC=NF*(TGP4(K,3)+TGP4(K,5))
02282      IF(B(NAN,1).EQ.7)BASIC=NF*(TGP4(K,2)+TGP4(K,4))
02283      IF(R5/1000.LE.5)GO TO 250
02284      RT=29.0+25.35
02285      IF(B(NAN,1).EQ.7)RT=25.5+21.8
02286      ADD=NF*(R5/1000-5)*RT
02287  250  CONTINUE
02288      SPCLST=(230.0)*(CRD-2)
02289      ACCESS=400
02290      PBPS=SCRAPE+BASIC+ADD+SPCLST+ACCESS
02291      WS=0.4*CRD+1.05*R3
02292      BOPC=26.0*CRD
02293      IF(R3.GE.5000)BOPC=850.0+165*CRD
02294      IF(BOPC.LT.280)BOPC=280
02295      TRANS=1*LKE/10
02296      RETRAN=1000+BOPC*TRANS*WS
02297      PSI=.3*WS
02298      HHP=10*PSI/40.8
02299      K=1
02300  300  CONTINUE
02301      IF(PSI.LT.TGP8(K,1))GO TO 310
02302      K=K+1
02303      GO TO 300
02304  310  CONTINUE
02305      PUMP=NF*HHP*TGP8(K,2)
02306      MIN=NF*1540*R3/10800+1
02307      IF(PUMP.LT.MIN)PUMP=MIN
02308      RNPMP=NF*0.09*HHP*(K3/20000+0.5)
02309      MMLAGE=R3/10800+1
02310      MILAGE=1.2*PUMP*(VMM)
02311      TPUMP=1.04*(PUMP+RNPMP+MILAGE)
02312      RETURN
02313      END
02314  C
02315  C
02316  C
02317  C
02318  C
02319  C
02320      SUBROUTINE C2SUB(TOPI,ASMP1)
02321      REAL MISC,MTC,INCEN
02322      INTEGER CLASS,STATE,REMOTE,TECH
02323      COMMON/SPECS/CASE1(5,2),CASE2(5,2),LOGG1(3,4),LOGG2(3,4),
02324      SNDR1(2,5),WHLC(2),MISC(2),CT(2),B(5,2),NDR1,NDR2,
02325      SVT,VVT,NC11,NC12,NLG1,NLG2,P,P,NDR1,NDR2,NTND1,NTND2
02326      COMMON/PP/SD,SOM,LLP,LFP,LNE,LWS,NF,HF,
02327      $ALPHA,BETA,TD,CLASS,STATE,REMOTE,WWD,P,GRAD
02328      COMMON/COSTS/CCOST(5,2),HEIGHT(5,2),CASING(2),TOTWT(2),
02329      $TANG(2),TXTANG(2),RLOCAT,RIGMBL,RMVCST,RIG(2),TGTTRIG,
02330      $RMC(2),FUEL,ATRSUP,WELL,BTSAB(2),BTCA(2),BTCST(5,2),SC(2),
02331      $RCNMC(2),TOTBIT(2),FCAB(2),TOTLC(2),TLRIG(2),WIT(2),KLC(2,2),
02332      $FTS(2),DERRIK,MTC,ATC,CTRAN,CORPER,PBPS,RETRAN,CRGST,TPUMP,
02333      $INCEN,SUPCOL,SHAKE(2),WELTOT(2),GANDA,HCRGST
02334      WRITE(13,50)TOPI,P,WP,ASMP1
02335  5C  FORMAT(1X,' ',/
02336      $F3.1,' CASE DRILLING ASSUMPTIONS',/)
02337      $
02338      WRITE(13,220)KLOCAT
02339      WRITE(13,221)RMVCST
02340      WRITE(13,222)RIGMBL
02341      WRITE(13,223)FUEL
02342      WRITE(13,224)WTRSUP
02343      WRITE(13,225)WELL
02344      WRITE(13,226)CORPER
02345      WRITE(13,227)PBPS
02346      WRITE(13,229)CRGST
02347      WRITE(13,231)TPUMP
02348      WRITE(13,230)DERRIK
02349      WRITE(13,228)RETRAN
02350      WRITE(13,240)CTRAN
02351      WRITE(13,232)MTC
02352      WRITE(13,250)ATC
02353      WRITE(13,255)SUPCOL
02354      WRITE(13,260)INCEN
02355      WRITE(13,270)GANDA
02356      WRITE(13,110)
02357      WRITE(13,115)WHLC(1),WHLC(2)
02358      WRITE(13,120)TANG(1),TANG(2)
02359      WRITE(13,130)TXTANG(1),TXTANG(2)
02360      WRITE(13,140)RIG(1),RIG(2)
02361      WRITE(13,160)TGTBIT(1),TGTBIT(2)
02362      WRITE(13,170)SC(1),SC(2)
02363      WRITE(13,180)RCNMC(1),RCNMC(2)
02364      WRITE(13,190)FCAB(1),FCAB(2)
02365      WRITE(13,150)RMC(1),RMC(2)
02366      WRITE(13,300)CT(1),CT(2)
02367      WRITE(13,310)TOTLC(1),TOTLC(2)
02368      WRITE(13,320)WIT(1),WIT(2)
02369      WRITE(13,330)FTS(1),FTS(2)
02370      WRITE(13,340)MISC(1),MISC(2)
02371      WRITE(13,350)SHARE(1),SHARE(2)
02372      WRITE(13,360)WELTOT(1),WELTOT(2)

