Appendix F

Description of Program Output

The sequence of possible output[1] from the HEC-5 program is:

1. Printout of input data (*Input Summary, *Routing Data, *Rule Curve Summary, *Operation Summary, *Map 1, *Map 2, *Reservoir Data, *Diversion Data, and *Routing / Operation Summary, *FLOWS)

2. Computation of incremental local flows (*LOCFL)

3. Printout of optimization trials and summary (*OPTRY and *OPSUM)

4. Results of all variables defined and requested by input data for the system operations arranged by downstream sequence of control points (*NORML)

5. Reservoir operation results arranged by sequence of time periods (*ROPER)

6. Results displayed in sequential time series: releases from reservoirs (*RRPER), regulated flows at all non-reservoir control points (*RQPER), diversion flows (*DVPER) and diversion shortages (*DVSHORT) at all locations, and percent flood control storage used by reservoirs (*FCPCT)

7. User-designed output based on **J8/JZ** Record input (*USERS)

8. Single flood summary of maximums for reservoirs and non-reservoirs

9. Multi-event summaries for flood control (*SUMFS) and conservation (*SUMPO)

10. Economic input data and damage computation (*ECDAM)

11. Flood frequency plots (*EPLOT)

12. Summary of damages or average annual damages, system costs and net benefits (*ESUMD, *ESUMC and *ESUMB)

13. Summary of discharge and stage reduction at each non-reservoir control point for each flood event (*HYEFF)

14. Computer check for possible errors (*ERROR), and

15. Listing of case designations defining reservoir releases (*CASES).

[1] Most of the output that is generated in the output file is controlled by the user (see the **J3** Record, field 1). The first 3 items in the above list are displayed from the HEC-5A program. The HEC-5B program displays all of the remaining output. The two programs are run sequentially in a single batch job.

The following sections provide a detailed description of the items that appear in an output file.

F.1 Printout of Input Data (*Input, *Routing, *Rule, *Operation, *Map, *Reservoir, *Diversion, *Routing/Operation, *FLOWS)

In addition to an "echo display" of the input data records (**T1**-**EJ**), the following summary information is "automatically" displayed in the output file:

***Input Summary** - a reflection of the Job Records (**J1**-**J4**) with the record's variable names and default values in instances where the values were not input. Also included in this section is a summary of control point locations along with their Channel Capacities and Minimum Flow requirements (from **CP** Records). Table F.1 is an excerpt from an example output file showing the input summary information.

Table F.1 Example Output Showing **Input Summary*

```
*Input Summary


J1 METRIC  ISTMO   NULEV  LEVCON  LEVTFC  LEVBUF  LEVPUM  NOADLV  LEVPRC
       1       1       5       3       4       2       3       0       2
J2 IFCAST  CFLOD  RATCHG   IPRIO   IOPMD  ISCHED   NCPTR  NCYCLE
       8    1.20    0.04       8       0      10       0       1
J3 IPRINT  PRCOL  IPLOTJ  FLONAT  CRITPR  ILOCAL  NOROUT  INTYPE  NOOPTS
       5    130.       0     -1.      0.      -1      24       0       0
J4 IANDAM  ECFCT  IPRECN  BCRFAC  COSFAC   PCVAL  PEPVAL  PESVAL  PEBVAL    J410
       0     1.0       0    1.00    1.00     0.0     0.0     0.0     0.0     0.0

Location:   ChCap    QMRatio  QMinD   QMinR  LQCP  QRatio QLag Location:


      33      150.   1.000     3.0     1.5     0   1.000    0. AVON DAM

      44      425.   1.000    20.0     2.0     0   1.000    0. BISHOP DAM

      40      450.   1.000     0.0     0.0     0   1.000    0. ZELMA

      22      100.   1.000     2.2     1.0     0   1.000    0. CARY DAM

      20      550.   1.000     0.0     0.0     0   1.000    0. CENTERVILLE

      11       25.   1.000     1.1     0.5     0   1.000    0. DONNER DAM

      10      870.   1.000     0.0     0.0     0   1.000    0. UNIONVILLE

       5      950.   1.000     0.0     0.0     0   1.000    0. DRY TOWN
```

***Routing Data** - the linkage between control point locations along with the Routing Methods input for each reach (from **RT** Records). Also shown is the internal program identification number (Index) for each location based on the order that the location was input. Table F.2 is an excerpt from an example output file showing the routing data information.

Table F.2 Example Output Showing **Routing Data*

*Routing Data

Index #	Location	Route To:	Method:	X	K	Lag
1	33	22	2.20	0.25	3.20	0
2	44	40	1.20	0.30	3.00	0
5	40	20	1.90	0.00	0.00	0
3	22	20	2.20	0.45	3.10	0
6	20	10	1.20	0.35	3.00	0
4	11	10	3.20	0.20	3.00	0
7	10	5	1.40	0.20	0.00	0
8	5	0	0.00	0.00	0.00	0

***Rule Curve Summary** - reservoir Storage values (**RL** Records) for each Level. If storage values vary by season (**CS** Record), then the corresponding seasons are also shown Table F.3 is an excerpt from an example output file showing a rule curve summary.

