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ADAPTATION OF WRENSS-FORTRAN-77 FOR A GIS APPLICATION FOR WATER-YIELD CHANGES

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TABLES

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ABSTRACT

The Water Resources Evaluation for Non-Point Silvicultural Sources (WRENSS) handbook includes a procedure and relationships for estimating changes in water yield that result from cutting or thinning forest vegetation. The method was originally programmed to automate the computations for northern forests by workers from the Canadian Forestry Service. A Fortran version of the program has been expanded to include relationships for both snow- and rain-dominated processes in hydrologic region 7 (Central Sierra) of the United States. The revised Fortran program has been used to calculate expected changes in water yield that would result from forest thinning for fuel control in the Central Sierra region of California. An attempt has been made to maintain the original programming style and include comment statements to facilitate understanding of the program components. A program listing, a few examples of program application and an input guide are included.

1. INTRODUCTION

This report documents a revised Fortran program (Bernier, 1986) that performs water yield calculations using the methodology in Chapter 3 of the Water Resources Evaluation for Non-point Silvicultural Sources (WRENSS) handbook (U.S. Forest Service, 1980). Although documentation and a program listing of the original Fortran code was published by Bernier (1986), the present version includes equations for hydrologic Region 7 (Central Sierra) for both snow and rain-dominated processes. Because the original source code is not easily obtained, a brief report is presented here to summarize the changes, document the revised code, and make future updates easier.

2. A BRIEF HISTORY OF WATER-YIELD COMPUTER PROGRAM DEVELOPMENT

The WRENSS water-yield methodology was derived from application of hydrologic models, data from experimental watershed studies and an objective to generalize estimation of the way changes in forest vegetation affects seasonal water yield as a function of climate, topography and physical location. An excellent overview of the approach and methodology was published previously (Troendle, 1979). It is an important contribution because the relationships came from direct field observations, which were extrapolated using models, to cover the full range of conditions across the North American continent. The WRENSS handbook presents manual calculations that use a series of graphs that relate evapotranspiration to seasonal precipitation, energy aspect and vegetative cover density. However, it was quickly recognized that the computational process would be more convenient as a computer program. In 1982, R.H. Swanson wrote a program in HP-BASIC for desktop calculator. Later, Bernier re-wrote the HP-BASIC program in Fortran and published it (Bernier, 1986). Because Forestry Canada sponsored the work, the focus was on snow-dominated processes, and did not include rain-dominated hydrologic processes. Swanson is currently working on a Visual Basic version of the WRENSS water-yield calculations for all of the regions in the United States (R.H. Swanson, personal communication, 1998).

3. ADAPTATION OF WRENSS-FORTRAN FOR APPLICATION TO THE CENTRAL SIERRA REGION OF THE UNITED STATES

3.1 APPROACH

The need to evaluate proposed forest-vegetation thinning over a large area in the Central Sierra Mountains in California prompted revisions to the original WRENSS-Fortran program. The concept uses a geographical information system (GIS) to generate spatially explicit program input, the WRENSS-Fortran program running on a Unix-based workstation for estimating water yield, then the GIS to examine spatial patterns in predicted changes. For ease of use in a Unix computing environment, the original WRENSS-Fortran program was revised, rather than transferring input and output between the Unix system and a PC. So far as practical, the programming approaches that were present in the original version (Bernier, 1986) were preserved. Liberal use of comments in the Fortran source code should facilitate understanding. The revised program was tested by comparing sample problem results from the WRENSS handbook, and also by comparisons with output from the WRNSHYD.EXE code (Swanson, 1991), which was made available to the project by R.H. Swanson. One feature that was added to the Fortran code was direct calculation of the change in annual water yield between the baseline condition ("forest" in the output) and the treated condition ("open" in the output). This is the difference between annual evapotranspiration for the two cases, and is not area-weighted.

3.2 SNOW-DOMINATED PROCESS MODIFICATIONS

The program required some refinements for application to the Central Sierra region. The original code did not include explicit specification of energy zones in addition to aspect. The WRENSS handbook and the WRNSHYD.EXE code include a separate distinction for energy aspects (see Figures III-50 through III-53 in the handbook). This corresponds to what is termed "high snow" units (intermediate and low energy aspects in the WRENSS handbook) and "low snow" units (high-energy aspects in the WRENSS handbook) in the WRNSHYD.EXE program. Explicit designation of the energy aspect was added to the required input data to specify the appropriate curves for modifier coefficients and precipitation-evapotranspiration relations for each season and aspect possible. Also, new coefficient tables for the evapotranspiration modifier coefficients and for estimating baseline evapotranspiration from precipitation for both the high snow and low snow energy zones were added. The evapotranspiration modifier coefficient curves from the WRENSS handbook were fitted with third-order polynomials. The process involved estimating several points along the curve, entering them into a spreadsheet, and using the curve fitting features of the spreadsheet to determine the coefficients. Table 1 presents a summary of the results of that analysis. It should also be noted that in the process of analyzing the approach used by Bernier, the order of the data statement for coefficient array C023 in the original code was discovered to be in error and was corrected.

3.3 RAIN-DOMINATED PROCESS MODIFICATIONS

For hydrologic region 7 (Central Sierra), rain-dominated process equations were needed. These equations use different parameters than those for snow-dominated processes. They were added by creating a new subroutine (ETMRD) for estimating evapotranspiration modifier coefficients for hydrologic units with rain-dominated processes. The subroutine that calculates evapotranspiration totals (ETMOD) was also revised to include rain-dominated process (RDP) equations. Input statements were changed to allow specification of RDP units and input of soil depth and seasonal leaf-area index values (rather than basal area, which is the measure of vegetation cover density for snow dominated processes). The modifier coefficient curves from the WRENSS handbook were each fitted with a fourth-order polynomial, following the same process for determining coefficients as that described for snow dominated processes. Since only one region was added to the new version of the program, the coefficient values were simply entered directly into the subroutine, rather than creating a coefficient array and generalizing the process. If the code is extended to other RDP regions, this generalization should be added. The equations that were derived for Region 7 rain-dominated units are presented in Table 2. Note that the values for leaf area index in these equations are for the projection of leaf area on a horizontal surface, rather than for total leaf area index, which is used in the WRENSS handbook. We assumed that total leaf area index is 2.5 times greater than the projected area on a horizontal surface.

3.3 VERIFICATION OF RESULTS

A limited number of verification tests were conducted. During development of the new coefficient arrays for the subroutines that calculate the evapotranspiration modifier coefficients, abbreviated programs were used to test the values of modifier coefficients over the full range of the curves. Sample output was manually compared to the curves in the WRENSS handbook to find any gross errors. Since the interpolation of the curves themselves is limited in precision (not to mention the uncertainty associated with the basic information used to generate the curves), minor discrepancies were allowed.

For testing the complete revised program, it seemed more appropriate to directly compare the revised Fortran program results with WRNSHYD.EXE than to rely on one or two relevant example calculations from the WRENSS handbook. An example set of cases for hi snow, lo snow and rain-dominated process units with varying aspects is presented in Table 3. Even though the goal was to only examine annual change in water yield, the results are presented by season, so it is possible to see where differences occur between the two programs. As noted earlier, because of differences in interpolating values from the WRENSS handbook curves, as well as curve-fitting techniques used in the two programs, an exact match was not expected. The absolute values for seasonal evapotranspiration are less important for the GIS application than the differences between sets of values (change in water yield). In any case, we believe the differences shown in Table 3 are acceptable

4. PROGRAM APPLICATION

4.1 INPUT GUIDE

Appendix A is an input guide for the revised WRENSS-Fortran water-yield estimation program. It was developed with a specific application in mind, but should be helpful to most users. The guide describes the sequence of input variables and sample input and output listings.

4.2 REVISED FORTRAN PROGRAM LISTING

Appendix B is a complete listing of the revised WRENSS-Fortran program code. Although Pierre Bernier is listed as a technical contact, the intent was simply to credit him with the original FORTRAN program. Any questions about the revised program should be directed to the authors of this report. It should also be noted that there is no claim of an error-free revised code, nor any responsibility for use of the code by others. Every attempt has been made to eliminate error, and it is hoped future discovery of any error will be shared with the authors.

5. REFERENCES

Bernier, P. Y. 1986. A programmed procedure for evaluating the effect of forest management on water yield. Forestry Management Note No. 37, Northern Forestry Center, Canadian Forestry Service, Edmonton, Alberta.

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Troendle, C. A. 1979. Hydrologic impacts of silvicultural activities. Proceedings Paper 14437. Journal of the Irrigation and Drainage Division, ASCE, 105:57-70, No. IR1.

U.S. Forest Service. 1980. An approach to water resources evaluation of non-point silvicultural sources (A procedural handbook). U.S. Environmental Protection Agency, Environmental Research Laboratory, Office of Research Development, Athens, Georgia.

Table 1. Summary of ET Modifier Coefficient Equations for Province 7 (Central Sierra)

HIGH SNOWFALL BASINS

Fall & Winter (aka early and late winter)

Fall (aka early winter) Season (J=1)

All aspects (1,2&3)

Cd/Cdmax	etmod	eqn
0	0.62	0.62
0.5	1	1
0.25		0.81
slope	0.76	
eqn	**Etmod=0.62+0.76*Cd for 0.≤Cd≤0.5**	
	Etmod=1.00 for .5 < Cd ≤ 1.0	

Winter (aka late winter) Season (J=2)

Energy aspect = 1 (N)

Cd/Cdmax	etmod	eqn
0	0.87	0.87
0.5	1.39	1.39
0.25		1.13
slope	1.04	
eqn	**Etmod=0.87+1.04*Cd for 0≤Cd≤0.5**	
0.5	1.39	1.39
1	1	1
0.75		1.195
slope	-0.78	
	Etmod=1.78-0.78*Cd for .5≤Cd≤1.	

Energy aspect = 2 (E+W)

Cd/Cdmax	etmod	eqn
0	0.92	0.92
0.5	1.3	1.3
0.25		1.11
slope	0.76	
eqn	**Etmod=0.92+0.76*Cd for 0≤Cd≤0.5**	
0.5	1.3	1.3
1	1	1
0.75		1.15
slope	-0.6	
	etmod=1.6-0.6*Cd for .5≤Cd≤1.	

Energy aspect = 3 (S)

Cd/Cdmax	etmod	eqn
0	0.94	0.94
0.5	1.24	1.24
0.25		1.09
slope	0.6	
eqn	**etmod=0.94+0.6*Cd for 0≤Cd≤.5**	
0.5	1.24	1.24
1	1	1
0.75		1.12
slope	-0.48	
	etmod=1.48-0.48*Cd for .5≤Cd≤1.	

Spring & Summer Seasons

Spring Season (J=3)

Energy aspect = 1 (N)

Cd/Cdmax	etmod	eqn
0	1.2	1.2
0.5	1.03	1.03
0.25		1.115
slope	-0.34	
eqn	**etmod=1.2-.34*Cd for 0≤Cd≤0.5**	
0.5	1.03	1.03
1	1	1
0.75		1.015
slope	-0.06	
	etmod=1.06-0.06*Cd for .5≤Cd≤1.	

Energy aspect = 2 (E+W)

Cd/Cdmax	etmod	eqn
0	1.147	1.147
0.5	1.03	1.03
0.25		1.0885
slope	-0.234	
eqn	**etmod=1.147-.234*Cd for 0≤Cd≤0.5**	
0.5	1.03	1.03
1	1	1
0.75		1.015
slope	-0.06	
	etmod=1.06-0.06*Cd for .5≤Cd≤1.	

Energy aspect = 3 (S)

Cd/Cdmax	etmod	eqn
0	1.1	1.1
0.5	1.03	1.03
0.25		1.065
slope	-0.14	
eqn	**etmod=1.2-.34*Cd for 0≤Cd≤0.5**	
0.5	1.03	1.03
1	1	1
0.75		1.015
slope	-0.06	
	etmod=1.06-0.06*Cd for .5≤Cd≤1.	

Summer Season (J=4)

All aspects (1,2&3)

Cd/Cdmax	etmod	eqn
0	0.3	0.3
0.5	1	1
0.25		0.65
slope	1.4	
eqn	**etmod=0.62+0.76*Cd for 0.≤Cd≤0.5**	
	etmod=1.00 for .5 < Cd ≤ 1.0	

Table 1. (continued)

MODERATE TO LOW SNOWFALL BASINS

Fall & Winter (aka early and late winter)

Fall (aka early winter) Season (J=1)

All aspects (1,2&3)

Cd/Cdmax	etmod	eqn
0	0.65	0.65
0.5	1	1
0.25		0.825
slope	0.7	

eqn **etmod=0.65+0.70*Cd for 0.≤Cd≤0.5**

etmod=1.00 for .5 <= Cd <= 1.0

Winter (aka late winter) Season (J=2)

Energy aspect = 1 (N)

Cd/Cdmax	etmod	eqn
0	0.66	0.66
0.5	1.19	1.19
0.25		0.925
slope	1.06	
eqn	**etmod=0.66+1.06*Cd for 0≤Cd≤0.5**	
0.5	1.19	1.19
1	1	1
0.75		1.095
slope	-0.38	

etmod=1.38-0.38*Cd for .5≤Cd≤1.

Energy aspect = 2 (E+W)

Cd/Cdmax	etmod	eqn
0	0.71	0.71
0.5	1.08	1.08
0.25		0.895
slope	0.74	
eqn	**etmod=0.71+0.74*Cd for 0≤Cd≤0.5**	
0.5	1.08	1.08
1	1	1
0.75		1.04
slope	-0.16	

etmod=1.16-0.16*Cd for .5≤Cd≤1.

Energy aspect = 3 (S)

Cd/Cdmax	etmod	eqn
0	0.74	0.74
0.5	1	1
0.25		0.87
slope	0.52	
eqn	**etmod=0.74+0.52*Cd for 0≤Cd≤.5**	
0.5	1	1
1	1	1
0.75		1
slope	0	

etmod=1.00-0.0*Cd for .5≤Cd≤1.