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RGICOST (cont)

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02373      WRITE(13,400)HRCOST
02374      100  FORMAT(1X,'COSTS BY INTERVAL',//
02375             $,23X,'INJECTOR',10X,'PRODUCER',//
02376             $,INTERVAL,CASING,BITS,CASING,BITS',//)
02377      110  FORMAT(1X,30X,'INJECTOR',10X,'PRODUCER',//)
02378      115  FORMAT(1X,'WELLHEAD & LINER HANGERS',4X,F10.2,8X,F10.2)
02379      120  FORMAT(1X,'TOTAL TANGIBLE COSTS',8X,F10.2,8X,F10.2)
02380      125  FORMAT(1X,'TAX ON TANGIBLES',12X,F10.2,8X,F10.2)
02381      140  FORMAT(1X,'DRILLING RIG COST',11X,F10.2,8X,F10.2)
02382      150  FORMAT(1X,'DRILLING FLUID COST',9X,F10.2,8X,F10.2)
02383      160  FORMAT(1X,'BIT COST',20X,F10.2,8X,F10.2)
02384      170  FORMAT(1X,'STABILIZER COST',13X,F10.2,8X,F10.2)
02385      180  FORMAT(1X,'NON-MAGNETIC COLLAR RENTAL',2X,F10.2,8X,F10.2)
02386      190  FORMAT(1X,'ANGLE BUILDUP FIXED COST',4X,F10.2,8X,F10.2)
02387      300  FORMAT(1X,'CEMENTING CCST',14X,F10.2,8X,F10.2)
02388      310  FORMAT(1X,'LOGGING COST',16X,F10.2,8X,F10.2)
02389      320  FORMAT(1X,'WATER INJECTION TEST',8X,F10.2,8X,F10.2)
02390      330  FORMAT(1X,'FLOWMETER & TEMP SURVEY',5X,F10.2,8X,F10.2)
02391      340  FORMAT(1X,'MISCELLANEOUS COSTS',9X,F10.2,8X,F10.2)
02392      350  FORMAT(1X,'SHARE OF COMMON COSTS',7X,F10.2,8X,F10.2)
02393      360  FORMAT(1X,'TOTALS',22X,F10.2,8X,F10.2)
02394      400  FORMAT(1X,'TOTAL CCST TO ESTABLISH A FOM RESERVOIR',1X,F12.2//)
02395      200  FORMAT(1X,3X,12,3X,4(1X,F10.2))
02396      210  FORMAT(1X,'TOTALS',4(1X,F10.2))
02397      220  FORMAT(1X,'LOCATION CCST',10X,F9.2)
02398      221  FORMAT(1X,'MOVE CCST',20X,F9.2)
02399      222  FORMAT(1X,'RIG MOBILIZATION CCST',7X,F10.2)
02400      223  FORMAT(1X,'RIG FUEL CCST',15X,F10.2)
02401      224  FORMAT(1X,'WATER SUPPLY SETUP CHARGES',3X,F9.2)
02402      225  FORMAT(1X,'WATER WELL CCST',14X,F9.2)
02403      226  FORMAT(1X,'CORRELATING & PERFORATING',5X,F9.2)
02404      227  FORMAT(1X,'PACKER, BOP, & SCAPEK',8X,F9.2)
02405      228  FORMAT(1X,'RENTAL EQUIP. & TRANS.',8X,F9.2)