Table F.3 Example Output Showing **Rule Curve Summary*

```
*Rule Curve Summary

   Initial   Cum     Start              Storage for Level:
   Storage   Days    Date         1         2         3         4         5


            -----------------------------------------
            Reservoir Number =   33     AVON DAM
            -----------------------------------------

   151400.     1    01 JAN    31100.    34050.   151400.   350550.   375000.

Season = 2   105    15 APR    31100.    34050.   151400.   350550.   375000.

         3   135    15 MAY    31100.    34050.   197000.   350550.   375000.

         4   151    31 MAY    31100.    34050.   310330.   350550.   375000.

         5   250    07 SEP    31100.    34050.   310330.   350550.   375000.

         6   274    01 OCT    31100.    34050.   254050.   350550.   375000.

         7   305    01 NOV    31100.    34050.   210500.   350550.   375000.

         8   331    27 NOV    31100.    34050.   151400.   350550.   375000.

         9   365    31 DEC    31100.    34050.   151400.   350550.   375000.


            -----------------------------------------
            Reservoir Number =   44     BISHOP DAM
            -----------------------------------------

   146480.     1    01 Jan   131438.   134000.   146480.   562248.   630063.


            -----------------------------------------
            Reservoir Number =   22     CARY DAM
            -----------------------------------------

   255480.     1    01 JAN    21438.   134000.   255480.   389248.   435563.

Season = 2   105    15 APR    21438.   134000.   255480.   389248.   435563.

         3   151    31 MAY    21438.   134000.   362008.   389248.   435563.

         4   250    07 SEP    21438.   134000.   362008.   389248.   435563.

         5   305    01 NOV    21438.   134000.   255480.   389248.   435563.

         6   365    31 DEC    21438.   134000.   255480.   389248.   435563.


            -----------------------------------------
            Reservoir Number =   11     DONNER DAM
            -----------------------------------------

    56480.     1    01 Jan     1638.     4000.    56480.   150200.   215000.
```

***Operation Summary** - a summary of which location each reservoir operates for (**RO** Record). Table F.4 is an excerpt from an example output file showing an operation summary.

Table F.4 Example Output Showing **Operation Summary*

```
*Operation Summary

 Res. No.  Operates for the Following Locations:


      33     33.     22.

      44     44.     40.     20.     10.      5.

      22     22.     20.     10.      5.

      11     11.     10.      5.
```

***Map 1** - a schematic showing the reservoirs that operate for each location (interpretation of the **RO** Records). Table F.5 is an excerpt from an example output file showing the first schematic (*Map 1) information.

Table F.5 Example Output Showing **Map 1*

```
 *Map 1

          HEC-5 Test for Output Displays for User's Manual  (July 1998)

                                 Upstream Reservoirs Operating for Each
Location

     33R              AVON DAM
     22R              CARY DAM           33
      |     .----44R  BISHOP DAM
      .----40         ZELMA              44
     20               CENTERVILL         44      22
      .----11R        DONNER DAM
     10               UNIONVILLE         44      22      11
      5               DRY TOWN           44      22      11
```

***Map 2** - a schematic with the following pertinent input data: “Incremental” Flood Control and Conservation storage values for reservoirs, Channel Capacities, Minimum flow requirements (Desired and Required), and Diversion locations. Table F.6 is an excerpt from an example output file showing the second schematic (*Map 2) summary information.

Table F.6 Example Output Showing **Map 2*

```
*Map 2

          HEC-5 Test for Output Displays for User's Manual  (July 1998)

                                   Channel   Flood     Conserv.  Min Des.  Min Req.  Divert     Map  Location
                                   Capacity  Storage   Storage     Flow      Flow      to    Number   Name

    33R              AVON DAM         150.   199150.   120300.       3.        2.        0       33 AVON DAM
    22R              CARY DAM         100.   133768.   234042.       2.        1.        0       22 CARY DAM
     |      .----44R BISHOP DAM       425.   415768.    15042.      20.        2.        0       44 BISHOP DAM
     .----40         ZELMA            450.        0.        0.       0.        0.        0       40 ZELMA
    20               CENTERVILL       550.        0.        0.       0.        0.        5       20 CENTERVILLE
     .----11R        DONNER DAM        25.    93720.    54842.       1.        1.        0       11 DONNER DAM
    10               UNIONVILLE       870.        0.        0.       0.        0.        0       10 UNIONVILLE
     5               DRY TOWN         950.        0.        0.       0.        0.       -1        5 DRY TOWN
```

***Reservoir Data** - summary of the following reservoir input data: Storage values (**RS** Record), along with corresponding Outlet Capacities (**RQ** Record), Areas (**RA** Record), and Elevations (**RE** Record). Table F.7 is an excerpt from an example output file showing the reservoir data summary information.