Spring & Summer Seasons

Spring Season (J=3)

All aspects (1,2&3)

Cd/Cdmax	etmod	eqn
0	0.7	0.7
0.5	1	1
0.25		0.85
slope	0.6	

eqn **etmod=0.7+0.6*Cd for 0.≤Cd≤0.5**

etmod=1.00 for .5 < Cd ≤ 1.0

Summer Season (J=4)

All aspects (1,2&3)

Cd/Cdmax	etmod	eqn
0	0.34	0.34
0.5	1	1
0.25		0.67
slope	1.32	

eqn **etmod=0.34+1.32*Cd for 0.≤Cd≤0.5**

etmod=1.00 for .5 < Cd ≤ 1.0

Table 2. Rain dominated process equations used in the WRENSS Fortran program for Region 7 (Central Sierra). These equations were derived from curves in the WRENSS handbook (U.S. Forest Service, 1980.)

Season	LAI (x) values	Equation for determining ET modifier coefficient (y)
1 (*Fall*)	$0 < x < 4$	$y = 0.28217 + 0.70398 \bullet x - 0.33404 \bullet x^2 + 0.078559 \bullet x^3 - 0.0071534 \bullet x^4$
	$4 \le x < 14$	$y = 0.95 + 0.005 \bullet (x - 4)$
	$x \ge 14$	$y = 1.00$
2 (*Winter*)	$0 < x < 14$	$y = 0.18984 + 0.20241 \bullet x - 0.026967 \bullet x^2 + 0.0018725 \bullet x^3 - 0.000048902 \bullet x^4$
	$x \ge 14$	$y = 1.00$
3 (*Spring*)	$0 < x < 7.2$	$y = 0.074623 + 0.51086 \bullet x - 0.14849 \bullet x^2 + 0.020677 \bullet x^3 - 0.0010697 \bullet x^4$
	$7.2 \le x < 14$	$y = 0.90 + 0.0147 \bullet (x - 7.2)$
	$x \ge 14$	$y = 1.00$
4 (*Summer*)	$0 < x < 4$	$y = 0.25732 + 0.92385 \bullet x - 0.48116 \bullet x^2 + 0.11359 \bullet x^3 - 0.0099372 \bullet x^4$
	$4 \le x < 14$	$y = 0.98 + 0.002 \bullet (x - 4)$
	$x \ge 14$	$y = 1.00$

Table 3. **Comparison of output variables between revised Fortran program and WRNSHYD.EXE**

<u>hi snow unit 1 of aspect east+west</u>

SEASON	PRECIP(MM)	ET(MM) FORTRAN FOREST	ET(MM) FORTRAN OPEN	ET(MM) WRNSHYD.EXE FOREST	ET(MM) WRNSHYD.EXE OPEN
1	250.	29.	29.	29.6	27.3
2	470.	49.	55.	56.0	53.0
3	210.	142.	144.	145.9	149.6
4	70.	228.	228.	227.0	193.8
ANNUAL	1000.	448.	456.	448.8	457.8
CHANGE		**-8.**		**-9.**	

lo snow unit 1 of aspect east+west

SEASON	PRECIP(MM)	ET(MM) FORTRAN FOREST	ET(MM) FORTRAN OPEN	ET(MM) WRNSHYD.EXE FOREST	ET(MM) WRNSHYD.EXE OPEN
1	250.	29.	29.	29. 6	29.6
2	470.	45.	47.	44.9	46.7
3	210.	142.	144.	140.6	140.6
4	70.	228.	228.	227.0	227.0
ANNUAL	1000.	442.	444.	442.1	443.9
CHANGE		**-2.**		**-1.8**	

rain-dominated processes unit 1 of aspect south

SEASON	PRECIP(MM)	ET(MM) FORTRAN FOREST	ET(MM) FORTRAN OPEN	ET(MM) WRNSHYD.EXE FOREST	ET(MM) WRNSHYD.EXE OPEN
1	250.	229.2	216.6	232. 3	217.4
2	470.	131.6	99.8	130.8	99.4
3	210.	254.0	215.0	251.6	210.2
4	70.	255.3	246.1	258.8	248.3
ANNUAL	1000.	870.1	777.5	873.5	775.3
CHANGE		**92.6**		**98.2**	

APPENDIX A. INPUT DATA SET GUIDE

A.1 GENERAL GUIDE TO REQUIRED INPUT DATA

In the following section, there is a sequential listing of input variables, their associated variable name in the program and their input format (given in parentheses after the parameter name), and a brief description of the variable meaning. This is followed by three examples of program input and resulting output. Each example relates to a different "energy aspect" as it is defined by the WRENSS handbook. Some explanation of the energy aspects is needed to understand the way the input is structured. There are two differing processes so far as input data structure is concerned: Snow Dominated Processes (SDP) and Rain Dominated Processes (RDP). There is also a distinction in the SDP units: high elevation, low energy (hi snow), and lower elevation, higher energy, (lo snow). Each type requires a distinct input set.

The general guide for input parameters in order of appearance follows:

Province number NPROV (I5):

> This is the number for the hydrologic region, as defined in the WRENSS handbook. For our examples, we use hydrologic province 7 (Central Sierra).

Basin name NAME (A30):

> This can be determined by the gis input. We use a name that identifies the location of the unit (e.g., latitude/longitude of the cell).

Wind Scour NRP8 (A1) (required input, but applies to SDP Only):

> A characterization of whether wind scour is important in large openings. For the Central Sierra, the WRENSS handbook recommends always using "N."

Basin area AREA (sq. km) (F7.2):

> This is the size of the unit in sq. km. It is assumed that within this area, the break out of areas for SDP and RDP (see later) could be available, and would sum to the basin area value.

Area in each Energy Aspect (sq. km) ASP1,ASP2,ASP3 (3F6.2):

> There are three categories: (N, E+W, S). For this application, only one of the aspects contains the total basin area. (The code will allow all three aspects in a single run, but that is not illustrated).
>
> To determine which aspect applies, use the following azimuth definitions:
>
> North : (<45 degrees or >315 degrees)
> South : (≥135 degrees and ≤225 degrees)
> E+W : everything else (i.e., not N or S)
>
> **Note:** The program takes each non-zero energy aspect area in sequence and all the variables for that area are included before going to the next area.

Number of units in non-zero area aspect(s) MNUM (3I2):

> Integer number of units within a given energy aspect. Examples use 1 unit, but up to three are possible.

Elevation class for all units in a given aspect (1 = hi snow, 2 = lo snow, 3 = RDP) IEC (3I2):
There are up to three entries possible, depending on the number of units assigned to each aspect. For the examples, only a single aspect and associated elevation class is used.

Although the elevation class should be based on hydrograph response, we've loosely associated the various classes to elevation bounds for our application. The categories were assigned as follows:

Hi Snow: $\geq$ 1220 m.
Lo Snow: 610 m. $\leq$ elev. < 1220 m.
RDP elevations: < 610 m. (Note that aspect is required as input, even though it is not used for RDP calculations).

Seasonal Precipitation (mm) IPRE (I8):
Seasonal precipitation is entered, one season per line. The seasons may be simplified as follows:

Season 1: October - December (Enter the sum of monthly precip for
Season 2: January - March the period included)
Season 3: April - June
Season 4: July - September

Wind Speed (m/sec) (used for SDP Only, but required in all cases) WSPEED (F7.2):
The wind speed is used as a trigger for doing detailed snow redistribution adjustments. However, the WRENSS handbook says Region 7 has wet snow and redistribution is not appropriate, so a default value of 0.0 is appropriate here.

Vegetative Characteristics: Includes tree type(s), Basal areas (actual & maximum potential) or Soil Depths and LAI values, and the (open) areas that have been "cut." A set of values is needed for each energy aspect that has non-zero area. The format for the SDP units (hi & lo snow) is the same, but differs for the RDP unit. The values are entered sequentially: first the baseline condition, then the treated or "cut" condition. Detailed inputs are:

Tree type ITRE (I5):
Each region (or hydrologic province) has a limited set of possible tree types. For Region 7, which is our first test case, the tree type can be either of two choices:

4 Lodgepole Pine (SDP and hi & lo snow)
1 Coniferous (RDP)

FOR SDP Units:
Basal Area B (sq. m/ha) (SDP Only) (F8.2):
This value is a stand characteristic, which depends on local conditions

Max. Basal Area BX (sq. m/ha) (SDP only) (F8.2):
This is the maximum (potential) basal area for the unit. This value corresponds to the point where further basal area increases do not cause appreciable increases in evapotranspiration on the unit.

FOR RDP Units:

Rooting Depth (ft.)   SD and Seasonal LAI values RLA (5F5.0):

Rooting depth is a measure of available water-holding capacity. The expected values range from shallow (1.5 ft or ~0.5 m) to average (3.0 ft or ~0.9 m) to deep (6.0 ft or ~1.8 m). If one assumes a typical range in moisture content between field capacity and wilting point is 0.1 m**3/m**3), then dividing the moisture holding capacity by ~0.1 is a simple way to estimate the rooting depth. The leaf-area index (LAI) values are assumed constant across all seasons for conifers for this application, but input could vary if data were available.

Cut Area (sq. km)   CAREA (F10.2):

This refers to any treated areas within the particular energy aspect class. For our purposes, we set the treated area to 0.998 times the total area, so the model will provide evapotranspiration calculation results for both the baseline and treated cases.

Basal area (SDP) or Leaf Area Index (RDP) for the cut area BB or RLAO (F10.2 or 5F5.0):

FOR SDP units: The post-thinning basal area for the unit.

FOR RDP units: The seasonal LAI values following treatment.

A.2 SAMPLE INPUT AND RESULTING OUTPUT EXAMPLES

Three examples of input data and resulting output are provided. They include examples for hi snow, lo snow and RDP units.

A.2.1 High Snow Energy Aspect Unit Example

The **first input data set** is for a unit with an East-West aspect, hi snow energy conditions, and Lodgepole Pine cover vegetation in Region 7:

```
7                     HYDROLOGIC REGION NUMBER
CL2567                    HYDROLOGIC UNIT IDENTIFIER
N                     WIND SCOUR FLAG (Y or N)
3.00                         AREA OF BASIN
0.0   3.0    0.0      AREA IN N,E+W,S ASPECTS (The non-zero input is for E+W)
 1                    NUMBER OF UNITS IN THIS ASPECT
 1                    ELEVATION CLASS IS HI SNOW
     250              SEASON 1 PRECIP.  integer (mm)
     470              SEASON 2 PRECIP.
     210              SEASON 3 PRECIP.
      70              SEASON 4 PRECIP.
    0.0               WIND SPEED (always 0.0)
    4                 TREE TYPE (IN 1 - 10 RANGE) 4 IS LODGEPOLE PINE
45.91                 STAND BASAL AREA (ASPECT E+W)  (SQ.M/HA)  LO SNO
64.31                 MAX. BASAL AREA  (SQ.M/HA)
     2.994            CUT AREA
30.00                 MODIFIED BASAL AREA IN TREATED AREA
```

The **output** from the model for the **first input data set** input set was:

```
NAME OF BASIN: CL2567
HYDROLOGIC REGION #  7
AREA OF BASIN (SQ.KM)=   3.00
AREA IN N, E+W AND SOUTH ASPECTS:   0.00  3.00  0.00
PRECIP (MM) FOR OCT01-DEC29:   250
PRECIP (MM) FOR DEC30-MAR28:   470
PRECIP (MM) FOR MAR29-JUN26:   210
PRECIP (MM) FOR JUN27-SEP30:    70
WINDSPEED (M/SEC): 0.00
INPUTS FOR UNIT 1 OF 1, ASPECT:EAST+WEST
 HI SNOW
AREA OF UNIT:              3.00  SQ.KM
TREE TYPE:        LODGEPOLE
BASAL AREA OF STAND:          45.91 SQ.M/HA
MAXIMAL BASAL AREA:           64.31 SQ.M/HA
TOTAL AREA OF CUTS:           2.99 SQ.KM
BASAL AREA IN CUTS:           30.00 SQ.M/HA
```

```
***** OUTPUT FOR EACH UNIT

 UNIT 1 OF ASPECT EAST+WEST
 HI SNOW
 SEASON     PRECIP(MM)        ET(MM)          FLOW(MM)
         FOREST OPEN     FOREST OPEN     FOREST OPEN
    1      250.  250.        29.   29.      221.  221.
    2      470.  470.        49.   55.      421.  415.
    3      210.  210.       142.  144.       68.   66.
    4       70.   70.       228.  228.     -158. -158.

***** OUTPUT FOR THE WHOLE BASIN

 SEASON:OCT01-DEC29:
       *......NORTH......*....EAST+WEST....*......SOUTH.....*
          FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.     250.     250.       0.       0.
 ET(MM)       0.       0.      29.      29.       0.       0.
 FLOW(MM)     0.       0.     221.     221.       0.       0.

 SEASON:DEC30-MAR28:
       *......NORTH......*....EAST+WEST....*......SOUTH.....*
          FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.     470.     470.       0.       0.
 ET(MM)       0.       0.      49.      55.       0.       0.
 FLOW(MM)     0.       0.     421.     415.       0.       0.

 SEASON:MAR29-JUN26:
       *......NORTH......*....EAST+WEST....*......SOUTH.....*
          FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.     210.     210.       0.       0.
 ET(MM)       0.       0.     142.     144.       0.       0.
 FLOW(MM)     0.       0.      68.      66.       0.       0.

 SEASON:JUN27-SEP30:
       *......NORTH......*....EAST+WEST....*......SOUTH.....*
          FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.      70.      70.       0.       0.
 ET(MM)       0.       0.     228.     228.       0.       0.
 FLOW(MM)     0.       0.    -158.    -158.       0.       0.


*****************************************
 BASIN PR,ET&WY (mm):     1000.0     456.5     543.5
 ET(forest)-ET(open) is change in water yield:      -8.0 mm
 YEARLY FLOW IN MM:   543.   ****IN CU.DAM=    1630.4
*****************************************
```