02406      229  FORMAT(1X,'COMPLETION RIG COST',11X,F9.2)
02407      230  FORMAT(1X,'PORTABLE DERRICK',14X,F9.2)
02408      231  FORMAT(1X,'PUMP TRUCK SERVICE',12X,F9.2)
02409      232  FORMAT(1X,'DRILLING FLUID TRANSPORTATION',1X,F9.2)
02410      240  FORMAT(1X,'CASING TRANSPORTATION',8X,F10.2)
02411      250  FORMAT(1X,'ADDITIONAL TRANSPORTATION',5X,F9.2)
02412      255  FORMAT(1X,'SUPERVISION & CC. LABOR',7X,F9.2)
02413      260  FORMAT(1X,'INCIDENTAL COSTS',13X,F10.2)
02414      270  FORMAT(1X,'G & A COSTS',18X,F10.2)
02415      RETURN
02416      END
02417  C
02418  C
02419      SUBROUTINE INITAL
02420      INTEGER CLASS,STATE,REMOTE,TECH
02421      COMMON/SPECS/CASE1(5,2),CASE2(5,2),LOGG1(3,4),LOGG2(3,4),
02422      $NDRT(2,5),WHLC(2),MISC(2),CT(2),B(5,2),NDF1,NDR2,
02423      $VT,VVT,NC11,NC12,NLG1,NLG2,WP,NDP1,NDP2,NTAD1,NTAD2,
02424      $NTNB1(5),NTNB2(5),NTRIP1(5),NTRIP2(5),DRT1(5),DRT2(5),NPB(2),
02425      $NTAD1,NTAB2,DRTAB1,DRTAB2,NIC1,NICA2,NTBC1,NTBCA2,DRTCA1,DRTCA2
02426      $COMMON/PP/SO,SDM,LLP,LFP,LPT,LKL,LWS,AF,HF,
02427      $ALPHA,BETA,TD,CLASS,STATE,REMOTE,WWU,P,FORM,TECH
02428      COMMON/COSTS/CCOST(5,2),WEIGHT(5,2),CASING(2),TOTW(2),
02429      $TANG(2),ITXANG(2),FLOCAT,KLUMBL,MVLCST,WIC(2),TOTW(2),
02430      $HMC(2),FUEL,WTRSUP,WELL,BISAB(2),BISCA(2),BTCST(5,2),SC(2),
02431      $RCNM(2),TOTBIT(2),FCAB(2),TOTLC(2),TLRIG(2),WIT(2),NLIC(5,2),
02432      $FTS(2),DERRIK,MTG,ATC,CTRAK,CLRPEK,PEFS,RETRAN,CRCST,TFUMP,
02433      $INC DEN,SUPCUL,SHARE(2),WELTUF(2),GANDA,HRCOST
02434      DO 10 I=1,5
02435      NTNB1(I)=0.0
02436      NTAB2(I)=0.0
02437      NTRIP1(I)=0.0
02438      NTRIP2(I)=0.0
02439      DRT1(I)=0.0
02440      DRT2(I)=0.0
02441      DO 10 J=1,2
02442      CASE1(I,J)=0.0
02443      CASE2(I,J)=0.0
02444      NDRT(I,J)=0.0
02445      B(I,J)=0.0
02446      CCOST(I,J)=0.0
02447      WEIGHT(I,J)=0.0
02448      10  CONTINUE
02449      DO 20 I=1,3
02450      DO 20 J=1,4
02451      LOGG1(I,J)=0.0
02452      LOGG2(I,J)=0.0
02453      20  CONTINUE
02454      NC11=0
02455      NC12=0
02456      NLG1=0
02457      NLG2=0
02458      NDP1=0
02459      NDP2=0
02460      RETURN
02461      END