Table F.7 Example Output Showing **Reservoir Data*

```
*Reservoir Data

                             ------------------------------------------
                             Reservoir Number =   33     AVON DAM
                             ------------------------------------------

RS   Storages (1000's m3) =         0.    31100.    34050.    53000.   100240.
                               151400.   201100.   256350.   297100.   350550.
                               375000.

RQ   Q Capacities (m3/sec)=      0.00     11.00    145.00    178.00    212.00
                                240.00    452.00    664.00   1457.00   1646.00
                               1829.00

RA   Areas not input      :  Only needed for Evaporation

RE   Elevations (Meters)  =    309.00    349.60    351.00    362.10    370.00
                                374.30    377.40    382.00    383.00    384.70
                                386.80


                             ------------------------------------------
                             Reservoir Number =   44     BISHOP DAM
                             ------------------------------------------

RS   Storages (1000's m3) =         0.   124113.   131438.   134000.   146480.
                               253628.   362008.   417740.   465211.   546342.
                               562248.   589251.   630063.

RQ   Q Capacities (m3/sec)=      0.00    333.00    665.00    668.00    681.00
                                796.00    872.00    912.00   2322.00   5664.00
                               6457.00   7646.00   9629.00

RA   Areas not input      :  Only needed for Evaporation

RE   Elevations (Meters)  =    209.70    249.60    250.20    250.40    251.50
                                262.10    270.50    274.30    277.40    282.20
                                283.20    284.70    286.80


                             ------------------------------------------
                             Reservoir Number =   11     DONNER DAM
                             ------------------------------------------

RS   Storages (1000's m3) =         0.     1638.     4000.    56480.    93008.
                               112740.   150200.   215000.

RQ   Q Capacities (m3/sec)=      0.00    657.00    681.00    796.00    872.00
                                912.00   2322.00   5664.00

RA   Areas not input      :  Only needed for Evaporation

RE   Elevations (Meters)  =     59.70     99.60    101.50    112.10    120.50
                                124.30    127.40    132.20
```

***Diversion Data** - summary showing the "from" and "to" locations where diversions are input. Also shown is the diversion type and input diversion data (**DR** Record).Table F.8 is an excerpt from an example output file showing the diversion data summary information.

Table F.8 Example Output Showing **Diversion Data*

*Diversion Data

Div No	From	To	Type	Div Q	%Return	Method	X	K	Div Ratio
1	20	5	0	88.00	25	1.10	1.00	0.00	1.00
2	5	0	1	0.00	100	1.10	1.00	0.00	1.00

***Routing / Operation Summary** - routing coefficients developed from the routing criteria (**RT** Record) are shown for those downstream locations that a reservoir operates for (**RO** Record). This information is useful in reviewing the reservoir releases for filling the downstream channel in conjunction with the forecast (**J2** Record, field 1). Table F.9 is an excerpt from an example output file showing the routing and operation summary information.

Table F.9 Example Output Showing **Routing / Operation Summary*

```
*Routing/Operation Summary  (Coefficients Based on 3 Hours)


ROUTING COEFFICIENTS  from Reservoir   33   to Downstream Location(s):
Loc=   22 0.0323 0.2269 0.4512 0.1962 0.0665 0.0203 0.0057 0.0010

ROUTING COEFFICIENTS  from Reservoir   44   to Downstream Location(s):
Loc=   40 0.1668 0.6949 0.1158 0.0193 0.0032
Loc=   20 0.0167 0.1780 0.5054 0.2511 0.0419 0.0069
Loc=   10 0.0022 0.0358 0.2021 0.4325 0.2474 0.0641 0.0135 0.0023
Loc=    5 0.0016 0.0262 0.1547 0.3669 0.3005 0.1166 0.0280 0.0055

ROUTING COEFFICIENTS  from Reservoir   22   to Downstream Location(s):
Loc=   20 0.0011 0.0594 0.8243 0.1052 0.0101
Loc=   10 0.0000 0.0086 0.1526 0.6433 0.1630 0.0287 0.0037
Loc=    5 0.0000 0.0062 0.1114 0.5030 0.3002 0.0671 0.0109 0.0013

ROUTING COEFFICIENTS  from Reservoir   11   to Downstream Location(s):
Loc=   10 0.0123 0.0948 0.2648 0.3248 0.1837 0.0786 0.0290 0.0095 0.0026
Loc=    5 0.0088 0.0712 0.2164 0.3079 0.2242 0.1087 0.0432 0.0151 0.0045
```

***FLOWS** - If requested (by including a 128 in the sum of the value in field 1 of the **J3** Record), a formatted listing (in 10-field record images) of input flow data is displayed in flood sets (if subdivision is required). Normally, this option is not requested since the input flow data values are included (by default) in the "echo display" of the input data records.

F.2 Computation of Incremental Local Flows (*LOCFL)

If incremental local flows are being computed from natural or observed data (see **J3** Record, field 6), the observed and routed flows can be shown in the output file for all control points by including a 64 in the sum specified in field 1 of the **J3** Record. For example, Table F.10 shows a HEC-5 input file where Incremental Local Flows are to be computed based on Natural flows (**J3** Record, field 6 = 20).