A.2.2 Low Snow Energy Aspect Unit Example

The **second input data set** is for an East+West aspect, with lo snow energy conditions and Lodgepole Pine cover vegetation in Region 7:

```
7                    HYDROLOGIC REGION NUMBER
CL2567                   HYDROLOGIC UNIT IDENTIFIER
N                    WIND SCOUR FLAG (Y or N)
3.00                        AREA OF BASIN
0.0   3.0    0.0     AREA IN N,E+W,S ASPECTS (The non-zero input is for E+W)
 1                   NUMBER OF UNITS IN THIS ASPECT
 2                   ELEVATION CLASS IS LO SNOW
     250             SEASON 1 PRECIP.  integer (mm)
     470             SEASON 2 PRECIP.
     210             SEASON 3 PRECIP.
      70             SEASON 4 PRECIP.
    0.0              WIND SPEED (always 0.0)
    4                TREE TYPE (IN 1 - 10 RANGE) 4 IS LODGEPOLE PINE
45.91                STAND BASAL AREA (ASPECT E+W)  (SQ.M/HA)  LO SNO
64.31                MAX. BASAL AREA  (SQ.M/HA)
     2.994           CUT AREA
30.00                MODIFIED BASAL AREA IN TREATED AREA
```

The **output** from the model for the **second input data set** was:

```
NAME OF BASIN: CL2567
 HYDROLOGIC REGION #  7
 AREA OF BASIN (SQ.KM)=   3.00
 AREA IN N, E+W AND SOUTH ASPECTS:   0.00  3.00  0.00
 PRECIP (MM) FOR OCT01-DEC29:   250
 PRECIP (MM) FOR DEC30-MAR28:   470
 PRECIP (MM) FOR MAR29-JUN26:   210
 PRECIP (MM) FOR JUN27-SEP30:    70
 WINDSPEED (M/SEC): 0.00

 INPUTS FOR UNIT 1 OF 1, ASPECT:EAST+WEST
  LO SNOW
 AREA OF UNIT:               3.00  SQ.KM
 TREE TYPE:         LODGEPOLE
 BASAL AREA OF STAND:          45.91 SQ.M/HA
 MAXIMAL BASAL AREA:           64.31 SQ.M/HA
 TOTAL AREA OF CUTS:           2.99 SQ.KM
 BASAL AREA IN CUTS:           30.00 SQ.M/HA

***** OUTPUT FOR EACH UNIT

 UNIT 1 OF ASPECT EAST+WEST
 LO SNOW
 SEASON     PRECIP(MM)        ET(MM)         FLOW(MM)
         FOREST OPEN     FOREST OPEN     FOREST OPEN
    1      250.  250.        29.   29.      221.  221.
    2      470.  470.        45.   47.      425.  423.
    3      210.  210.       140.  140.       70.   70.
    4       70.   70.       228.  228.     -158. -158.
```

```
***** OUTPUT FOR THE WHOLE BASIN

 SEASON:OCT01-DEC29:
       *......NORTH......*....EAST+WEST....*......SOUTH.....*
          FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.     250.     250.       0.       0.
 ET(MM)       0.       0.      29.      29.       0.       0.
 FLOW(MM)     0.       0.     221.     221.       0.       0.

 SEASON:DEC30-MAR28:
       *......NORTH......*....EAST+WEST....*......SOUTH.....*
          FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.     470.     470.       0.       0.
 ET(MM)       0.       0.      45.      47.       0.       0.
 FLOW(MM)     0.       0.     425.     423.       0.       0.

 SEASON:MAR29-JUN26:
       *......NORTH......*....EAST+WEST....*......SOUTH.....*
          FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.     210.     210.       0.       0.
 ET(MM)       0.       0.     140.     140.       0.       0.
 FLOW(MM)     0.       0.      70.      70.       0.       0.

 SEASON:JUN27-SEP30:
       *......NORTH......*....EAST+WEST....*......SOUTH.....*
          FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.      70.      70.       0.       0.
 ET(MM)       0.       0.     228.     228.       0.       0.
 FLOW(MM)     0.       0.    -158.    -158.       0.       0.
*****************************************
 BASIN PR,ET&WY (mm):     1000.0     444.4     555.6
 ET(forest)-ET(open) is change in water yield:      -1.6 mm

 YEARLY FLOW IN MM:   556.   ****IN CU.DAM=    1666.9
*****************************************
```

A.2.3 Rain-Dominated Unit Example

The **third input data set** is for a South aspect, in a rain-dominated processes area, using coniferous cover vegetation in Region 7:

```
7
CL3541        (Cluster ID)
N
3.00           AREA OF BASIN
0.0   0.0    3.0     AREA IN N,E+W,S ASPECTS
 1            (RDP UNIT IN THIS ASPECT)
 3            (Elev. class is RDP)
    250      SEASON 1 PRECIP.  integer (mm)
    470      season 2 precip.
    210      season 3 precip.
     70      season 4 precip.
 0.0      WIND SPEED IN M/SEC (ZERO WILL SKIP SCOUR CALC)
    1     TREE TYPE  1 IS CNF for RDP
 3.0  5.0  5.0  5.0  5.0   SDEP, LAI FOR N ASPECT PART
     2.994  CUT AREA
 2.5  2.5  2.5  2.5   Modified seasonal LAI's in cut
```

The **output** from the model for the **third input data set** was:

```
 N NAME OF BASIN: CL3541        (Cluster ID)
 HYDROLOGIC REGION #  7
 AREA OF BASIN (SQ.KM)=   3.00
 AREA IN N, E+W AND SOUTH ASPECTS:   0.00  0.00  3.00
 PRECIP (MM) FOR OCT01-DEC29:   250
 PRECIP (MM) FOR DEC30-MAR28:   470
 PRECIP (MM) FOR MAR29-JUN26:   210
 PRECIP (MM) FOR JUN27-SEP30:    70
 WINDSPEED (M/SEC): 0.00

 INPUTS FOR UNIT 1 OF 1, ASPECT:SOUTH
  RAIN DOMINATED
 AREA OF UNIT:              3.00  SQ.KM
 TREE TYPE:        CONIFEROUS
 ROOT DEPTH:                    3.00 FT.
 SEASONAL LAI:                  5.00  5.00  5.00  5.00
 TOTAL AREA OF CUTS:           2.99 SQ.KM
 ROOT DEPTH:                    3.00 FT.
 SEASONAL LAI IN CUTS:             2.50  2.50  2.50  2.50

***** OUTPUT FOR EACH UNIT

 UNIT 1 OF ASPECT SOUTH
 RAIN DOMINATED
 SEASON     PRECIP(MM)        ET(MM)         FLOW(MM)
         FOREST OPEN     FOREST OPEN     FOREST OPEN
    1      250.  250.      229.2  216.6      20.8   33.4
    2      470.  470.      131.6   99.8     338.4  370.2
    3      210.  210.      254.0  215.0     -44.0   -5.0
    4       70.   70.      255.3  246.1    -185.3 -176.1

***** OUTPUT FOR THE WHOLE BASIN
 SEASON:OCT01-DEC29:
      *......NORTH......*....EAST+WEST....*......SOUTH.....*
         FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.      0.0      0.0    250.0    250.0
 ET(MM)       0.       0.      0.0      0.0    229.2    216.6
 FLOW(MM)     0.       0.      0.0      0.0     20.8     33.4

 SEASON:DEC30-MAR28:
      *......NORTH......*....EAST+WEST....*......SOUTH.....*
         FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.      0.0      0.0    470.0    470.0
 ET(MM)       0.       0.      0.0      0.0    131.6     99.8
 FLOW(MM)     0.       0.      0.0      0.0    338.4    370.2

 SEASON:MAR29-JUN26:
      *......NORTH......*....EAST+WEST....*......SOUTH.....*
         FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.      0.0      0.0    210.0    210.0
 ET(MM)       0.       0.      0.0      0.0    254.0    215.0
 FLOW(MM)     0.       0.      0.0      0.0    -44.0     -5.0

 SEASON:JUN27-SEP30:
      *......NORTH......*....EAST+WEST....*......SOUTH.....*
         FOREST     OPEN   FOREST     OPEN   FOREST     OPEN
 PRECIP(MM)   0.       0.      0.0      0.0     70.0     70.0
 ET(MM)       0.       0.      0.0      0.0    255.3    246.1
 FLOW(MM)     0.       0.      0.0      0.0   -185.3   -176.1
*****************************************
 BASIN PR,ET&WY (mm):     1000.0     777.7     222.3
 ET(forest)-ET(open) is change in water yield:      92.6 mm
 YEARLY FLOW IN MM:   222.   ****IN CU.DAM=     666.9
                        *****************************************
```