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APPENDIX D

HDR3

Los Alamos Identification No. LP-1467

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00001 *****
00002 *****
00003 ** HDR3 -- RGI AND GEC WELL COSTS **
00004 ** TOTAL COST VERSION **
00005 *****
00006 *****
00007 **
00008 *** THIS PROGRAM DETERMINES TOTAL COSTS OF ESTABLISHING AN HDR
00009 *** RESERVOIR AND REDRILLING WHEN NECESSARY VIA EITHER SAME
00010 *** DEPTH OR DEEPER DEPTH REDRILLING TECHNIQUES. A PREHEAT OPTION
00011 *** IS ALSO INCLUDED.
00012 **
00013 *** PARAMETERS ARE TO BE STORED ON TAPE 1, FILE "LOOPCN". RGI
00014 *** DRILLING COSTS ARE STORED ON TAPE 2, FILE "WICST_", WHERE
00015 *** _ IS THE NUMBER OF FRACTURES.
00016 **
00017 *** OUTPUT IS PRINTED DIRECTLY AT THE TERMINAL. ONLY TOTAL
00018 *** COSTS ARE GIVEN. IF INTERMEDIATE COST DATA IS DESIRED IT
00019 *** IS NECESSARY TO ALTER THE PROGRAM. ALL INTERMEDIATE COST
00020 *** DATA ARE STORED, SO ONLY ADDITIONAL WRITE STATEMENTS ARE
00021 *** REQUIRED.
00022 **
00023 **
00024 DIMENSION R(3),DCIF(3),FCIF(3),CC(10),TRUCK(10),C(10,31),T(10,31),TA(10),TTA(10),TXX(10,31),TTXX(10,31),TTT(10,31),TTTXX(10,31),
00025 DIMENSION RGICST(9,13),RGICD(10),RGILEV(10,3,3,3),RGIODD(10,3,3,3),RGISE(10,3,3),RGISL(10,3,3),RGIPH(10,3,3,3),RGISD(10,3,3,3),
00026 DIMENSION GECD(10),GEOR(10,3,3,3),GEUSD(10,3,3),GEOTSD(10,3,3),GEOPH(10,3,3,3),GECD(10,3,3,3),GECD(10,3,3,3),GECD(10,3,3,3),
00027 DOUBLE PRECISION BTUS,SMDOT,MODT(10,31),HDRBTU,BARREL,BENFIT,TUTBEN(3,3),NETEN(6)
00028 COMMON IT(10,31)
00029 REAL HICST,HF
00030 INTEGER TONE,TTWO,THREE
00031 CALL OPSYS('ALLO', 'LOOPCN', 1)
00032 CALL OPSYS('ALLO', 'WICST3', 2)
00033 READ(1,*)NR,(R(I),I=1,NR),NDCIF,(DCIF(I),I=1,NDCIF),NFCIF,(FCIF(I),I=1,NFCIF),BTUS,TC,G,ITH,DB,TGB,DELT,HFRAC,HF,AP
00034 DO 10 I=1,9
00035 10 READ(2,*)LN,(RGICST(I,J),J=1,LN)
00036 **
00037 *** INITIAL DRILLING COSTS AND TEMPERATURE DRAWDOWN.
00038 *** DETERMINES YEAR THAT REDRILLING TAKES PLACE.
00039 **
00040 FCRBTU=(BTUS*(.32+.11))*1.05
00041 BARREL=BTUS/(144000.*42.)
00042 CR=G/(1000.*3.28084)
00043 SMDOT=(HDRBTU*3.779)/(DELT*500.*8760.*60.*1.8)
00044 TINJ=TD-DELT
00045 DO 2000 L=1,9
00046 CC(L)=RGICST(L,1)
00047 TRUCK(L)=TGB+(DD(L)-DB)*CR
00048 DO 3000 I=1,NR
00049 DO 4000 II=1,NDCIF
00050 DO 5000 III=1,NFCIF
00051 ICTBEN(I,III)=0.0
00052 DO 77 IPS=1,ITH
00053 BENFIT=(BARREL*RP)*((1+FCIF(III))*IPS)/(1000000.*((1+R(I))*IPS))
00054 ICTBEN(I,III)=TUTBEN(I,III)+BENFIT
00055 77 CONTINUE
00056 RGICD(L)=RGICST(L,2)/1000000.
00057 CALL GEUCST(DB,DD(L),HFRAC,GECD,CFRAC)
00058 GECD(L)=GEUCST*CFRAC
00059 T(L,1)=TRUCK(L)
00060 TT(L,1)=T(L,1)
00061 TTT(L,1)=T(L,1)
00062 DO 20 J=1,ITH
00063 MODT(L,J)=SMDOT*(TD-TINJ)/(T(L,J)-TINJ)
00064 CALL FLOWNFRAC,HF,J,MODT(L,J),Z(L,J),ERF(L,J)
00065 T(L,J+1)=TINJ+(TRUCK(L)-TINJ)*ERF(L,J)
00066 TT(L,J+1)=T(L,J+1)
00067 TTT(L,J+1)=T(L,J+1)
00068 IF(T(L,J+1).LE.TDIGO TO 30
00069 20 CONTINUE
00070 DO 5555
00071 30 CONTINUE
00072 IF(T(L,ITH+1).EQ.TDIGO TO 5555
00073 **
00074 *** SAME DEPTH REDRILLING -- RGI COSTS.
00075 *** PREHEAT OPTION -- COMPARES CALCULATED COSTS TO THOSE
00076 *** FOR REDRILLING. CHOOSES THE MINIMUM COST.