Table F.10 Example HEC-5 Input for Computing Incremental Local Flows

```
T1      Example for COMPUTING LOCAL FLOWS FROM NATURAL FLOWS
T2      THREE RESERVOIR OPERATION FOR FLOOD CONTROL
T3      2 PARALLEL, 2 TANDEM
J1       0       1       3       2       3       1
J2      24       1    .167
J3     511                                      20
J8 20.02   30.02   20.00   20.24   20.02   50.02    2.99   10.02   10.24
J8 30.02   30.24   30.10   20.02   20.24   20.10   50.10   50.02   10.24   10.02
RL      30                           50000
RO       1      20
RS       2       0   50000
RQ       2    6000  100000
R2 99999   99999
CP      30    6000
ID RES30
RT      30      20       0       0
RL      20                          275000
RO       1      10
RS       2       0  275000
RQ       2   21000   21000
R2 99999   99999
CP      20   21000
ID RES20
RT      20      10     1.1     3.1
C       20      10
RL      50                          200000
RO       1      10
RS       2       0  200000
RQ       2   12000   12000
R2 99999   99999
CP      50   12000
ID RES50
RT      50      10     1.1     3.2
C       50      10
CP      10   25000
ID CPT10
RT      10       0
ED
BF       0      17       0       045062112       0       6                            1900
IN      30               0       0    3000   18000   37000   42000   50000   27000
IN 20000   13000    5000       0       0       0       0       0       0
IN      20               0       0    3000   24000   57000   99000  150000  117000
IN 90000   63000   42000   24000   24000   15000    9000    3000       0
IN      50               0    6000   27000   60000  105000   78000   60000   45000
IN 33000   24000   18000   12000   12000    9000    6000    3000       0
IN      10               0    8000   42000   73000  149000  181000  217000  194000
IN181000  140000  109000   93000   61000   42000   31000   19000   10000
NQ      30               0       0    3000   18000   37000   42000   50000   27000
NQ 20000   13000    5000       0       0       0       0       0       0
NQ      20               0       0    3000   24000   57000   99000  150000  117000
NQ 90000   63000   42000   24000   24000   15000    9000    3000       0
NQ      50               0    6000   27000   60000  105000   78000   60000   45000
NQ 33000   24000   18000   12000   12000    9000    6000    3000       0
NQ      10               0    8000   42000   73000  149000  181000  217000  194000
NQ181000  140000  109000   93000   61000   42000   31000   19000   10000
EJ
```

In this example, the time series data represent “total flows” at all of the model locations. Table F.11 shows a schematic map of the example model locations.

Table F.11 Example Schematic of Input for Computing Incremental Locals

```
*Map 1

 Example for COMPUTING LOCAL FLOWS FROM NATURAL FLOWS


              Upstream Reservoirs Operating for Each Location

    30R         RES30
    20R         RES20           30
     .----50R   RES50
    10          CPT10           20      50
```

The process for computing incremental locals includes routing the upstream total flow hydrograph to the next downstream location and then subtracting these routed flows from the total flow at the downstream location. Included in the output file is a section labeled "Incremental LOCAL FLOW Information" as illustrated in Table F.12 where the observed (or natural) flows are shown twice for each control point. The first group shows the computed value obtained by subtracting the sum of the upstream routed hydrograph from the observed (or natural) hydrograph and the second group shows the adjusted values. The adjustment is made to eliminate any resulting negative local flows and to preserve the correct volume. By default, all negative local flows are set to zero and the negative volume is proportioned to the positive values. However, the user can specify a **negative** value in field 6 of the **J3** Record and the program will allow the computation and use of negative incremental local flows, as illustrated in Table F.13.

Table F.12 Printout of Computation of *"Positive"* Incremental Local Flows

```
          "Incremental"  LOCAL FLOW  Information:
           -------------------------------------

*LOCFL


OBS Q AT   30

M=    30               0.      0.   3000.  18000.  37000.  42000.  50000.
                   27000.  20000.  13000.   5000.      0.      0.      0.
                       0.      0.      0.
SUM=   215000.

ROUTED Q FROM MX=  30 TO   20
RTMD=      1.10 RTCOF=      1.00 K=      0.00

              COEF=   1.00000

M=    20               0.      0.   3000.  18000.  37000.  42000.  50000.
                   27000.  20000.  13000.   5000.      0.      0.      0.
                       0.      0.      0.
SUM=   215000.

OBS Q AT   20

M=    20               0.      0.   3000.  24000.  57000.  99000. 150000.
                  117000.  90000.  63000.  42000.  24000.  24000.  15000.
                    9000.   3000.      0.
SUM=   720000.

ROUTED Q FROM MX=  20 TO   10
RTMD=      1.10 RTCOF=      3.10 K=      0.00

              COEF=   0.33333   0.33333   0.33333

M=    10               0.      0.   1000.   9000.  28000.  60000. 102000.
                  122000. 119000.  90000.  65000.  43000.  30000.  21000.
                   16000.   9000.   4000.
SUM=   719000.

OBS Q AT   50

M=    50               0.   6000.  27000.  60000. 105000.  78000.  60000.
                   45000.  33000.  24000.  18000.  12000.  12000.   9000.
                    6000.   3000.      0.
SUM=   498000.

ROUTED Q FROM MX=  50 TO   10
RTMD=      1.10 RTCOF=      3.20 K=      0.00

              COEF=   0.00000   0.33333   0.33333   0.33333

M=    10               0.      0.   2000.  11000.  31000.  64000.  81000.
                   81000.  61000.  46000.  34000.  25000.  18000.  14000.
                   11000.   9000.   6000.
SUM=   494000.
SUM OF ROUTED FLOWS TO C.P.    10

M=    10               0.      0.   3000.  20000.  59000. 124000. 183000.
                  203000. 180000. 136000.  99000.  68000.  48000.  35000.
                   27000.  18000.  10000.


INC LOCAL FLOWS COMPUTED
```

... Continued ...