APPENDIX B: REVISED WRENSS PROGRAM LISTING

```
C         *********************************************************************
C         *                      REV 7  BY DDH  (9/98)                         *
C         *     WRENSS PROCEDURE FOR HYDROLOGICAL PROVINCES 1,4,5,6            *
C         *                                                                    *
C         *     HANDBOOK REFERENCE:                                            *
C         *                       AN APPROACH TO WATER RESOURCES EVALUATION    *
C         *                       OF NON-POINT SILVICULTURAL SOURCES           *
C         *                       USDA FOR. SER. AUGUST, 1980                  *
C         *                       INTERAGENCY AGREEMENT EPA-IAG-D6-0660        *
C         *                       PUBL.REF. # EPA-600/8-80-012                 *
C         *                                                                    *
C         *     ORIGINAL PROGRAMMING BY:                                       *
C         *                       PIERRE Y. BERNIER                            *
C         *                       NORTHERN FORESTRY CENTRE                     *
C         *                       5320-122 STREET                              *
C         *                       EDMONTON, ALBERTA T6H 3S5                    *
C         *                                                                    *
C         *     MARCH, 1986                                                    *
C         *                                                                    *
C         *     MODIFIED BY:                                                   *
C         *                       DALE D. HUFF                                 *
C         *                       ENVIRONMENTAL SCIENCES DIVISION              *
C         *                       OAK RIDGE NATIONAL LABORATORY                *
C         *                       OAK RIDGE, TENNESSEE 38731-6038              *
C         *     TO ADD RDP CALCULATIONS AND SDP FOR NPROV = 7                  *
C         *     JULY, 1998                                                     *
C         *********************************************************************
C
C.............................GLOSSARY OF VARIABLES.........................
C
C   ADJPRE(J,K,L,M)          ADJUSTED PRECIP. (IN) AFTER SNOW REDISTRIBUTION
C   AREA                     AREA OF BASIN (SQ.KM)
C   ASP(L)                   FRACTION OF BASIN PER ASPECT (INPUT AS %)
C   BA(K,L,M)                BASAL AREA (SQFT) OF CUT & UNCUT (INPUT AS SQM)
C   BAMAX(L,M)               MAXIMUM BASAL AREA (SQFT) FOR MATURE STAND
C   CD(K)                    COVER DENSITY (%) OF CUT AND UNCUT
C   CDMAX                    MAXIMUM COVER DENSITY
C   CO1(3,ITREE(L,M))        COEFF. TO CONVERT BASAL AREA TO COVER DENSITY
C   CO2N(2,2,L,J)            COEFF. TO COMPUTE ET MODIFIER COEFFICIENTS
C   CO3N(4,L,J)              COEFF. TO COMPUTE ET FROM ADJPRE
C   ET(J,K,L,M)              EVAPOTRANSPIRATION PER J,K,L (IN)
C   ETMC(J,K,L,M)            ET MODIFIER COEFF. COMPUTED FROM CD
C   FLO                      TOTAL ANNUAL FLOW OF BASIN (IN)
C   FLO4(J,K,L,M)            FLOW (IN) PER J,K,L AND M
C   IEC(M)                   ELEVATION CLASS (1=HI SNOW,2=LO SNOW,3=RDP)
C   ITREE(L,N)               VEGETATION TYPE (SEE TOP OF SUB. QUEST1)
C   J                        SEASON COUNTER, 1=WINTER OR EARLY WINTER
C   JSEAS                    NUMBER OF SEASONS
C   K                        1=FOREST, 2=OPENINGS
C   L                        ASPECT COUNTER 1=N, 2=E+W, 3=S
C   M                        UNIT COUNTER
C   MNUM(L)                  NUMBER OF UNITS PER ASPECT (MAXIMUM=4)
C   N                        PROVINCE COUNTER 1=1, 2=4, 3=5, 4=6 AND 5=7
C   NAME                     NAME OF BASIN
C   NPROV                    PROVINCE NUMBER (SEE WRENSS HANDBOOK)
C   NRP1-8                   OPTIONS OFFERED TO USER
C   OPEN(L,M)                FRACTION OF BASIN IN CUTS (INPUT AS %)
C   OPLGTH(L,M)              WINDWARD LENGTH OF OPENING (IN TREE HEIGHTS)
C   PRECP(J)                 SEASONAL PRECIPITATION (INCHES, INPUT IN CM)
C   RLAI(J,K,L,M)            SEASONAL LEAF AREA INDEX
C   ROUGH(L,M)               ROUGHNESS COEFFICIENT FOR OPENINGS
C   SDEP(L,M)                ROOTING DEPTH (M) FOR RDP UNITS
C   SNODAY                   NUMBER OF DAYS WITH SNOW ON THE GROUND
C   TREEH(L,M)               HEIGHT OF TREES (FT, INPUT AS M)
C   UAREA(L,M)               AREA OF UNITS (IN SQ. KM)
C
```

```
      BLOCK DATA
      COMMON/INPUT/NPROV,N,AREA,MNUM(3),ASP(3),PRECP(4),ITREE(3,4),
     *          TREEH(3,4),BA(2,3,4),BAMAX(3,4),UAREA(3,4),WSPEED,
     *             ROUGH(3,4),JSEAS,OPEN(3,4),OPLGTH(3,4),SNODAY
     *            ,SDEP(3,4),RLAI(4,2,3,4)
C
C    THE FOLLOWING COMMON BLOCK WAS UPDATED FOR ADDING REGION 7
      COMMON/COEFF/CO1(3,10),CO21(2,2,3,4),CO22(2,2,3,4),CO23(2,2,3,4),
     *           CO24(2,2,3,4),CO25(2,2,3,4),CO26(2,2,3,4),CO31(4,3,4),
     *     CO32(4,3,4),CO33(4,3,4),CO34(4,3,4),CO35(4,3,4),CO36(4,3,4)
      COMMON/ANSWER/NRP1,NRP2,NRP3,NRP4,NRP5,NRP6,NRP7,NRP8,IYES,NYES
      CHARACTER * 1 NRP1,NRP2,NRP3,NRP4,NRP5,NRP6,NRP7,NRP8,IYES,NYES
C  Note****  Line below from CO1 array was modified for region 7
C          for the Lodgepole Pine relationship only. DDH 7/22/98.
C    *           4.5, 0.30, -0.0003, 2.9, 0.21, -0.0003,
C
      DATA CO1 / 5.5, 0.27, -0.0004, 4.1, 0.20, -0.0002,
     *           4.5, 0.30, -0.0003, 0.0, 0.252, -0.00024,
     *           1.2, 0.15, -0.0002,
     *           2.6, 0.40, -0.0006,-1.2, 0.39, -0.0006,
     *           4.5, 0.30, -0.0003, 3.3, 0.28, -0.0004,
     *           2.9, 0.21, -0.0003 /
      DATA CO21/ 1.12, 0.0, 1.24,-0.24, 1.09,-0.02, 1.16,-0.16,
     *           1.06,-0.06, 1.06,-0.06,
     *           0.87, 0.20, 0.94, 0.06, 0.87, 0.20, 0.94, 0.06,
     *           0.87, 0.20, 0.94, 0.06,
     *           0.52, 0.80, 0.84, 0.06, 0.52, 0.80, 0.84, 0.16,
     *           0.52, 0.80, 0.84, 0.16,
     *           0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0,
     *           0.0, 0.0, 0.0, 0.0/
      DATA CO22/ 0.60, 0.80, 1.00, 0.0,  0.60, 0.80, 1.00,  0.0,
     *           0.60, 0.80, 1.00, 0.0,
     *           1.10,-0.16, 1.04,-0.04, 1.07,-0.10, 1.04,-0.04,
     *           1.04,-0.04, 1.04,-0.04,
     *           0.44, 1.22, 1.00,  0.0, 0.55, 0.90, 1.00,  0.0,
     *           0.60, 0.80, 1.00, 0.0,
     *            0.0,  0.0,  0.0, 0.0,   0.0,  0.0,  0.0,  0.0,
     *            0.0,  0.0,  0.0, 0.0/
C
C  THE CO23 DATA STATEMENT WAS CHANGED 7/21/98 BY DDH TO FIX
C  AN ORDERING PROBLEM THAT SEEMED TO BE THERE FOR SEASON 2.
C
      DATA CO23/ 0.55, 0.90, 1.00, 0.0,  0.55, 0.90, 1.00,  0.0,
     *           0.55, 0.90, 1.00, 0.0,
     *           1.02, 0.86, 1.90,-0.90, 0.96, 0.76, 1.68,-0.68,
     *           0.90, 0.68, 1.48,-0.48,
     *           1.25,-0.50, 1.00, 0.0,  0.88, 0.24, 1.00,  0.0,
     *           0.53, 0.94, 1.00, 0.0,
     *           0.40, 1.20, 1.00, 0.0,  0.53, 0.94, 1.00,  0.0,
     *           0.62, 0.76, 1.00, 0.0/
      DATA CO24/ 0.60, 0.50, 0.70, 0.30, 0.60, 0.50, 0.70, 0.30,
     *           0.60, 0.50, 0.70, 0.30,
     *           0.80, 0.26, 0.86, 0.14, 0.77, 0.32, 0.86, 0.14,
     *           0.73, 0.40, 0.86, 0.14,
     *           0.63, 0.74, 1.00,  0.0, 0.63, 0.74, 1.00,  0.0,
     *           0.63, 0.74, 1.00,  0.0,
     *            0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,  0.0,
     *            0.0,  0.0,  0.0,  0.0/
C   ADD THE NEW COEFFICIENTS FOR REGION 7 CURVES FROM WRENSS
C          (HI SNOW BASINS)
      DATA CO25/ 0.62, 0.76, 1.00,  0.0, 0.62, 0.76, 1.00,  0.0,
     *           0.62, 0.76, 1.00,  0.0,
     *           0.87, 1.04, 1.78,-0.78, 0.92, 0.76, 1.60,-0.60,
     *           0.94, 0.60, 1.48,-0.48,
     *           1.20,-0.34, 1.06,-0.06,1.147,-0.234, 1.06,-0.06,
     *           1.10,-0.14, 1.06,-0.06,
     *           0.30, 1.40, 1.00,  0.0, 0.30, 1.40, 1.00,  0.0,
     *           0.30, 1.40, 1.00,  0.0/
C           (LO SNOW BASINS)
      DATA CO26/ 0.65, 0.70, 1.00,  0.0, 0.65, 0.70, 1.00,  0.0,
```

```
     *           0.65, 0.70, 1.00,  0.0,
     *           0.66, 1.06, 1.38,-0.38, 0.71, 0.74, 1.16, -0.16,
     *           0.74, 0.52, 1.00,  0.0,
     *           0.70, 0.60, 1.00,  0.0, 0.70, 0.60, 1.00,  0.0,
     *           0.70, 0.60, 1.00,  0.0,
     *           0.34, 1.32, 1.00,  0.0, 0.34, 1.32, 1.00,  0.0,
     *           0.34, 1.32, 1.00,  0.0/
      DATA CO31/ 1.45,  0.0,   0.00,  99., 1.92,    0.0,   0.00,  99.,
     *           2.40,  0.0,   0.00,  99.,
     *          -1.56, 2.82,-0.5650,  2.0,   1.60, 0.50,-0.1000,  2.0,
     *           1.90, 0.62,-0.1250,  2.0,
     *           4.42, 1.12,-0.0317,  16.,   4.31, 1.35,-0.0422,  16.,
     *           4.47, 1.46,-0.0450,  16.,
     *            0.0,  0.0,   0.00,  0.0,    0.0,  0.0,   0.00,  0.0,
     *            0.0,  0.0,   0.00,  0.0/
      DATA CO32/ 1.40,  0.0,   0.00,  99.,   1.80,  0.0,   0.00,  99.,
     *           2.30,  0.0,   0.00,  99.,
     *          -0.64, 1.38,-0.0716,  11.,  -0.78, 1.43,-0.0653,  11.,
     *          -1.37, 1.73,-0.0802,  11.,
     *           0.10, 2.57,-0.1846,  9.0,   0.10, 2.57,-0.1846,  9.0,
     *           0.10, 2.57,-0.1846,  9.0,
     *            0.0,  0.0,   0.00,  0.0,    0.0,  0.0,   0.00,  0.0,
     *            0.0,  0.0,    0.0,  0.0/
      DATA CO33/ 1.60,  0.0,   0.00,  99.,   2.20,  0.0,   0.00,  99.,
     *           3.00,  0.0,   0.00,  99.,
     *           1.20,  0.0,   0.00,  99.,   1.70,  0.0,   0.00,  99.,
     *           2.20,  0.0,   0.00,  99.,
     *          -1.76, 2.11,-0.1631,   7.,  -0.60, 1.40,-0.0639,  10.,
     *          -1.12, 1.54,-0.0493,  10.,

     *           0.83, 2.72,-0.2756,  5.0,   0.47, 3.01,-0.2492,  5.0,
     *          -0.19, 3.68,-0.2792,  5.0/
      DATA CO34/ 1.30,  0.0,   0.00,  99.,   1.90,  0.0,   0.00,  99.,
     *           2.60,   .0,   0.00,  99.,
     *           0.68, 0.38,-0.0084,  22.,   1.09, 0.60,-0.0180,  15.,
     *           0.28, 1.33,-0.0661,  9.3,
     *           1.68, 1.24,-0.0589,  8.4,   1.68, 1.24,-0.0589,  8.4,
     *           1.68, 1.24,-0.0589,  8.4,
     *            0.0,  0.0,    0.0,  0.0,    0.0,  0.0,    0.0,  0.0,
     *            0.0,  0.0,    0.0,  0.0/
C        (HI SNOW UNITS)
      DATA CO35/ 0.84,  0.0,   0.00,  99.,   1.16,  0.0,   0.00,  99.,
     *           1.49,  0.0,   0.00,  99.,
     *           1.19,  0.0,   0.00,  99.,   1.71,  0.0,   0.00,  99.,
     *           2.18,  0.0,   0.00,  99.,
     *   1.1278, 0.6547,-0.0166, 20.0, 1.0519, 0.6677,-0.015245, 20.0,
     *   0.9289, 0.69446,-0.014773, 22.5,
     *   4.2891, 4.4429,-1.0485, 1.75, 0.86465, 5.61492,-0.94865, 2.5,
     *   0.86465, 5.61492,-0.94865, 2.5/
C        (LO SNOW UNITS)
      DATA CO36/ 0.84,  0.0,   0.00,  99.,   1.16,  0.0,   0.00,  99.,
     *           1.49,  0.0,   0.00,  99.,
     *           1.19,  0.0,   0.00,  99.,   1.71,  0.0,   0.00,  99.,
     *           2.18,  0.0,   0.00,  99.,
     *   1.1278, 0.6547,-0.0166, 20.0, 1.0519, 0.6677,-0.015245, 20.0,
     *   0.9289, 0.69446,-0.014773, 22.5,
     *   0.86465, 5.61492,-0.94865, 2.5, 0.86465, 5.61492,-0.94865, 2.5,
     *   -5.08171, 9.04181, -1.4573, 3.0/
      DATA NRP1,NRP2,NRP3,NRP4,NRP5,NRP6,NRP7,NRP8,IYES,NYES/'N',
     *      'N','N','N','N','N','N','Y','Y','y'/
      DATA NPROV,AREA,MNUM,UAREA/0,0.,0,0,0,0.,0.,0.,0.,0.,
     *       0.,0.,0.,0.,0.,0.,0./
      END
C
C
C     FUNCTION AMAX1(R1,R2)
C     AMAX1 = R1
C     IF(R2.GT.R1) AMAX1 = R2
C     RETURN
C     END
```

```
C      FUNCTION AMIN1(R1,R2)
C      AMIN1 = R1
C      IF(R2.LT.R1) AMIN1 = R2
C      RETURN
C      END
C
C      MAIN PROGRAM
       COMMON/INPUT/NPROV,N,AREA,MNUM(3),ASP(3),PRECP(4),ITREE(3,4),
     *             TREEH(3,4),BA(2,3,4),BAMAX(3,4),UAREA(3,4),WSPEED,
     *             ROUGH(3,4),JSEAS,OPEN(3,4),OPLGTH(3,4),SNODAY
     *            ,SDEP(3,4),RLAI(4,2,3,4)
       COMMON/ELCLASS/IEC(3)
C      COMMON/FLAG/ITYP
C....   Set up read and write files
C
       open(unit=15, status='old', file='wrnsgis.dat')
       open(unit=6, status='new', file='wrnsgis.prt')
C
C.... DECIDE ON WHERE TO WRITE THE OUTPUT
       CALL QUEST1
C.... READ DESCRIPTION OF BASIN, VEGETATION AND TREATMENT
       CALL QUEST2
C.... WRITE BASIN DESCRIPTION TO FILE
       CALL OUT1
C.... DO FOR ALL ASPECTS
       DO 20 L=1,3
          IF(ASP(L).LE.0.) GO TO 20
C....     DO FOR ALL UNITS