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HDR3 (cont)

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CCC77 "
CCC78 A=J
CCC79 TX(L)=T(L,J+1)
CCC80 TX(L)=T(L,J)
CCC81 NRD(L)=1
CCC82 RGISD(L,I,11)=0.0
CCC83 RGISD(L,I,11)=0.0
CCC84 THTCST=0.0
CCC85 NN(L,NRD(L))=N
CCC86 TCNE=NN(L,NRD(L))
CCC87 MM=TCNE
CCC88 NKK=TCNE-1
CCC89 NKK=1
CCC90 40 CONTINUE
CCC91 CC 121 NKK=NK,NKK
CCC92 IF (NKK+J-1.GT.ITH+1)GO TC 221
CCC93 121 T(L,NKK+J-1)=T(L,NKK)
CCC94 221 CCNTINUE
CCC95 RGICDD(L,I,11,NN(L,NRD(L)))=(RGICST(L,3)+.358160.)*(1+DCIF(11))*N/(1+K(11))*N
CCC96 RGISD(L,I,11)=RGISD(L,I,11)+RGICDD(L,I,11,NN(L,NRD(L)))
CCC97 NRD(L)=NRD(L)+1
CCC98 A=N+J-1
CCC99 NN(L,NRD(L))=N
CCC100 TTC=NN(L,NRD(L))
CCC101 IF (TTC.GT.ITH)TTC=ITH+1
CCC102 CALL HEAT(L,TONE,TTC,MM,RP,TINJ,TCK(L),SMDCT,R(1),FCIF(11),TD,NFRAC,HF,HTCST(NRD(L)-1))
CCC103 IF (HTCST(NRD(L)-1).GE.RGICDD(L,I,11,TCNE))GO TO 123
CCC104 MM=MM+(TTC-TCNE)
CCC105 GO TO 124
CCC106 123 NKK(N(L,NRD(L)))=1
CCC107 HTCST(NRD(L)-1)=RGICDD(L,I,11,TCNE)
CCC108 MM=(TTC-TONE)+1
CCC109 124 CCNTINUE
CCC110 THTCST=HTCST+HTCST(NRD(L)-1)
CCC111 IF (NN(L,NRD(L)).GT.ITH)GO TO 45
CCC112 NKK=TCNE
CCC113 NKK=TTC-1
CCC114 CC 122 NKK=NK,NKK
CCC115 IF (NKK+J-1.GT.ITH+1)GO TC 222
CCC116 122 T(L,NKK+J-1)=T(L,NKK)
CCC117 222 CCNTINUE
CCC118 RGIEVN(L,I,11,NN(L,NRD(L)))=(RGICST(L,4)+.358160.)*(1+DCIF(11))*N/(1+K(11))*N
CCC119 RGISD(L,I,11)=RGISD(L,I,11)+RGIEVN(L,I,11,NN(L,NRD(L)))
CCC120 NRD(L)=NRD(L)+1
CCC121 A=A+J-1
CCC122 NN(L,NRD(L))=N
CCC123 TTTHREE=NN(L,NRD(L))
CCC124 IF (TTTHREE.GT.ITH)TTTHREE=ITH+1
CCC125 CALL HEAT(L,TTC,TTTHREE,MM,RP,TINJ,TCK(L),SMDCT,R(1),FCIF(11),TD,NFRAC,HF,HTCST(NRD(L)-1))
CCC126 IF (HTCST(NRD(L)-1).GE.RGIEVN(L,I,11,TTTHREE))GO TO 125
CCC127 MM=MM+(TTTHREE-TTC)
CCC128 GO TO 126
CCC129 125 NKK(N(L,NRD(L)))=1
CCC130 HTCST(NRD(L)-1)=RGIEVN(L,I,11,TTTHREE)
CCC131 MM=(TTTHREE-TTC)+1
CCC132 126 CCNTINUE
CCC133 TCNE=TTTHREE
CCC134 THTCST=HTCST+HTCST(NRD(L)-1)
CCC135 IF (NN(L,NRD(L)).GT.ITH)GO TC 45
CCC136 NKK=TTTHREE
CCC137 NKK=TCNE-1
CCC138 GO TO 40
CCC139 45 RGISD(L,I,11)=RGICD(L)+RGISD(L,I,11)
CCC140 THTCST=HTCST+RGICD(L)
CCC141 RCIPHIL(L,I,11,111)=THTCST
CCC142 NRD(L)=NRD(L)-1
CCC143 "
CCC144 *** SAME DEPTH REDRILLING -- GEG COSTS.
CCC145 *** PREHEAT OPTION -- COMPARES COSTS CALCULATED ABOVE
CCC146 *** WITH THOSE FOR REDRILLING. CHOOSES THE MINIMUM COST.
CCC147 "
CCC148 GEOSD(L,I,11)=0.
CCC149 GEOTSC(L,I,11)=0.0
CCC150 THTCST=0.0
CCC151 NKK=NRD(L)
CCC152 CC 129 NKK=1,NKK
CCC153 A=NN(L,NKK)-1
CCC154 GEORD(L,I,11,NN(L,NKK))=(1.5*GEODCT+GFRAC+.35816)*(1+DCIF(11))*N/(1+K(11))*N
CCC155 GEOSD(L,I,11)=GEOSD(L,I,11)+GEORD(L,I,11,NN(L,NKK))