Table F.12 Printout of Computation of *"Positive"* Incremental Local Flows *(Continued)*

```
RES INFLOW,OUTFLOW=   215000.        0. ALL RES I-0=        0.

M=    30                 0.      0.   3000.  18000.  37000.  42000.  50000.
                     27000.  20000.  13000.   5000.      0.      0.      0.
                         0.      0.      0.

M=    30                 0.      0.   3000.  18000.  37000.  42000.  50000.
                     27000.  20000.  13000.   5000.      0.      0.      0.
                         0.      0.      0.
SUM=   215000. -SUM=        0. -MAX=        0.


RES INFLOW,OUTFLOW=   720000.        0. ALL RES I-0=        0.

M=    20                 0.      0.      0.   6000.  20000.  57000. 100000.
                     90000.  70000.  50000.  37000.  24000.  24000.  15000.
                      9000.   3000.      0.

M=    20                 0.      0.      0.   6000.  20000.  57000. 100000.
                     90000.  70000.  50000.  37000.  24000.  24000.  15000.
                      9000.   3000.      0.
SUM=   505000. -SUM=        0. -MAX=        0.


RES INFLOW,OUTFLOW=   498000.        0. ALL RES I-0=        0.

M=    50                 0.   6000.  27000.  60000. 105000.  78000.  60000.
                     45000.  33000.  24000.  18000.  12000.  12000.   9000.
                      6000.   3000.      0.

M=    50                 0.   6000.  27000.  60000. 105000.  78000.  60000.
                     45000.  33000.  24000.  18000.  12000.  12000.   9000.
                      6000.   3000.      0.
SUM=   498000. -SUM=        0. -MAX=        0.


RES INFLOW,OUTFLOW=  1550000.        0. ALL RES I-0=        0.

M=    10                 0.   8000.  39000.  53000.  90000.  57000.  34000.
                     -9000.   1000.   4000.  10000.  25000.  13000.   7000.
                      4000.   1000.      0.


M=    10                 0.   7792.  37986.  51621.  87659.  55517.  33116.
                         0.    974.   3896.   9740.  24350.  12662.   6818.
                      3896.    974.      0.

SUM=   337000. -SUM=    -9000. -MAX=    -9000.
SUM ALL INC FLOWS(CFS-PER)=            1555000. AVE=    91471.

SUM LAST MX=            1550000. D.S.VOL(RES.I-0,+MX)=  1550000.


********
* NOTE *   INCREMENTAL LOCAL FLOWS HAVE BEEN "COMPUTED"
********
```

Table F.13 Printout of Computation of *“Negative”* Incremental Local Flows

```
          "Incremental"  LOCAL FLOW  Information:
           ------------------------------------

*LOCFL


OBS Q AT   30

M=    30               0.      0.   3000.  18000.  37000.  42000.  50000.
                   27000.  20000.  13000.   5000.      0.      0.      0.
                       0.      0.      0.
SUM=   215000.

ROUTED Q FROM MX=  30 TO   20
RTMD=      1.10 RTCOF=      1.00 K=      0.00

              COEF=   1.00000

M=    20               0.      0.   3000.  18000.  37000.  42000.  50000.
                   27000.  20000.  13000.   5000.      0.      0.      0.
                       0.      0.      0.
SUM=   215000.

OBS Q AT   20

M=    20               0.      0.   3000.  24000.  57000.  99000. 150000.
                  117000.  90000.  63000.  42000.  24000.  24000.  15000.
                    9000.   3000.      0.
SUM=   720000.

ROUTED Q FROM MX=  20 TO   10
RTMD=      1.10 RTCOF=      3.10 K=      0.00

              COEF=   0.33333   0.33333   0.33333

M=    10               0.      0.   1000.   9000.  28000.  60000. 102000.
                  122000. 119000.  90000.  65000.  43000.  30000.  21000.
                   16000.   9000.   4000.
SUM=   719000.

OBS Q AT   50

M=    50               0.   6000.  27000.  60000. 105000.  78000.  60000.
                   45000.  33000.  24000.  18000.  12000.  12000.   9000.
                    6000.   3000.      0.
SUM=   498000.

ROUTED Q FROM MX=  50 TO   10
RTMD=      1.10 RTCOF=      3.20 K=      0.00

              COEF=   0.00000   0.33333   0.33333   0.33333

M=    10               0.      0.   2000.  11000.  31000.  64000.  81000.
                   81000.  61000.  46000.  34000.  25000.  18000.  14000.
                   11000.   9000.   6000.
SUM=   494000.
SUM OF ROUTED FLOWS TO C.P.    10

M=    10               0.      0.   3000.  20000.  59000. 124000. 183000.
                  203000. 180000. 136000.  99000.  68000.  48000.  35000.
                   27000.  18000.  10000.


INC LOCAL FLOWS COMPUTED
```

... Continued ...