          DO 15 M=1,MNUM(L)
C....        COMPUTE ET MODIFIER COEFFICIENTS
             IF(IEC(M).LT.0.OR.IEC(M).GT.3)  STOP 1234
             IF(IEC(M).LE.2) CALL ETMOD(L,M)
             IF(IEC(M).EQ.3) CALL ETMRD(L,M)
C....        COMPUTE ADJUSTED PRECIPITATION FOR FOREST AND OPENINGS
             CALL ADJPRC(L,M)
C.....       COMPUTE EVAPOTRANSPIRATION AND STREAMFLOW
   15        CALL ETCOM(L,M)
   20 CONTINUE
C.... PRINT THE RESULTS
       CALL OUT2
C.... NORMAL END OF EXECUTION FOR A BASIN
       END
C
C
C
C
```

```
      SUBROUTINE ETMOD(L,M)
      COMMON/INPUT/NPROV,N,AREA,MNUM(3),ASP(3),PRECP(4),ITREE(3,4),
     *             TREEH(3,4),BA(2,3,4),BAMAX(3,4),UAREA(3,4),WSPEED,
     *             ROUGH(3,4),JSEAS,OPEN(3,4),OPLGTH(3,4),SNODAY
     *            ,SDEP(3,4),RLAI(4,2,3,4)
      COMMON/COEFF/CO1(3,10),CO21(2,2,3,4),CO22(2,2,3,4),CO23(2,2,3,4),
     *           CO24(2,2,3,4),CO25(2,2,3,4),CO26(2,2,3,4),CO31(4,3,4),
     *     CO32(4,3,4),CO33(4,3,4),CO34(4,3,4),CO35(4,3,4),CO36(4,3,4)
      COMMON/CORE/CDMAX,CD(2),ETMC(4,2,3,4),ADJPRE(4,2,3,4),
     * ET(4,2,3,4),FLO4(4,2,3,4)
      COMMON/ELCLASS/IEC(3)
C.... THIS SUBROUTINE COMPUTES THE ET MODIFIER COEFFICIENTS FROM ACTUAL
C.... AND MAX. COVER DENSITY, BOTH FOR FOREST AND CUTS (K).
C.... FIRST, CONVERT BASAL AREA TO COVER DENSITY.
C
      CDMAX=CO1(1,ITREE(L,M))+CO1(2,ITREE(L,M))*BAMAX(L,M)+
     *      CO1(3,ITREE(L,M))*(BAMAX(L,M)**2)
      DO 10 K=1,2
      IF(K.EQ.1.AND.OPEN(L,M).GE.1.) GO TO 9
      IF(K.EQ.2.AND.OPEN(L,M).LE.0.) GO TO 9
      CD(K)=CO1(1,ITREE(L,M))+CO1(2,ITREE(L,M))*BA(K,L,M)+
     *      CO1(3,ITREE(L,M))*(BA(K,L,M)**2)
```

```
      CD(K)=AMIN1(CD(K),BA(K,L,M))
      CDMAX=AMIN1(CDMAX,BAMAX(L,M))
      write(16,40)K,L,M,ITREE(L,M),CD(K),BA(K,L,M),CDMAX,BAMAX(L,M)
C.... NOW, COMPUTE ET M0D. COEFF. BY SEASON (J) AND ASPECT (L)
C.... CHOOSE THE PORTION OF CURVE TO BE USED:
      MM=1
      IF(CD(K).GE.CDMAX/2.) MM=2
           CX=CD(K)/CDMAX
           DO 8 J=1,JSEAS
           IF(N.EQ.1) ETMC(J,K,L,M)=CO21(1,MM,L,J)+CO21(2,MM,L,J)*CX
           IF(N.EQ.2) ETMC(J,K,L,M)=CO22(1,MM,L,J)+CO22(2,MM,L,J)*CX
           IF(N.EQ.3) ETMC(J,K,L,M)=CO23(1,MM,L,J)+CO23(2,MM,L,J)*CX
           IF(N.EQ.4) ETMC(J,K,L,M)=CO24(1,MM,L,J)+CO24(2,MM,L,J)*CX
C....  Region 7 and HI SNOW
           IF((N.EQ.5).AND.(IEC(M).EQ.1))
     *         ETMC(J,K,L,M)=CO25(1,MM,L,J)+CO25(2,MM,L,J)*CX
C....  Region 7 and LO SNOW
           IF((N.EQ.5).AND.(IEC(M).EQ.2))
     *         ETMC(J,K,L,M)=CO26(1,MM,L,J)+CO26(2,MM,L,J)*CX
C.....      ELIMINATE ETMC IF NO FOREST OR NO CUTS.
CC.....      ETMC CANNOT BE GREATER THAN 1 (PERS. COMM. C.A.TROENDLE)
C            ETMC(J,K,L,M)=AMIN1(1.,ETMC(J,K,L,M))
C  SINCE WRENSS HANDBOOK HAS ETMC>1 FOR REGION 7, DON'T LIMIT.(DDH)
           IF(K.EQ.1.AND.OPEN(L,M).GE.1.0) ETMC(J,K,L,M)=0.
           IF(K.EQ.2.AND.OPEN(L,M).LE.0.0) ETMC(J,K,L,M)=0.
           write(16,50)J,K,L,M,MM,CX,ETMC(J,K,L,M)
  8        CONTINUE
  9     CONTINUE
   10 CONTINUE
  40   format(' K,L,M,ITREE,CD,BA,CDMAX,BAMAX: ',4I3,4F8.3)
  50       format(' J,K,L,M,MM,CX,ETMC: ',5I3,2F8.3)
      RETURN
      END
C
C
C
```

```
SUBROUTINE ETMRD(L,M)
      DIMENSION RDMC(4,2,3,4),ETMCR(4,2,3,4)
      COMMON/INPUT/NPROV,N,AREA,MNUM(3),ASP(3),PRECP(4),ITREE(3,4),
     *             TREEH(3,4),BA(2,3,4),BAMAX(3,4),UAREA(3,4),WSPEED,
     *             ROUGH(3,4),JSEAS,OPEN(3,4),OPLGTH(3,4),SNODAY
     *            ,SDEP(3,4),RLAI(4,2,3,4)
      COMMON/RCORE/RDMC,ETMCR
C*********************************************************************
C ... NOTE***** THIS SUBROUTINE ONLY APPLIES TO RDP & REGIONS 5,6,7
C*********************************************************************
C.... THIS SUBROUTINE COMPUTES THE ET AND ROOT DEPTH MODIFIER
C     COEFFICIENTS FROM ACTUAL LEAF AREA INDEX , BOTH FOR FOREST
C     AND CUTS (K).
C....
C
      DO 10 K=1,2
C....    IF WHOLE BASIN IS CLEARED, SKIP FORESTED (K=1) CALCS
      IF(K.EQ.1.AND.OPEN(L,M).GE.1.) GO TO 9
C....    IF WHOLE BASIN IS FOREST, SKIP OPEN (K=2) CALCS
      IF(K.EQ.2.AND.OPEN(L,M).LE.0.) GO TO 9
C
C.... NOW, COMPUTE RDP ET M0D. COEFF. FOR SEASON (J) AND VEGETATION
C.... STATUS (K)
C....
       DO 8 J=1,JSEAS
        IF (J.GT.1) GO TO 15
C....  FALL SEASON ROOTING DEPTH MODIFIERS
        RD = SDEP(L,M)
        IF(RD.LT.3.) RDMC(J,K,L,M)=0.5340019 + 0.2332411*RD
     * - 0.02731786*(RD**2)
        IF((RD.GE.3.).AND.(RD.LE.6.)) RDMC(J,K,L,M)=1.00+0.02*(RD-3.)
        IF (RD.GT.6.) RDMC(J,K,L,M) = 1.06
```

```
C....  FALL SEASON ET MODIFIERS
        RL = RLAI(J,K,L,M)
        IF(RL.LT.4.) ETMCR(J,K,L,M)=2.8217E-01 + 7.0398E-01*RL
     * - 3.3404E-01*(RL**2) + 7.8559E-02*(RL**3) -
     * 7.1534E-03*(RL**4)
        IF ((RL.GE.4.).AND.(RL.LE.14.)) ETMCR(J,K,L,M) =
     *  0.95 + 0.005*(RL-4.)
        IF (RL.GT.14.) ETMCR(J,K,L,M) = 1.00
        GO TO 8
  15    IF(J.GT.2) GO TO 16
C.....  WINTER SEASON ROOTING DEPTH MODIFIERS
         RDMC(J,K,L,M) = 1.0
C.....  WINTER SEASON ET MODIFIERS (RDP)
         RL = RLAI(J,K,L,M)
         ETMCR(J,K,L,M) = 1.8984E-01 + 2.0241E-01*RL - 2.6967E-02*
     *  (RL**2) + 1.8725E-03*(RL**3) - 4.8902E-05*(RL**4)
        GO TO 8
  16    IF(J.GT.3) GO TO 17
C....  SPRING SEASON ROOTING DEPTH MODIFIERS
        RDMC(J,K,L,M) = 1.00
C....  SPRING SEASON ET MODIFIERS (RDP)
        RL = RLAI(J,K,L,M)
        IF(RL.LT.7.2) ETMCR(J,K,L,M)= 7.4623E-02 + 5.1086E-01*RL
     *  - 1.4849E-01*(RL**2) + 2.0677E-02*(RL**3)
     *  - 1.0697E-03*(RL**4)
        IF ((RL.GE.7.2).AND.(RL.LT.14.)) ETMCR(J,K,L,M) =
     *     0.90 + 0.0147*(RL - 7.2)
        IF (RL.GE.14.) ETMCR(J,K,L,M) = 1.00
        GO TO 8
C....  SUMMER SEASON ROOTING DEPTH MODIFIER
  17    RD = SDEP(L,M)
        IF(RD.LT.3.) RDMC(J,K,L,M) = 0.912 + 0.044*(RD - 3.0)
        IF(RD.GE.3.) RDMC(J,K,L,M) = 1.00
C....  SUMMER SEASON ET MODIFIER (RDP)
        RL = RLAI(J,K,L,M)
        IF(RL.LE.4) ETMCR(J,K,L,M)=2.5732E-01 + 9.2385E-01*RL
     *  - 4.8116E-01*(RL**2) + 1.1359E-01*(RL**3)
     *  - 9.9372E-03*(RL**4)
        IF((RL.GT.4.).AND.(RL.LE.14.)) ETMCR(J,K,L,M) =
     *            0.98+0.002*(RL-4.)
        IF(RL.GT.14.) ETMCR(J,K,L,M) = 1.00
C.....  END OF MODIFIER COEFFICIENT SETTING FOR RDP UNITS
 8      CONTINUE
 9     CONTINUE
   10 CONTINUE
      RETURN
      END
C
C
C
C
```

```
      SUBROUTINE ADJPRC(L,M)
      COMMON/INPUT/NPROV,N,AREA,MNUM(3),ASP(3),PRECP(4),ITREE(3,4),
     *             TREEH(3,4),BA(2,3,4),BAMAX(3,4),UAREA(3,4),WSPEED,
     *             ROUGH(3,4),JSEAS,OPEN(3,4),OPLGTH(3,4),SNODAY
     *            ,SDEP(3,4),RLAI(4,2,3,4)
C     COMMON/FLAG/ITYP
      COMMON/CORE/CDMAX,CD(2),ETMC(4,2,3,4),ADJPRE(4,2,3,4),
     * ET(4,2,3,4),FLO4(4,2,3,4)
      COMMON/ANSWER/NRP1,NRP2,NRP3,NRP4,NRP5,NRP6,NRP7,NRP8,IYES,NYES
      CHARACTER * 1 NRP1,NRP2,NRP3,NRP4,NRP5,NRP6,NRP7,NRP8,IYES,NYES
      COMMON/ELCLASS/IEC(3)
      DIMENSION R(2)
C.... THIS SUBROUTINE COMPUTES ADJUSTED WINTER PRECIP. (SNOW) ACCORDING
C.... TO OPENING SIZE AND PERCENT OF BASIN CUT.
C
C.... DO FOR ALL SEASONS
      DO  30 J=1,JSEAS
          R(1)=1.
```

```
          R(2)=1.
C....     SKIP THE ADJUSTMENTS FOR RDP UNITS
          IF(IEC(M).EQ.3) GO TO 20
          IF(NPROV.EQ.7) GO TO 20
C         Region 7 has wet snow, don't do redistribution (DDH, 7/98)
C....     REDISTRIBUTION OF PRECIP. OCCURS IN THE WINTER MONTHS ONLY.
          IF(J.GT.2) GO TO 20
C
C....     FIRST, COMPUTE THE EFFECT OF IN-SITU SUBLIMATION
C....     COMPUTE AN EFFECTIVE OPENING DIAMETER AS AFFECTED BY REGROWTH
          EFFLGH=OPLGTH(L,M)-AMIN1(1.,2.*AMAX1(0.0,0.3-(CD(2)/CDMAX)))
C....     COMPUTE A DAILY SUBL. LOSS, WITH WIND MODIFIED BY OPENING DIAM.
          DAYLOS=.15*WSPEED*(.0214+.0067*EFFLGH+.00084*EFFLGH**2)
C....     COMPUTE SUBLIMATION LOSS BY SEASON, LOSS < OR = TO PRECIP.
          SEALOS=(DAYLOS*SNODAY/2)/25.4
C
C     THE PROCEDURE IS DIFFERENT FOR OPENINGS LARGER THAN 14H.
      IF(OPLGTH(L,M).GE.14) GO TO 10
C
C.... COMPUTE SNOW RETENTION COEFF. FOR OPENINGS 14H
      R(2)=1-0.040409*OPLGTH(L,M)+.581189*(1-1/EXP(OPLGTH(L,M)))
C.... MODIFY RESULT IF MORE THAN 50% OF THE BASIN IS CUT:
      IF(OPEN(L,M).GT.0.5) R(2)=1.+(R(2)-1)*(0.5/OPEN(L,M))
C.... COMPUTE COEFF. FOR FORESTED PORTION OF THE BASIN:
      IF(OPEN(L,M).LT.1.0) R(1)=(1-R(2)*OPEN(L,M))/(1-OPEN(L,M))
      GO TO 25
C
C....  PROCEDURE FOR OPENINGS >14H.
  10   P=PRECP(J)/12.
       D=TREEH(L,M)*OPLGTH(L,M)
       A=0.14**(TREEH(L,M)*0.001)
       B=0.14**((D-5.*TREEH(L,M))*0.0001)
       C=0.14**(D*0.0001)
       PZ2=AMAX1(0.,P-0.35*ROUGH(L,M))
       PZ1=PZ2/3.
C....  PRECIPITATION SWEPT FROM THE OPENING
       PR=(5*TREEH(L,M)*PZ1)+PZ2*(D-13*TREEH(L,M))
C....  PRECIPITATION SWEPT INTO THE FOREST (CUFT/FT)
       Q=AMIN1(PR,5000.*(PZ2*AMAX1(0.,(A-B))+PZ1*(B-C)))
C....  FRACTION OF PRECIP LEFT IN OPENINGS:
       R(2)=(P-PR/D)/P
C....  DO NOT COMPUTE R(1) IF ALL THE BASIN IS CUT (OPEN(L,M)=1.0)
       IF(OPEN(L,M).GE.1.0) GO TO 20
C....  ACCUMULATION COEFF. FOR FOREST(=1 IF NO SNOW FROM OPENINGS)
       R(1)=(P+(Q/D)*OPEN(L,M)/(1.-OPEN(L,M)))/P
C
C....  IS THERE WIND SCOURING IN THE LARGE OPENINGS?
       IF(NRP8.EQ.IYES.OR.NRP8.EQ.NYES) GO TO 25
  20   R(1)=AMIN1(1.,R(1))
       R(2)=AMAX1(1.,R(2))
  25   IF(OPEN(L,M).GE.1.0) R(1)=0.
       IF(OPEN(L,M).LE.0.0) R(2)=0.
C....  COMPUTE ADJUSTED FRECIPITATION:
       ADJPRE(J,1,L,M)= PRECP(J)*R(1)
       ADJPRE(J,2,L,M)= PRECP(J)*R(2)
       IF(IEC(M).GT.2) GO TO 30
C....  REMOVE THE IN-SITU SUBLIMATION (SDP UNITS ONLY)
       ADJPRE(J,2,L,M)=AMAX1(0.,ADJPRE(J,2,L,M)-SEALOS)
       write(6,50) J,L,M,ADJPRE(J,1,L,M)
  50   format(' J,1,L,M,ADJPRE: ',I3,'  1',2I3,F10.3)
  30   CONTINUE
       RETURN
       END
C
C
C
C**********************************************************
      SUBROUTINE ETCOM(L,M)
      COMMON/INPUT/NPROV,N,AREA,MNUM(3),ASP(3),PRECP(4),ITREE(3,4),
     *             TREEH(3,4),BA(2,3,4),BAMAX(3,4),UAREA(3,4),WSPEED,
```

```
     *              ROUGH(3,4),JSEAS,OPEN(3,4),OPLGTH(3,4),SNODAY
     *             ,SDEP(3,4),RLAI(4,2,3,4)
C     COMMON/FLAG/ITYP
      COMMON/COEFF/CO1(3,10),CO21(2,2,3,4),CO22(2,2,3,4),CO23(2,2,3,4),
     *           CO24(2,2,3,4),CO25(2,2,3,4),CO26(2,2,3,4),CO31(4,3,4),
     *     CO32(4,3,4),CO33(4,3,4),CO34(4,3,4),CO35(4,3,4),CO36(4,3,4)
      COMMON/CORE/CDMAX,CD(2),ETMC(4,2,3,4),ADJPRE(4,2,3,4),
     * ET(4,2,3,4),FLO4(4,2,3,4)
      COMMON/RCORE/RDMC(4,2,3,4),ETMCR(4,2,3,4)
      COMMON/ELCLASS/IEC(3)
      DIMENSION CO3(4,3,4)
C.... THIS SUBROUTINE COMPUTES ET AND FLOW BY SEASON (J), CUT AND
C.... UNCUT (K), ASPECT (L) AND UNIT (M) AS MODIFIED BY THE COVER
C.... DENSITY RELATED ET MODIFIER COEFFICIENTS.
      DO 20    J=1,JSEAS
      DO 20 K=1,2
         IF (K.EQ.1.AND.OPEN(L,M).GE.1) GO TO 20
         IF (K.EQ.2.AND.OPEN(L,M).LE.0) GO TO 20
         IF (IEC(M).EQ.3) GO TO 25
         DO 10 I=1,4
            IF(NPROV.EQ.1) CO3(I,L,J)=CO31(I,L,J)
            IF(NPROV.EQ.4) CO3(I,L,J)=CO32(I,L,J)
            IF(NPROV.EQ.5) CO3(I,L,J)=CO33(I,L,J)
            IF(NPROV.EQ.6) CO3(I,L,J)=CO34(I,L,J)
C...   REGION 7 has IEC(M)=1 for HI SNOW and IEC(M)=2 for LO SNOW
            IF((NPROV.EQ.7).AND.(IEC(M).EQ.1))  CO3(I,L,J)=CO35(I,L,J)
 10         IF((NPROV.EQ.7).AND.(IEC(M).EQ.2))  CO3(I,L,J)=CO36(I,L,J)
C        COMPUTES ET
         P=AMIN1(ADJPRE(J,K,L,M),CO3(4,L,J))
         ET(J,K,L,M)=AMAX1(0.,(CO3(1,L,J)+CO3(2,L,J)*P +
     *              CO3(3,L,J)*(P*P))*ETMC(J,K,L,M))
         write(16,50)J,K,L,M,P,ETMC(J,K,L,M),ET(J,K,L,M)
         IF((NPROV.NE.7).OR.(IEC(M).NE.2)) GO TO 15
         IF(P.GT.1.) GO TO 15
C....   LO SNOW, SOUTH ASPECT AND P<1. IN. CURVE PATCH
         IF((IEC(M).EQ.3).AND.(L.EQ.3).AND.(J.EQ.4)) ET(J,K,L,M) =
     *      AMAX1(0.,(-0.9+3.4*P))
         write(16,50)J,K,L,M,P,ETMC(J,K,L,M),ET(J,K,L,M)
 15      CONTINUE
C        COMPUTE WATER AVAILABLE FOR FLOW (INCHES):
         FLO4(J,K,L,M)=(ADJPRE(J,K,L,M)-ET(J,K,L,M))
         GO TO 20
C
C....   FOLLOWING DOES ET AND WY FOR RDP UNITS
C
 25      IF(J.GT.1) GO TO 26
         ET(J,K,L,M) = (24.0/2.54)*ETMCR(J,K,L,M)*RDMC(J,K,L,M)
         GO TO 29
 26      IF(J.GT.2) GO TO 27
         ET(J,K,L,M) = (18.0/2.54)*ETMCR(J,K,L,M)*RDMC(J,K,L,M)
         GO TO 29
 27      IF(J.GT.3) GO TO 28
         ET(J,K,L,M) = (30.5/2.54)*ETMCR(J,K,L,M)*RDMC(J,K,L,M)
         GO TO 29
 28      ET(J,K,L,M) = (26.0/2.54)*ETMCR(J,K,L,M)*RDMC(J,K,L,M)
 29      CONTINUE
         FLO4(J,K,L,M)=(ADJPRE(J,K,L,M)-ET(J,K,L,M))
 20      continue
 50      format(' J,K,L,M,P,ETMC,ET: ',4I3,3F10.3)
         RETURN
         END
C
C
```