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HDR3 (cont)

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00156 IF (HTCST(NK).GE.GEORD(L,I,II,NN(L,NK)))GO TO 127
00157 GO TO 128
00158 127 NKKKN(L,NK)=1
00159 HTCST(NK)=GEORD(L,I,II,NN(L,NK))
00160 128 CONTINUE
00161 HTCST=HTCST+HTCST(NK)
00162 IF (NN(L,NK).GT.III)GO TO 55
00163 129 CONTINUE
00164 55 GEOTSD(L,I,II)=GEODD(L,I,II)+GEOSD(L,I,II)
00165 HTCST=HTCST+GECCD(L)
00166 GECPH(L,I,II,III)=HTCST
00167 "
00168 *** DEEPER DEPTHS REDRILLING -- RGI AND GEC COSTS.
00169 "
00170 RGICD(L,I,II)=0.
00171 GEODD(L,I,II)=0.
00172 N=J
00173 K(L)=0
00174 J=4
00175 70 CONTINUE
00176 J=J+1
00177 K(L)=K(L)+1
00178 TXX(L,K(L))=TTT(L,N+1)
00179 TTX(L,K(L))=TTT(L,N)
00180 NNN(L,K(L))=N
00181 C(L,NNN(L,K(L)))=DU(L)+(FF*K(L))
00182 TTRCK=TDB+(C(L,NNN(L,K(L)))-DB)*GR
00183 TTT(L,N)=TTRCK
00184 IF (RGICST(L,J).EQ.0.)GO TO 300
00185 RGID(L,I,II,K(L))=(RGICST(L,J)+358160.)*(1+DCIF(II))*N-1)/(100000.*(1+K(I))*N-1)
00186 FGIDD(L,I,II)=RGIDD(L,I,II)+RGIC(L,I,II,K(L))
00187 200 CALL GECST(DB,D(L,NNN(L,K(L))),NFRAC,GECRR,GFRAC)
00188 GEOD(L,I,II,K(L))=(.5*GECRRD+GFRAC+.35816)*N-1)/(1+DCIF(II))*N-1)/(1+K(I))*N-1)
00189 GEODD(L,I,II)=GEOD(L,I,II)+GEUC(L,I,II,K(L))
00190 MM=1
00191 CC 80 M=N,ITF
00192 MDCT(L,M)=SMOOT*(TD-TINJ)/(TTT(L,M)-TINJ)
00193 CALL FLON(NFRAC,MF,MM,MDCT(L,M),Z(L,M),ERF(L,M))
00194 TTT(L,M+1)=TINJ+(TTRCK-TINJ)*ERF(L,M)
00195 IF (TTT(L,M+1).LE.TD)GO TO 90
00196 M=M+1
00197 80 CONTINUE
00198 90 CONTINUE
00199 N=M
00200 IF (N.GE.III)GO TO 100
00201 GO TO 70
00202 ICC RGITDD(L,I,II)=RGIDC(L,I,II)+RGICD(L)
00203 GEOTDD(L,I,II)=GEODD(L,I,II)+GECCD(L)
00204 TXX(L,I)=TX(L)
00205 TTX(L,I)=TTX(L)
00206 5000 CONTINUE
00207 4000 CONTINUE
00208 3000 CONTINUE
00209 2000 CONTINUE
00210 5555 CONTINUE
00211 "
00212 *** WRITE STATEMENTS
00213 "
00214 CC 750 L=1,9
00215 WRITE(6,2303)
00216 WRITE(6,3505)NFRAC,DO(L)
00217 WRITE(6,3606)
00218 WRITE(6,3707)
00219 WRITE(6,3808)RGICD(L),GECCD(L)
00220 IF (NRD(L).EQ.0)GO TO 790
00221 WRITE(6,3909)
00222 WRITE(6,3933)
00223 WRITE(6,3707)
00224 WRITE(6,4101)
00225 WRITE(6,4202)
00226 WRITE(6,4303)
00227 CC 760 I=1,NK
00228 CC 770 II=1,NDCIF
00229 CC 780 III=1,NFCIF
00230 NETBEN(1)=TOTBEN(I,III)-RGITSC(L,I,III)
00231 NETBEN(2)=TOTBEN(I,III)-GEOTSD(L,I,III)
00232 NETBEN(3)=TOTBEN(I,III)-RGITCC(L,I,III)
00233 NETBEN(4)=TOTBEN(I,III)-GEOTDD(L,I,III)
00234 NETBEN(5)=TOTBEN(I,III)-RGIPH(L,I,III,III)