Table F.13 Printout of Computation of *"Negative"* Incremental Local Flows *(Continued)*

```
RES INFLOW,OUTFLOW=   215000.        0. ALL RES I-0=        0.

M=    30                  0.      0.   3000.  18000.  37000.  42000.  50000.
                      27000.  20000.  13000.   5000.      0.      0.      0.
                          0.      0.      0.

M=    30                  0.      0.   3000.  18000.  37000.  42000.  50000.
                      27000.  20000.  13000.   5000.      0.      0.      0.
                          0.      0.      0.
SUM=   215000. -SUM=        0. -MAX=        0.


RES INFLOW,OUTFLOW=   720000.        0. ALL RES I-0=        0.

M=    20                  0.      0.      0.   6000.  20000.  57000. 100000.
                      90000.  70000.  50000.  37000.  24000.  24000.  15000.
                       9000.   3000.      0.

M=    20                  0.      0.      0.   6000.  20000.  57000. 100000.
                      90000.  70000.  50000.  37000.  24000.  24000.  15000.
                       9000.   3000.      0.
SUM=   505000. -SUM=        0. -MAX=        0.


RES INFLOW,OUTFLOW=   498000.        0. ALL RES I-0=        0.

M=    50                  0.   6000.  27000.  60000. 105000.  78000.  60000.
                      45000.  33000.  24000.  18000.  12000.  12000.   9000.
                       6000.   3000.      0.

M=    50                  0.   6000.  27000.  60000. 105000.  78000.  60000.
                      45000.  33000.  24000.  18000.  12000.  12000.   9000.
                       6000.   3000.      0.
SUM=   498000. -SUM=        0. -MAX=        0.


RES INFLOW,OUTFLOW=  1550000.        0. ALL RES I-0=        0.

M=    10                  0.   8000.  39000.  53000.  90000.  57000.  34000.
                      -9000.   1000.   4000.  10000.  25000.  13000.   7000.
                       4000.   1000.      0.

M=    10                  0.   8000.  39000.  53000.  90000.  57000.  34000.
                      -9000.   1000.   4000.  10000.  25000.  13000.   7000.
                       4000.   1000.      0.

SUM=   337000. -SUM=    -9000. -MAX=    -9000.
SUM ALL INC FLOWS(CFS-PER)=            1555000. AVE=    91471.

SUM LAST MX=            1550000. D.S.VOL(RES.I-0,+MX)=  1550000.


********
* NOTE *   INCREMENTAL LOCAL FLOWS HAVE BEEN "COMPUTED"
********
```

F.3 Printout of Optimization Trials and Summary

F.3.1 Printout From Each Optimization Trial (*OPTRY)

Table F.14 shows an example input file for optimization of monthly power requirements and installed capacity for Reservoir 1 (**J7** Record, field 1 = 1.1)

Table F.14 Example Input for Hydropower Optimization

```
T1               BOSWELL  RES. POWER OPT. - PHONEY TW CURVE
T2  NATIONAL HYDROPOWER STUDY TEST
T3  MUDDY BOGGY CREEK
J1     0      10       4       3       4       2
J2                                     3
J3     4                                       1
J6  2.31    1.23    -.14    -.14    -.14    1.23    1.23    2.31    5.34    7.64
J6  7.64    5.34
J7   1.1                                                       2       6    0.05
J8 1.090   1.100   1.120   1.130   1.150   1.160   1.110   1.220   1.210   1.250
J8 1.161   1.162   1.163   1.164
C      1       1                                                              20
C      2      83     199
RL     1  483242  158238  158238  483242 1130000
RO     1       1
RS     9      0.   1184.   9468.  31955.  84559. 197454. 393897. 697031.1130000.
RQ     91000000.1000000.1000000.1000000.1000000.1000000.1000000.1000000.1000000.
RA     9      0.   299.0  1196.0  2691.0  6638.7 12699.9 20710.0 30669.0 42576.8
RE     9      0.   11.88   23.75   35.63   47.50   59.38   71.25   83.13   95.00
P1     1     1.0
PR-.0506  -.0645  -.0551  -.0467  -.1066  -.1201  -.1828  -.1699  -.1006  -.0381
PR-.0187  -.0463
PQ     0  100000
PT     1       2
CP     1 9999999
IDBOSWELL RESERVOIR
RT     1       2
CP     2 9999999
IDMUDDY BOGGY CREEK
RT     2
ED
BF     0     360                38100000                     720
IN     1  101938      63     230    1506    2760   16708    3827    3638    3701
IN   903    1121     450      17       0       7       9      26     703     498
IN  2321     186      94     247      46       1       0       0       0       1
IN   150      43    4642    4705    2154    1874     454     128      14    1135
IN  1966    1943    4078     389    6775    2697     813     193     156      50
IN  5416    3555    1309     690    1746    1278   20137    2990    7068    1558
IN   135     577     154    1261    2217     190     211    1221    2321    8532
IN  1046      70       1       5     247      13     364     836    4789    4747
IN   918    4391    1089      48      14      55     767     224     732     429
IN  8469   15432   11355    4538   15725    3074    5228    3764    3220     447
IN   173    2802    8615    2072    2656    2488    1815     234     274      86
IN     9    6566    8866     368      97     920    7089    7612    2865     257
IN    44      70       5      72     824    1324    3534    2467      83    3283
IN  2760    1723      20      24       3       7      17    1286    4140    2865
IN   811    6169    2530     105      92     447     650      36     324    3680
.
.  (flows for periods 149 thru 360 not shown)
.
EJ
ER
```

The corresponding HEC-5 printout for the Hydropower Optimization example is shown in Table F.15 and is discussed in detail in the following paragraphs:

a. The first group of output ① shows the allowable error criteria for the optimization process (**J7** Record, field 10). The heading "ALL. PERC NEGATIVE ERROR = .05, POSITIVE ERROR = .05, IND FOR ONE MORE TRY = 0" means that the allowable error for too much drawdown (negative error) and too little drawdown (positive error) are both 5%, and that an additional routing to straighten out HEC-5B output (extra 500,000 units of storage, etc.) will not be made.

b. The second group of output ② shows the periods of the critical drawdown (e.g., from periods 12 to 30) and the average values of several items during the critical drawdown period. The items, described below, are used to calculate estimates of firm energy.