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      SUBROUTINE QUEST1
C.... IN THIS SUBROUTINE, THE USER DEFINES THE NAME OF THE FILE
C.... WHERE RESULTS OF CALCULATION ARE TO BE ROUTED.
C     *         PLEASE REPORT PROBLEMS TO:
C     *                   P.Y.BERNIER
C     *                   NORTHERN FORESTRY CENTRE
```

```
C     *                   CANADIAN FORESTRY SERVICE
C     *                   5320-122 STREET
C     *                   EDMONTON, ALTA T6H 3S5
C     *                   TEL: 1-403-435-7210
C
C.... DEFINE THE NAME OF THE FILE TO SAVE
C
C     READ(15,40) NFILE
C  40 FORMAT(A15)
C     write(6,41) NFILE
C 41  FORMAT(1X,' NFILE: ',A15)
      OPEN (UNIT =8, status='new', NAME='results.dat')
      OPEN (UNIT = 16, status='new', NAME='input.err')
C.... UNIT 16 WILL CONTAIN ANY ERROR NOTES FOR INPUT FILE
C
      RETURN
      END
C
C
C
C
```

```
      SUBROUTINE QUEST2
      COMMON/INPUT/NPROV,N,AREA,MNUM(3),ASP(3),PRECP(4),ITREE(3,4),
     *             TREEH(3,4),BA(2,3,4),BAMAX(3,4),UAREA(3,4),WSPEED,
     *             ROUGH(3,4),JSEAS,OPEN(3,4),OPLGTH(3,4),SNODAY
     *            ,SDEP(3,4),RLAI(4,2,3,4)
C     COMMON/FLAG/ITYP
      COMMON/CORE/CDMAX,CD(2),ETMC(4,2,3,4),ADJPRE(4,2,3,4),
     * ET(4,3,2,4),FLO4(4,2,3,4)
      COMMON/TITLE/NAME(15)
      COMMON/BUFFER/IPRE(4),ITRE,B,BX,BB,CAREA,TREH,OP,XROUGH,
     *RLA(4),RLAO(4),SD
      COMMON/ANSWER/NRP1,NRP2,NRP3,NRP4,NRP5,NRP6,NRP7,NRP8,IYES,NYES
      COMMON/ELCLASS/IEC(3)
      CHARACTER * 1 NRP1,NRP2,NRP3,NRP4,NRP5,NRP6,NRP7,NRP8,IYES,NYES
      CHARACTER*9 ASPECT
      CHARACTER*12 SEASON
C
C...  ADD IN EXTRA STUFF FOR RDP CODE
C
C
C.... THIS SUBROUTINE READS ALL INPUT DATA.
C
C.... INITIALIZE VARIABLES
      DO 1 J= 1,4
      RLA(J)=0.
      RLAO(J)=0.
   1  IPRE(J)=0
      ASP1=0.
      ASP2=0.
      ASP3=0.
      ITRE=0
C     ITYP=0
      B=0.
      BB=0.
      BX=0.
      CAREA=0.
      CSIZE=0.
      TREH=0.
      OP=0.
      XROUGH=0.3
C      LC=999
C      MC=999
C
C...  SPECIAL VARIABLES FOR RDP CASES
C
      SD=0.
C
C***** BASIN DESCRIPTION ***********************************
```

```
C
      READ(15,25,ERR=30) NPROV
      write(16,22) NPROV
  22  format(1x,'NPROV: ',I5)
  25  FORMAT(3I2)
  30  N=NPROV
      IF(N.GT.1) N=N-2
      IF(N.LT.1.OR.N.GT.5) STOP 25
C.... STOP AND FIX THE INPUT FILE
      JSEAS=3
      IF(NPROV.EQ.5)JSEAS=4
      IF(NPROV.EQ.7)JSEAS=4
C
C.... NAME OF BASIN
      READ(15,50) NAME
   50 FORMAT(15A2)
      write(16,51) NAME
  51  format(' NAME: ',15A2)
C
C...  ADD IN INFO ABOUT PROCESS DOMINANT TYPE
C...  Remove the ITYP flag
C
C     READ(15,23) ITYP
C
C 23  FORMAT(I2)
C     WRITE(16,2300) ITYP
C2300 FORMAT(' ITYP: ',I3)
C     IF((ITYP.LT.1).OR.(ITYP.GT.2)) STOP 23
C...  STOP PROCESSING IF THE PROCESS TYPE ISN'T CORRECT
C     IF(IEC(M).GT.2) GO TO 132
C
C.... WIND SCOUR. IS IT EXTENSIVE IN LARGE OPENINGS? (Y/N)
      READ(15,131) NRP8
 131  format(a1)
      write(16,131) NRP8
C
C.... AREA OF BASIN (SQ. KM)
 132  CONTINUE
      READ(15,26,ERR=57) AREA
 26   FORMAT(F7.2)
      write(16,4300) AREA
 4300 format(' AREA: ',f7.2)
      go to 58
  57  STOP 57
C.... STOP AND FIX INPUT IF WRONG
  58  continue
C
C.... AREA OF ASPECTS (SQ. KM FOR EACH CLASS (N,E+W,S)
      READ(15,27,ERR=63) ASP1,ASP2,ASP3
 27   FORMAT(3F6.2)
      write(16,21) ASP1,ASP2,ASP3
 21   format(' asp1,asp2,asp3: ',3f8.2)
  63  XASP=ASP1+ASP2+ASP3
      IF(XASP+0.001.GT.AREA.AND.XASP-0.001.LT.AREA) GO TO 70
      WRITE(16,65) AREA
  65  FORMAT(' ***ERROR*** SUM OF ASPECTS IS NOT EQUAL TO BASIN',
     *       ' AREA (',F6.2,' SQ.KM)')
      STOP 65
C...  STOP AND FIX INPUT FILE BEFORE PROCEEDING
C
  70  ASP(1)=ASP1/AREA
      ASP(2)=ASP2/AREA
      ASP(3)=ASP3/AREA
      DO 100 L=1,3
         IF(ASP(L).LE.0) GO TO 100
         IF(L.EQ.1)ASPECT='NORTH    '
         IF(L.EQ.2)ASPECT='EAST+WEST'
         IF(L.EQ.3)ASPECT='SOUTH    '
C
C.... FIND NUMBER AND AREA OF UNITS IN EACH ASPECT
```

```
C....
         READ(15,25,ERR=85) MNUM(L)
         write(16,71) L,MNUM(L)
  71     format(' L,MNUM(L): ',2I7)
C      READ ELEV CLASS FOR ALL UNITS IN ASPECT L
       READ(15,25) (IEC(LL),LL=1,3)
       write(16,3333) (iec(ll),ll=1,MNUM(L))
3333   format(' iec values are: ',3i3)
C
C....  IF ONLY ONE UNIT IN THE ASPECT L
  85   IF(MNUM(L).EQ.1) UAREA(L,1)=ASP(L)*AREA
       IF(MNUM(L)-1)75,100,87
  75   WRITE(16,76) L,MNUM(L)
  76   FORMAT(' ERROR.. L= ',I2,' MNUM(L)= ',I2)
       STOP 75
C....  IF MORE THAN ONE UNIT IN ASPECT L
  87   XAREA=0.
       X=AREA*ASP(L)
C....  READ AREA VALUES FOR ALL UNITS IN ASPECT L
       READ(15,88,ERR=92)(UAREA(L,M),M=1,MNUM(L))
  88   FORMAT(4F8.2)
C
C....  NOTE:  CURRENT SETTING IS FOR A MAX OF 4 UNITS PER ASPECT!!
C
  92   XAREA=0.
       DO 95 M=1,MNUM(L)
  95       XAREA=XAREA+UAREA(L,M)
       IF(XAREA.GE.ASP(L)*AREA-0.001.AND.XAREA.LE.ASP(L)*AREA+0.001)
     *    GO TO 100
       X=ASP(L)*AREA
       WRITE(16,97) X
  97   FORMAT(' ***ERROR*** SUM OF UNITS IS NOT EQUAL TO AREA',
     *        ' OF ASPECT (', F5.2,' SQ.KM)')
          GO TO 75
  100 CONTINUE
C
C.... CORRECTIONS?  NOT NEEDED FOR FILE INPUT???
C  102 CALL CHECK(1,1,1)
C      WRITE(6,105)
C  105 FORMAT(' DO YOU WISH TO MODIFY THE BASIN DESCRIPTION?')
C      READ(15,131) NRP7
C      IF(NRP7.EQ.IYES.OR.NRP7.EQ.NYES) GO TO 10
C  131 FORMAT(A1)
C
C.... DO FOR ALL ASPECTS
  127 CONTINUE
C
C
C
C*****  BASIN CLIMATE
        DO 165 J=1,JSEAS
           IFIRST=(N*10)+J
           IF(IFIRST.EQ.11) SEASON='OCT01-JAN31:'
           IF(IFIRST.EQ.12) SEASON='FEB01-APR30:'
           IF(IFIRST.EQ.13) SEASON='MAY01-SEP30:'
           IF(IFIRST.EQ.21) SEASON='OCT01-FEB28:'
           IF(IFIRST.EQ.22) SEASON='MAR01-JUN30:'
           IF(IFIRST.EQ.23) SEASON='JULO1-SEP30:'
           IF(IFIRST.EQ.31) SEASON='OCT01-DEC29:'
           IF(IFIRST.EQ.32) SEASON='DEC30-MAR28:'
           IF(IFIRST.EQ.33) SEASON='MAR29-JUN26:'
           IF(IFIRST.EQ.34) SEASON='JUN27-SEP30:'
           IF(IFIRST.EQ.41) SEASON='OCT01-FEB28:'
           IF(IFIRST.EQ.42) SEASON='MAR01-JUN30:'
           IF(IFIRST.EQ.43) SEASON='JUL01-SEP30:'
           IF(IFIRST.EQ.51) SEASON='OCT01-DEC29:'
           IF(IFIRST.EQ.52) SEASON='DEC30-MAR28:'
           IF(IFIRST.EQ.53) SEASON='MAR29-JUN26:'
           IF(IFIRST.EQ.54) SEASON='JUN27-SEP30:'
C
```