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HDR3 (cont)

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00235 NETBEN(6)=TOTBEN(1,111)-CECPH(L,1,11,111)
00236 WRITE(6,4404)R(1),DCIF(111),FCIF(111),RGITSD(L,1,11),GEITSD(L,1,11),RGITDD(L,1,11),GEITDD(L,1,11),RGIPHC(L,1,11),GEIPHC(L,1,11)
00237 WRITE(6,4505)NETBEN(1),NETBEN(2),NETBEN(3),NETBEN(4),NETBEN(5),NETBEN(6)
00238 780 CCNTINUE
00239 WRITE(6,*)
00240 770 CCNTINUE
00241 760 CCNTINUE
00242 WRITE(6,*)
00243 WRITE(6,*)
00244 WRITE(6,4606)DELT,HDRBTU,TD,SMOCT,G,DB,ITH
00245 J=NPD(L)
00246 JJ=K(L)
00247 WRITE(6,4808)(AN(L,I),I=1,J)
00248 WRITE(6,4909)(NNN(L,I),I=1,JJ)
00249 GO 755 I=1,J
00250 IF(NKKN(L,I).EQ.1)WRITE(6,5202)AN(L,I)
00251 IF(NKKK(L,I).EQ.1)WRITE(6,5404)
00252 755 CCNTINUE
00253 WRITE(6,2303)
00254 WRITE(6,5707)
00255 KJ=1
00256 KK=1
00257 KKK=1
00258 855 IF(KJ.EQ.NN(L,KK))GO TO 860
00259 IF(KJ.EQ.NNN(L,KKK))GO TO 865
00260 WRITE(6,5808)KJ,T(L,KJ),TTT(L,KJ),MDCT(L,KJ),TT(L,KJ)
00261 GO TO 870
00262 860 IF(KJ.EQ.NNN(L,KKK))GO TO 861
00263 WRITE(6,5909)KJ,T(L,KJ),TX(L),TTT(L,KJ),MDCT(L,KJ),TT(L,KJ)
00264 KJ=KJ+1
00265 IF(KJ.GT.ITH+1)GO TO 875
00266 IF(KJ.EQ.NNN(L,KKK))GO TO 862
00267 WRITE(6,5909)KJ,T(L,KJ),TX(L),TTT(L,KJ),MDCT(L,KJ),TT(L,KJ)
00268 KK=KK+1
00269 GO TO 870
00270 861 WRITE(6,6202)KJ,T(L,KJ),TX(L),TTT(L,KJ),TTXX(L,KKK),MDCT(L,KJ),TT(L,KJ)
00271 KJ=KJ+1
00272 IF(KJ.GT.ITH+1)GO TO 875
00273 WRITE(6,6202)KJ,T(L,KJ),TX(L),TTT(L,KJ),TTXX(L,KKK),MDCT(L,KJ),TT(L,KJ)
00274 KK=KK+1
00275 KKK=KKK+1
00276 GO TO 870
00277 862 WRITE(6,6202)KJ,T(L,KJ),TX(L),TTT(L,KJ),TTXX(L,KKK),MDCT(L,KJ),TT(L,KJ)
00278 KJ=KJ+1
00279 IF(KJ.GT.ITH+1)GO TO 875
00280 WRITE(6,6101)KJ,T(L,KJ),TTT(L,KJ),TTXX(L,KKK),MDCT(L,KJ),TT(L,KJ)
00281 KK=KK+1
00282 KKK=KKK+1
00283 GO TO 870
00284 863 WRITE(6,6202)KJ,T(L,KJ),TX(L),TTT(L,KJ),TTXX(L,KKK),MDCT(L,KJ),TT(L,KJ)