Col	Item	Description
1	INFLOW	Average reservoir inflow in m^3/s (ft^3/s)
2	POW-REL	Average power release in m^3/s (ft^3/s)
3	EL-BTW	Tailwater block-loading elevation in meters (ft)
4	DRAW-RAT	Ratio of drawdown depth to maximum drawdown of conservation pool
5	DIV-Q	Average diversion in m^3/s (ft^3/s)
6	EVAP-P	Average evaporation in m^3/s (ft^3/s)
7	RELEASE	Average reservoir release (for any purpose) in m^3/s (ft^3/s)
8	STORAGE	Average reservoir storage (500,000 has been added) in 1000 m^3 (acre-ft)
9	ELEV	Average elevation in meters (ft)
10	EN-REQ	Average energy requirement in 1000 kWh

c. The third output group ③ shows the periods used in the routing for the current trial and the average values of several items, including four of those previously described. The new items are described below:

Col	Item	Description
3	HEAD	Average pool elevation minus tailwater elevation and hydraulic losses
5	QSPILL	Average quantity of water spilled without generating hydropower
6	TAILWATER	Average tailwater used during the routing
8	H-TOP-C	Head from top of conservation pool to the tailwater (Col 6)
9	H-BOT-C	Head from bottom of conservation pool to the tailwater (Col 6)

Table F.15 Printout of Hydropower Optimization Example *(*OPTRY)*

```
*************************************************************************************************************************
*
 *OPTRY

 ROUTING CYCLE=       1   OPT TRIAL=       1

 ①      ALL. PERC NEGATIVE ERROR=     0.050  POSITIVE ERROR=    0.0500  IND FOR ONE MORE TRY=       0


 ②      AVG. CRITICAL DRAW DOWN RESULTS FROM PER      12  TO      30


      INFLOW      POW-REL      EL-BTW     DRAW-RAT      DIV-Q      EVAP-P     RELEASE     STORAGE       ELEV
EN-REQ
       228.89      450.92       66.54        0.37        0.00       60.80      450.92   830519.75       67.62
1688.88

 ③       AVG. ROUTING PERIOD RESULTS FROM PER       1  TO      34

      INFLOW      POW-REL      HEAD      DRAW-RAT     QSPILL    TAILWATER    RELEASE      H.TOP-C     H-BOT-C
      1547.97     1166.54      69.23        0.23      304.76        1.07     1471.29       73.67       54.17

 MIN HEAD=       55.04 CORR EL=       56.13 TW=        1.09 Q=     8503.92 PF=    0.2949    QMXPOW=       6351.

 GENERATION     1595.88  SHOULD EXCEED DEMAND     1688.88 RATIO=      0.9449

 SX=   354012.75  PSX=   343943.75
 GEN LESS DEMAND,NEW ERRORS ARE-,ERROR= 0.058275 ERR=     -18940.     325004.     343944.      18940.


 ④  OP TRIAL  ERROR-RAT  ERR-STG   TAR-MIN-STG  MIN-STG   PER-MIN-STG  TOP-STG     LOC.TYP
          1    0.058275   -18940.   658238.     658238.        30       983242.      1.10
************
```

... Continued ...

d. A summary of the trial's results is shown in the fourth summary ④ . This output represents the following:

Col	Item	Description
1	OP TRIAL	Trial number
2	ERROR-RAT	Ratio showing error in storage drawdown from top of conservation pool (Col 7) to minimum storage in routing (Col 5)
3	ERR-STG	Error in storage drawdown in 1000 m^3 (acre-ft)
4	TAR-MIN-STG	Target for minimum storage (drawdown) in 1000 m^3 (acre-ft)
5	MIN-STG	Minimum storage reached in current routing in 1000 m^3 (acre-ft)
6	PER-MIN-STG	Time period number of maximum drawdown
7	TOP-STG	Storage at top of conservation and power pool in 1000 m^3 (acre-ft)
8	LOC.TYP	Location number and type of optimization (e.g., 1.1=location 1, firm energy optimization)

e. The fifth group of output ⑤ shows the average annual plant factors. The first annual plant factor shown represents the ratio of the total annual energy generated in the routing (firm and secondary) to the maximum annual energy possible with the assumed installed capacity (INS CAP). The second annual plant factor shown represents the ratio of the annual firm energy generated in the routing to the maximum annual energy possible with the assumed installed capacity.

f. The sixth set of output ⑥ shows the variable being optimized (ITYOPT) and the multiplier which is used to adjust energy and capacity values for the next trial. In addition, the current installed capacity estimate and the projected value of that capacity based on the multiplier are shown. The other items are used in calculating the next estimate of the variable and are described as follows:

Col	Item	Description
1	ASSUMED	Assumed value for the first month of current trial
2	NEXT ASSUM	Value to be assumed for first month of next trial
3	PTWO	Value to be assumed if the two-point projection is used for the next trial
4	EST3	Value to be assumed if accounting estimate (projection using average values in routing) is used for the next trial
5	ER-IMPROVE	Error in storage
6	EST-BOUND	Value of estimate if maximum and minimum boundaries are used for the next trial