```
C....  ENTER PRECIP BY SEASON IN MM OF WATER
           READ(15,162,ERR=1640) IPRE(J)
           write(16,163) J,IPRE(J)
           go to 165
  163      format(' J,IPRE(J): ', 2I8)
  162   FORMAT(I8)
 1640      write(16,1641) J,IPRE(J)
 1641      format(' input error, J,IPRE(J):',i2,1x,i8)
C.....     CONVERT TO INCHES
 165    PRECP(J)=FLOAT(IPRE(J))/25.4
C
C.....  WIND SPEED
C.....  ENTER THE AVERAGE WIND SPEED IN METRES/SECOND
C
               READ(15,168,ERR=170) WSPEED
        write(16,167) WSPEED
 167    format(' WSPEED: ',f7.2)
 168    FORMAT(F7.2)
C
C.....  DAYS WITH SNOW COVER
 170    IF(WSPEED.LE.0) GO TO 182
C.....  ENTER THE NUMBER OF DAYS WITH SNOW ON THE GROUND
        READ(15,173,ERR=182) SNODAY
        write(16,174) SNODAY
  174   format(' SNODAY: ', f6.0)
 173    FORMAT(F6.0)
C
C.....  CORRECTIONS? NOT NEEDED IN THE GIS VERSION...
 182    CONTINUE
C
C
      DO 600 L=1,3
C
C       IF(LC.NE.999.AND.L.NE.LC) GO TO 600
C...    LC NE 999 IMPLIES A CORRECTION WILL BE MADE.  NOT NEEDED
C
         IF(ASP(L).LE.0.) GO TO 580
         IF(L.EQ.1) ASPECT='NORTH    '
         IF(L.EQ.2) ASPECT='EAST+WEST'
         IF(L.EQ.3) ASPECT='SOUTH    '
         DO 550 M=1,MNUM(L)
C            IF(MC.NE.999.AND.M.NE.MC) GO TO 550
C 190        IF(NRP4.EQ.IYES.OR.NRP4.EQ.NYES) GO TO 290
C
C
C
C*****      STAND CHARACTERISTICS ******************************
C           WRITE(6,192)M,MNUM(L),ASPECT
C192        FORMAT(//////////////' ****** STAND CHARACTERISTICS ',
C    *             '******',/,
C    *             'UNIT',I2,' OF',I2,',    ASPECT: ',9A)
C           IF(NRP1.EQ.IYES.OR.NRP1.EQ.NYES) GO TO 275
C
C.....      TREE TYPE. VALUES RANGE FROM 1 TO 10 (SEE LIST)
            READ(15,201,ERR=202) ITRE
 201        FORMAT(I5)
 202        ITREE(L,M)=ITRE
            NX=ITREE(L,M)
            IF(N.EQ.1.AND.NX.LE.2) GO TO 225
            IF(N.EQ.2.AND.(NX.GE.3.AND.NX.LE.5)) GO TO 225
            IF(N.EQ.3.AND.(NX.GE.6.AND.NX.LE.7)) GO TO 225
            IF(N.EQ.4.AND.NX.GE.8) GO TO 225
            IF(N.EQ.5.AND.NX.EQ.4.AND.IEC(M).LT.3) GO TO 225
            IF(N.EQ.5.AND.NX.EQ.1.AND.IEC(M).GT.2) GO TO 225
            WRITE(16,205) NX,N,ITRE
 205        FORMAT(' ***ERROR*** TREE TYPE DOES NOT MATCH REGION',3I7)
            STOP 205
C
C.....      BASAL AREA OF STAND
C
```

```
C.....      ENTER STAND BASAL AREA IN SQ.M/HA
 225        CONTINUE
C
C...   DON'T INPUT BASAL AREA IF IEC(M) > 2 (RDP)
C
            IF(IEC(M).GT.2) GO TO 271
C
C...   FOLLOWING DOES SDP UNITS FOR VEGETATION PROPERTIES
C
            READ(15,231,ERR=232) B
 231        FORMAT(F8.2)
 232        IF(B.GT.70 .AND. N.NE.5) WRITE(16,235)
            IF(B.GT.92.) WRITE(16,235)
 235        FORMAT(' ***WARNING*** LARGE BASAL AREA ... RELATIONSHIPS',
     *             ' WILL BE EXTRAPOLATED')
C
C.....      MAXIMUM BASAL AREA
C
C.....      ENTER MAX BASAL AREA OF MATURE STAND, SQ.M/HA
C
            READ(15,261,ERR=262) BX
 261        FORMAT(F8.2)
 262        IF(BX.GE.B) GO TO 270
            WRITE(16,265)
 265        FORMAT(' ***ERROR*** ACTUAL BASAL AREA EXCEEDS MAXIMUM')
            STOP 265
 270        BA(1,L,M)=B*4.354
            BAMAX(L,M)=BX*4.354
            GO TO 272
C
C.....      INPUT THE RDP VEGETATION PROPERTIES HERE
C
 271        READ(15,275) SD,(RLA(J), J=1,4)
 275        FORMAT(5F5.0)
            DO 2750 J=1,4
 2750       RLAI(J,1,L,M) = RLA(J)
            SDEP(L,M) = SD
C
C...   RLAI AND SDEP ARE LEAF AREA INDEX AND ROOTING DEPTH (FOREST AREAS)
C
 272        CONTINUE
C
C
C*****      TREATMENT***************************************************
C
C.....   TOTAL AREA OF CUTS
C.....   ENTER TOTAL AREA OF CUTS IN UNIT (SQ.KM)
         READ(15,301,ERR=302) CAREA
 301     FORMAT(F10.2)
 302     IF(CAREA-UAREA(L,M)) 310,307,303
 303     WRITE(16,305) UAREA(L,M)
 305     FORMAT(' ***ERROR*** AREA OF CUT EXCEEDS AREA OF UNIT (',
     *          F6.2,'SQ.KM)' )
         STOP 303
 307     IF (IEC(M).GT.2) GO TO 310
         WRITE(16,308)
 308     FORMAT(' ***** WARNING: A 100% CUT MIGHT CAUSE',
     *          ' ARTIFICIAL LOSS OF SNOW.',/,
     *          ' LEAVE A SMALL PORTION UNCUT (0.1% FOR EXAMPLE)'
     *          ' TO AVOID THIS PROBLEM')
 310     IF(CAREA.LE.0.) GO TO 510
         IF(IEC(M).GT.2) GO TO 380
C
C...     BASAL AREA LEFT IN CUTS
C
C...     ENTER BASAL AREA LEFT IN CUT (SQ M/HA)
C
         READ(15,369,ERR=370) BB
 369     FORMAT(F10.2)
         go to 371
```

```
 370     write(16,372) bb
 372     format(' BB= ', f10.2)
 371     continue
         if(NPROV.EQ.7) go to 510
C        skip precip adjustments input for nprov=7
C
C.....   HEIGHT OF SURROUNDING TREES
C
C.....   ENTER HEIGHT OF SURROUNDING TREES, IN METRES
C
         READ(15,399,ERR=400)TREH
 399     FORMAT(F10.2)
 400     IF(CAREA.GE.UAREA(L,M)) GO TO 340
C
C....    WINDWARD LENGTH  ENTER 0 IF UNKNOWN
C
C....    ENTER WINDWARD LENGTH OF CUTS IN METRES
C
         READ(15,429,ERR=430) OP
 429     FORMAT(F10.2)
 430     IF(OP.GT.0.) GO TO 445
C
C....    AVERAGE CUT BLOCK SIZE ENTER 0 IF UNKNOWN
C
C....    ENTER AVERAGE SIZE OF CUT BLOCKS, IN HA
         READ(15,331,ERR=332) CSIZE
 331     FORMAT(F10.2)
C
 332     IF(CSIZE-AMAX1(.001,AMIN1(CSIZE,CAREA*100)))437,440,333
 333     WRITE(16,335) CAREA
 335     FORMAT(' ***ERROR*** AVERAGE SIZE EXCEEDS TOTAL AREA CUT',
     *          ' (',F6.3,'SQ.KM)')
         STOP 332
 340     CSIZE=UAREA(L,M)*100.
         GO TO 440
C
C....    LAST CHANCE FOR ESTIMATING WINDWARD LENGTH OF OPENINGS
 437     WRITE(16,438)
 438     FORMAT(/' YOU MUST ENTER AN APPROXIMATE NUMBER OF CUT',
     *          ' BLOCKS ON THE UNIT')
         READ(15,436,ERR=437) NCUT
 436     FORMAT(I5)
         IF(NCUT.LE.0) STOP 437
C
C....    STOP THE RUN.  ERROR IN INPUT MUST BE FIXED
C
         CSIZE=CAREA*100./NCUT
 440     OP=(CSIZE**0.5)*100.
 445     IF(OP/TREH.LT.13) GO TO 510
C....    LABEL 510 IS FOR SMALL OPENINGS (<13 H)
C
C....    ROUGHNESS COEFFICIENT
C
C....    ENTER ROUGHNESS COEFFICIENT
         READ(15,509,ERR=510) XROUGH
 509     FORMAT(F10.2)
C
         GO TO 510
C... RDP OPEN AREA PARAMETERS ARE SET
 380     READ(15,275) (RLAO(J),J=1,4)
         DO 3801 J=1,4
 3801    RLAI(J,2,L,M) = RLAO(J)
C... RLAI(2,L,M) IS LEAF AREA INDEX IN OPEN AREAS.
C... ASSUME ROOTING DEPTH IS SAME AS FOREST FOR TREATED AREAS.
C
C....    PERFORM APPROPRIATE TRANSFORMATIONS
 510     OPEN(L,M)=CAREA/UAREA(L,M)
         IF(CAREA.LE.0.) GO TO 525
         IF(IEC(M).GT.2) GO TO 550
C
```

```
C...  SDP SETUP FOLLOWS
C...  Note: Conversion factor revised to match forested calculations (12/98)
         BA(2,L,M)=BB*4.354
         if(NPROV.EQ.7) go to 525
C...     skip rest of setup for NPROV = 7
         TREEH(L,M)=TREH*3.28
         OPLGTH(L,M)=OP/TREH
         ROUGH(L,M)=XROUGH*3.28
C
C....    CORRECTIONS?
 525     CONTINUE
C        CALL CHECK(L,M,4) ***** REMOVED FROM CODE ******
 550  CONTINUE
C
C
C.... INITIALIZE VALUES AT 0.
 580  DO 590 J=1,JSEAS
         DO 590 M=1,4
            DO 590 K=1,2
               ET(J,K,L,M)=0.
               ADJPRE(J,K,L,M)=0.
 590           FLO4(J,K,L,M)=0.
 600  CONTINUE
C
C
C
C*****CORRECTIONS? *********************************************
C
C....  NO CORRECTIONS WILL BE ALLOWED IN THE GIS VERSION
C
      RETURN
      END
C
C
C
C
C      SUBROUTINE CHECK(L,M,LL) WAS REMOVED FROM THIS VERSION
C
C
C
C
C
C     SUBROUTINE QUEST3 WAS REMOVED FROM CODE
C..... THIS SUBROUTINE ASKS THE USER WHETHER HE WANTS TO CONTINUE
C..... USING THE PROGRAM OR NOT.
C
C
```

```
      SUBROUTINE OUT1
      COMMON/INPUT/NPROV,N,AREA,MNUM(3),ASP(3),PRECP(4),ITREE(3,4),
     *             TREEH(3,4),BA(2,3,4),BAMAX(3,4),UAREA(3,4),WSPEED,
     *             ROUGH(3,4),JSEAS,OPEN(3,4),OPLGTH(3,4),SNODAY
     *            ,SDEP(3,4),RLAI(4,2,3,4)
C     COMMON/FLAG/ITYP
      COMMON/TITLE/NAME(15)
      COMMON/ELCLASS/IEC(3)
      COMMON/ANSWER/NRP1,NRP2,NRP3,NRP4,NRP5,NRP6,NRP7,NRP8,IYES,NYES
      CHARACTER * 1 NRP1,NRP2,NRP3,NRP4,NRP5,NRP6,NRP7,NRP8,IYES,NYES
      CHARACTER*9   ASPECT
      CHARACTER*12  SEASON
      CHARACTER*10  TRETYP
      DIMENSION IPR(4)
C.....THIS SUBROUTINE ECHOES THE INPUTS TO AN OUTPUT FILE SELECTED IN
C.....SUBROUTINE QUEST1
C
      ASP1=AREA*ASP(1)
      ASP2=AREA*ASP(2)
      ASP3=AREA*ASP(3)
C
      WRITE(8,810) NAME
```