00285 KJ=KJ+1
00286 IF(KJ.GT.ITH+1)GO TO 875
00287 WRITE(6,5909)KJ,T(L,KJ),TX(L),TTT(L,KJ),MDCT(L,KJ),TT(L,KJ)
00288 KK=KK+1
00289 KKK=KKK+1
00290 GO TO 870
00291 865 WRITE(6,6101)KJ,T(L,KJ),TTT(L,KJ),TTXX(L,KKK),MDCT(L,KJ),TT(L,KJ)
00292 KJ=KJ+1
00293 IF(KJ.EQ.NN(L,KK))GO TO 863
00294 WRITE(6,6101)KJ,T(L,KJ),TTT(L,KJ),TTXX(L,KKK),MDCT(L,KJ),TT(L,KJ)
00295 KKK=KKK+1
00296 870 KJ=KJ+1
00297 IF(KJ.GT.ITH+1)GO TO 875
00298 GO TO 855
00299 875 CCNTINUE
00300 750 CCNTINUE
00301 GO TO 795
00302 790 WRITE(6,3404)
00303 WRITE(6,2303)
00304 WRITE(6,4606)DELT,HDRBTU,TD,SMOCT,G,DB,ITH
00305 795 CCNTINUE
00306 *
00307 *** FORMAT STATEMENTS
00308 *
00309 2303 FORMAT(////)
00310 3303 FORMAT(54X,'NET BENEFITS IN PARENTHESES')
00311 3404 FORMAT(43X,'*** NEVER REDRILL, TOTAL CCST = INITIAL COST ***',//)
00312 3505 FORMAT(28X,'*** 1,2, * FRACTURES ***',20X,'*** INITIAL DEPTH = ',F6.2,' FEET ***',//)
00313 3606 FORMAT(56X,'INITIAL DRILLING COSTS')
00314 3707 FORMAT(58X,'( 1980 $ MILLICNS )',//)

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HDR3 (cont)

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00394 HICST=0.0
00395 JJ=JJ+1
00396 KK=MM
00397 CC=151 K=J,JJ
00398 CALL FLOW(INFRAL,HF,KK,MDCT,ZZ,ERROR)
00399 TIL(K+1)=TINJ+(TROCK-TINJ)*ERRCK
00400 TAVG=(TIL(K)+TIL(K+1))/2
00401 KK=KK+1
00402 IF(TAVG-GE.TD)GO TO 152
00403 FRTU=(MDCT*4200.*(TD-TAVG)*31536000.*1.27)/1054.
00404 EAR=HRTU/(144000.*42.)
00405 CBTUR=BAR*(KP*((1+FCIF)**(K-1))/(1000000.*((1+F)**(K-1)))
00406 GO TO 153
00407 152 TAVG=(TAVG+TIL(K+1))/2
00408 FRTU=(MDCT*4200.*(TD-TAVG)*31536000.*1.27)/(1054.*2)
00409 EAR=HRTU/(144000.*42.)
00410 CBTUR=BAR*(KP*((1+FCIF)**(K-1+.5))/(1000000.*((1+R)**(K-1+.5)))
00411 IF(TTAVG-GE.TD)CBTUR=0.0
00412 153 HICST=HICST+CBTUR
00413 151 CCNTINUE
00414 JJ=JJ+1
00415 RETURN
00416 END

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