```
810  FORMAT(' NAME OF BASIN: ',15A2)
     WRITE(8,800)NPROV
800  FORMAT(' HYDROLOGIC REGION # ',I2)
     IF(NPROV.EQ.7) GO TO 801
     IF(NRP8.EQ.IYES.OR.NRP8.EQ.NYES) WRITE(8,805)
     IF(NRP8.NE.IYES.AND.NRP8.NE.NYES) WRITE(8,807)
805  FORMAT(' WIND SCOURING: EXTENSIVE')
807  FORMAT(' WIND SCOURING: NOT EXTENSIVE')
801  CONTINUE
     WRITE(8,820)AREA
820  FORMAT(' AREA OF BASIN (SQ.KM)= ',F6.2)
     WRITE(8,830) ASP1,ASP2,ASP3
830  FORMAT(' AREA IN N, E+W AND SOUTH ASPECTS: ',3F6.2)
     DO 10 J=1,JSEAS
        IPR(J)=(PRECP(J)*25.4)+0.5
        IFIRST=(N*10)+J
          IF(IFIRST.EQ.11) SEASON='OCT01-JAN31:'
          IF(IFIRST.EQ.12) SEASON='FEB01-APR30:'
          IF(IFIRST.EQ.13) SEASON='MAY01-SEP30:'
          IF(IFIRST.EQ.21) SEASON='OCT01-FEB28:'
          IF(IFIRST.EQ.22) SEASON='MAR01-JUN30:'
          IF(IFIRST.EQ.23) SEASON='JULO1-SEP30:'
          IF(IFIRST.EQ.31) SEASON='OCT01-DEC29:'
          IF(IFIRST.EQ.32) SEASON='DEC30-MAR28:'
          IF(IFIRST.EQ.33) SEASON='MAR29-JUN26:'
          IF(IFIRST.EQ.34) SEASON='JUN27-SEP30:'
          IF(IFIRST.EQ.41) SEASON='OCT01-FEB28:'
          IF(IFIRST.EQ.42) SEASON='MAR01-JUN30:'
          IF(IFIRST.EQ.43) SEASON='JUL01-SEP30:'
          IF(IFIRST.EQ.51) SEASON='OCT01-DEC29:'
          IF(IFIRST.EQ.52) SEASON='DEC30-MAR28:'
          IF(IFIRST.EQ.53) SEASON='MAR29-JUN26:'
          IF(IFIRST.EQ.54) SEASON='JUN27-SEP30:'
        WRITE(8,832) SEASON,IPR(J)
832     FORMAT(' PRECIP (MM) FOR ',A12,I6)
  10 CONTINUE
     WRITE(8,833) WSPEED
833  FORMAT(' WINDSPEED (M/SEC):',F5.2)
     IF( WSPEED.GT.0.0) WRITE(8,834)SNODAY
834  FORMAT(' NUMBER OF DAYS WITH CONTINUOUS SNOW COVER:',F5.0)
     DO 50 L=1,3
        IF(L.EQ.1) ASPECT='NORTH    '
        IF(L.EQ.2) ASPECT='EAST+WEST'
        IF(L.EQ.3) ASPECT='SOUTH    '
        IF(ASP(L).LE.0.) GO TO 50
        DO 40 M=1,MNUM(L)
           WRITE(8,835)M,MNUM(L),ASPECT
835        FORMAT(///,' INPUTS FOR UNIT',I2,' OF',I2,', ASPECT:',9A)
           IF((N.EQ.5).AND.(IEC(M).EQ.1)) WRITE(8,836)
           IF((N.EQ.5).AND.(IEC(M).EQ.2)) WRITE(8,837)
           IF((N.EQ.5).AND.(IEC(M).GT.2)) WRITE(8,838)
 836       FORMAT('  HI SNOW ')
 837       FORMAT('  LO SNOW ')
 838       FORMAT('  RAIN DOMINATED ')
           WRITE(8,840)UAREA(L,M)
840        FORMAT(' AREA OF UNIT:            ',F6.2,'  SQ.KM')
           IF(ITREE(L,M).EQ.1) TRETYP='CONIFEROUS'
           IF(ITREE(L,M).EQ.2) TRETYP='DECIDUOUS '
           IF(ITREE(L,M).EQ.3) TRETYP='SPRUCE-FIR'
           IF(ITREE(L,M).EQ.4) TRETYP='LODGEPOLE '
           IF(ITREE(L,M).EQ.5) TRETYP='PONDEROSA '
           IF(ITREE(L,M).EQ.6) TRETYP='HEM-SPRUCE'
           IF(ITREE(L,M).EQ.7) TRETYP='DOUG.FIR  '
           IF(ITREE(L,M).EQ.8) TRETYP='SPRUCE-FIR'
           IF(ITREE(L,M).EQ.9) TRETYP='WEST.LARCH'
           IF(ITREE(L,M).EQ.10)TRETYP='LODDGEPOLE'
           WRITE(8,850)TRETYP
 850       FORMAT(' TREE TYPE:        ',10A)
         IF(IEC(M).GT.2) GO TO 20
           B=BA(1,L,M)/4.354
```

```
            WRITE(8,855)B
 855        FORMAT(' BASAL AREA OF STAND:         ',F6.2,' SQ.M/HA')
            BX=BAMAX(L,M)/4.354
            WRITE(8,860)BX
 860        FORMAT(' MAXIMAL BASAL AREA:          ',F6.2,' SQ.M/HA')
            GO TO 25
 20         CONTINUE
            WRITE(8,1200) SDEP(L,M)
 1200       FORMAT(' ROOT DEPTH:                  ',F6.2,' FT. ')
            WRITE(8,1210) (RLAI(J,1,L,M), J=1,4)
 1210       FORMAT(' SEASONAL LAI:                ',4F6.2)
 25         CONTINUE
            CAREA=UAREA(L,M)*OPEN(L,M)
            WRITE(8,865)CAREA
 865        FORMAT(' TOTAL. AREA OF CUTS:         ',F6.2,' SQ.KM')
            IF(CAREA.LE.0.) GO To 40
          IF(IEC(M).GT.2) GO TO 30
            BB=(BA(2,L,M)/4.354)+0.0001
            WRITE(8,875)BB
 875        FORMAT(' BASAL AREA IN CUTS:          ',F6.2,' SQ.M/HA')
          IF(NPROV.EQ.7) go to 39
C         skip the precip adjustments output for NPROV = 7
            TREH=TREEH(L,M)/3.28
            WRITE(8,880)TREH
 880        FORMAT(' HEIGHT OF TREES:             ',F6.2,' M')
            OP=OPLGTH(L,M)*TREH
            WRITE(8,885)OP
 885        FORMAT(' WINDWARD LENGTH OF CUTS:     ',F6.2,' M')
            IF(OPLGTH(L,M).LT.15) GO TO 40
            XROUGH=ROUGH(L,M)/3.28
            WRITE(8,890)XROUGH
 890        FORMAT(' ROUGHNESS COEFFICIENT:       ',F4.2,' M')
          GO TO 39
 30      WRITE(8,1200) SDEP(L,M)
         WRITE(8,1220) (RLAI(J,2,L,M), J=1,4)
 1220    FORMAT(' SEASONAL LAI IN CUTS:          ',4F6.2)
 39      CONTINUE
 40      CONTINUE
 50   CONTINUE
      END
C
C
C
C
```

```
      SUBROUTINE OUT2
      COMMON/INPUT/NPROV,N,AREA,MNUM(3),ASP(3),PRECP(4),ITREE(3,4),
     *             TREEH(3,4),BA(2,3,4),BAMAX(3,4),UAREA(3,4),WSPEED,
     *             ROUGH(3,4),JSEAS,OPEN(3,4),OPLGTH(3,4),SNODAY
     *            ,SDEP(3,4),RLAI(4,2,3,4)
      COMMON/CORE/CDMAX,CD(2),ETMC(4,2,3,4),ADJPRE(4,2,3,4),
     * ET(4,2,3,4),FLO4(4,2,3,4)
      CHARACTER * 12 SEASON
      COMMON/ELCLASS/IEC(3)
      CHARACTER * 9 ASPECT
C
C..... THIS SUBROUTINE PRINTS ALL RESULTS OF THE CALCULATIONS
C..... FIRST, CONVERT TO METRIC
      DO 100 J=1,JSEAS
         DO 100 K=1,2
            DO 100 L=1,3
               DO 100 M=1,MNUM(L)
                  ADJPRE(J,K,L,M)=ADJPRE(J,K,L,M)*25.4
                  ET(J,K,L,M)=ET(J,K,L,M)*25.4
 100              FLO4(J,K,L,M)=FLO4(J,K,L,M)*25.4
C.....PRINT, IF DESIRED, RESULTS FROM INDIVIDUAL UNITS TO OUTPUT FILE
C     IF(NRP6.NE.IYES.AND.NRP6.NE.NYES) GO TO 210
      WRITE(8,105)
 105  FORMAT(///,'***** OUTPUT FOR EACH UNIT')
      DO 200 L=1,3
```

```
        IF(ASP(L).LE.0.) GO TO 200
        IF(L.EQ.1) ASPECT='NORTH    '
        IF(L.EQ.2) ASPECT='EAST+WEST'
        IF(L.EQ.3) ASPECT='SOUTH    '
        DO 190 M=1,MNUM(L)
           WRITE(8,110)M,ASPECT
 110       FORMAT(//,' UNIT',I2,' OF ASPECT ',9A)
           IF((N.EQ.5).AND.(IEC(M).EQ.1)) WRITE(8,111)
           IF((N.EQ.5).AND.(IEC(M).EQ.2)) WRITE(8,112)
           IF((N.EQ.5).AND.(IEC(M).EQ.3)) WRITE(8,113)
 111       FORMAT(' HI SNOW ')
 112       FORMAT(' LO SNOW ')
 113       FORMAT(' RAIN DOMINATED ')
            WRITE(8,120)
 120       FORMAT(' SEASON     PRECIP(MM)        ET(MM) ',
     *              '        FLOW(MM)',/,'          FOREST OPEN   ',
     *              '  FOREST OPEN     FOREST OPEN')
           DO 190  J=1,JSEAS
              WRITE(8,130)J,(ADJPRE(J,K,L,M),K=1,2),(ET(J,K,L,M),
     *                        K=1,2),(FLO4(J,K,L,M),K=1,2)
 130          FORMAT('   ',I2,5X,F5.0,F6.0,6X,F5.0,F6.0,5X,F5.0,F6.0)
 190    CONTINUE
 200  CONTINUE
      WRITE(8,205)
 205  FORMAT(////,'***** OUTPUT FOR THE WHOLE BASIN')
C.... COMPUTE INTERMEDIATE VALUES AND TOTAL FLOW
      FLO=0.
      sumet=0.
      sumdf=0.
      sumpr=0.
      DO 5 J=1,JSEAS
         DO 5 L=1,3
            DO 5 K=1,2
               W=0.
               X=0.
               Y=0.
               Z=0.
               DO 5 M=1,MNUM(L)
                  IF(K.EQ.1)V=UAREA(L,M)*(1.-OPEN(L,M))
                  IF(K.EQ.2)V=UAREA(L,M)*OPEN(L,M)
                  FLO=FLO+FLO4(J,K,L,M)*V
                  if(K.eq.1) sumdf=sumdf+ET(J,1,L,M)-ET(J,2,L,M)
                  sumet=sumet+ET(J,K,L,M)*V
                  sumpr=sumpr+ADJPRE(J,K,L,M)*V
                  W=W+V
                  X=X+ET(J,K,L,M)*V
                  Y=Y+FLO4(J,K,L,M)*V
                  Z=Z+ADJPRE(J,K,L,M)*V
                  IF(M.NE.MNUM(L)) GO TO 5
                  ET(J,K,L,1)=0.
                  FLO4(J,K,L,1)=0.
                  ADJPRE(J,K,L,1)=0.
               IF(W.LE.0.) GO TO 5
               ET(J,K,L,1)=X/W
               FLO4(J,K,L,1)=Y/W
               ADJPRE(J,K,L,1)=Z/W
   5  CONTINUE
      FLO=FLO/AREA
      sumpr=sumpr/AREA
      sumet=sumet/AREA
C.... IN CUBIC DECAMETRES TOTAL FLOW IS:
      CUDAM=FLO*AREA
C
C.... NOW, PRINT:
      DO 60 J=1,JSEAS
         IFIRST=(N*10)+J
           IF(IFIRST.EQ.11) SEASON='OCT01-JAN31:'
           IF(IFIRST.EQ.12) SEASON='FEB01-APR30:'
           IF(IFIRST.EQ.13) SEASON='MAY01-SEP30:'
           IF(IFIRST.EQ.21) SEASON='OCT01-FEB28:'
```

```
          IF(IFIRST.EQ.22) SEASON='MAR01-JUN30:'
          IF(IFIRST.EQ.23) SEASON='JULO1-SEP30:'
          IF(IFIRST.EQ.31) SEASON='OCT01-DEC29:'
          IF(IFIRST.EQ.32) SEASON='DEC30-MAR28:'
          IF(IFIRST.EQ.33) SEASON='MAR29-JUN26:'
          IF(IFIRST.EQ.34) SEASON='JUN27-SEP30:'
          IF(IFIRST.EQ.41) SEASON='OCT01-FEB28:'
          IF(IFIRST.EQ.42) SEASON='MAR01-JUN30:'
          IF(IFIRST.EQ.43) SEASON='JUL01-SEP30:'
          IF(IFIRST.EQ.51) SEASON='OCT01-DEC29:'
          IF(IFIRST.EQ.52) SEASON='DEC30-MAR28:'
          IF(IFIRST.EQ.53) SEASON='MAR29-JUN26:'
          IF(IFIRST.EQ.54) SEASON='JUN27-SEP30:'
      WRITE(6,10) SEASON
      WRITE(6,20)
      WRITE(6,30)((ADJPRE(J,K,L,1),K=1,2),L=1,3)
      WRITE(6,40)((ET(J,K,L,1),K=1,2),L=1,3)
      WRITE(6,50)((FLO4(J,K,L,1),K=1,2),L=1,3)
C.... PRINT TO OUTPUT FILE
      WRITE(8,10) SEASON
      WRITE(8,20)
      WRITE(8,30)((ADJPRE(J,K,L,1),K=1,2),L=1,3)
      WRITE(8,40)((ET(J,K,L,1),K=1,2),L=1,3)
      WRITE(8,50)((FLO4(J,K,L,1),K=1,2),L=1,3)
      CONTINUE
 10      FORMAT(/,' SEASON:',12A)
 20      FORMAT('       *......NORTH......*....EAST+WEST....*',
     *'......SOUTH.....*',/,
     *'         FOREST     OPEN   FOREST     OPEN   FOREST',
     *'     OPEN')
 30      FORMAT(' PRECIP(MM)',F5.0,5F9.0)
 40      FORMAT(' ET(MM)    ',F5.0,5F9.0)
 50      FORMAT(' FLOW(MM)  ',F5.0,5F9.0)
 60      CONTINUE
C
      WRITE(6,70)FLO,CUDAM
      write(8,80)
      write(8,75) sumpr,sumet,FLO
 75   format(' BASIN PR,ET&WY (mm): ',3F10.1)
      write(8,76) sumdf
 76   format(' ET(forest)-ET(open) is change in water yield: ',
     > f10.2,' mm')
      WRITE(8,70)FLO,CUDAM
      WRITE(8,80)
 70   FORMAT(/' YEARLY FLOW IN MM: ',F6.0,'   ****IN CU.DAM=  ',F8.1)
 80   FORMAT(//,'*****************************************',//)
      RETURN
      END
```

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