Table F.15 Printout of Hydropower Optimization Example *(*OPTRY)* - Continued

```
⑤  AVE ANNUAL PLANT FACTOR(FOR AAE)=     0.204  AVE MONTHLY PLANT FACTOR(FOR FIRM-EN)=     0.083


ANN DES Q ANN REQ Q ANN DIV Q     INS CAP  ANN FIRM E   AVG ANN E
      0.0      0.00      0.00      29614.      21525.      52859.


        ALL. PERC NEGATIVE ERROR=     0.010  POSITIVE ERROR=    0.0500  IND FOR ONE MORE TRY=       0


⑥   ITYOPT=   1  MULTIPLIER=       0.969155

 CHANGE CAPACITY FROM    29614.  TO    28700.

  ASSUMED   NEXT-ASSUM         PTWO         EST3   ER-IMPROVE   EST-BOUND      BNDMAX     BNDMIN   ERR-BN-MAX
ERR-BN-MIN
  1114.85      1080.47         0.00      1080.47         1.00        0.00     1114.85       0.00    -18939.75
0.00

 *Routing/Operation Summary  (Coefficients Based on 744 Hours)



          "Incremental"  LOCAL FLOW  Information:
           -------------------------------------

********
* NOTE *   INCREMENTAL LOCAL Flows were Read from "IN" Records
********                       OR  were Read from DSS

           ELAPSED TIME:   0:00:01
```

Col	Item	Description (continued)
7	BNDMAX	Maximum value of variable being optimized from all previous trials
8	BNDMIN	Minimum value of variable being optimized from all previous trials
9	ERR-BN-MAX	Error in storage corresponding to maximum boundary
10	ERR-BN-MIN	Error in storage corresponding to minimum boundary

g. The seventh set of output ⑦ shows the optimization results for the second trial for the critical period.

h. In this example output, since the error ratio (ERROR-RAT) of 0.026531 is within the allowable error of 5% (**J7** Record, field 10), then the eighth output ⑧ section shows the optimized results being applied for the entire period (periods 1 to 360). Note that an allowable error of .95 is printed out when the period of record is routed, regardless of the value in field 10 of the **J7** Record.

i. Finally, the ninth output ⑨ section shows the Firm Yield Optimization Results of Optimized Monthly Energy. These values could subsequently be input as monthly power requirements on the **PR** Record.

Table F.15 Printout of Hydropower Optimization Example *(*OPTRY)* - Continued

```
***************************************************************************************************************************

⑦

ROUTING CYCLE=       1   OPT TRIAL=       2

        AVG. CRITICAL DRAW DOWN RESULTS FROM PER      12  TO      30


     INFLOW      POW-REL      EL-BTW     DRAW-RAT      DIV-Q      EVAP-P     RELEASE     STORAGE        ELEV       EN-REQ
      228.89      449.38       67.04        0.34        0.00       61.90      449.38   838668.06       68.13      1636.79

        AVG. ROUTING PERIOD RESULTS FROM PER       1  TO      34

     INFLOW      POW-REL      HEAD       DRAW-RAT     QSPILL    TAILWATER    RELEASE      H.TOP-C     H-BOT-C
     1547.97     1159.85       69.52        0.21      310.53        1.07     1470.38       73.67       54.17


MIN HEAD=       55.98 CORR EL=       57.06 TW=       1.08 Q=     8104.39 PF=    0.3043    QMXPOW=       6155.

GENERATION     1594.48  SHOULD EXCEED DEMAND     1636.79 RATIO=      0.9742


SX=   338572.63  PSX=   333626.63
GEN LESS DEMAND,NEW ERRORS ARE-,ERROR= 0.026531 ERR=      -8623.     325004.     333627.       8623.



 OP TRIAL     ERROR-RAT   ERR-STG   TAR-MIN-STG   MIN-STG   PER-MIN-STG  TOP-STG     LOC.TYP
          2  0.026531     -8623.      658238.    658238.        30      983242.       1.10
************


AVE ANNUAL PLANT FACTOR(FOR AAE)=     0.209  AVE MONTHLY PLANT FACTOR(FOR FIRM-EN)=     0.083


ANN DES Q ANN REQ Q ANN DIV Q      INS CAP  ANN FIRM E   AVG ANN E
      0.0      0.00      0.00      28700.      20861.      52612.
```

... Continued ...

Table F.15 Printout of Hydropower Optimization Example *(*OPTRY)* - Continued

```
 ITYOPT=   1  MULTIPLIER=       0.985936

CHANGE CAPACITY FROM    28700.  TO    28297.

ASSUMED   NEXT-ASSUM       PTWO         EST3   ER-IMPROVE   EST-BOUND       BNDMAX       BNDMIN   ERR-BN-MAX   ERR-BN-MIN
1080.47      1065.27    1051.73      1065.27     10318.13        0.00      1080.47         0.00     -8622.63         0.00

==================== Firm Yield Optimization Results =====================
Location:   1     Optimized Monthly Energy in mW Hours
                   1080.     1333.     1177.      997.     2056.     2565.
                   3777.     3628.     2079.      814.      399.      957.

           DUR       VOL-DUR         PER-START        PER-END        Q-RIVER        Q+QSTOR        EST-STG        DEP CAP
          18.          4306.             12.            29.           239.         538.              0.        36134.

    START-PER        END-PER           DATE
            1            360       38100100

      CON-STG          QMEAN      RAT-STG/Q       DRAW-DUR   APPROX. DEP CAP.
      325004.          1782.          0.252            18.         36134.


*Routing/Operation Summary  (Coefficients Based on 744 Hours)

          "Incremental"  LOCAL FLOW  Information:
           -------------------------------------

********
* NOTE *   INCREMENTAL LOCAL Flows were Read from "IN" Records
********                     OR  were Read from DSS

           ELAPSED TIME:   0:00:01

           ****************************
           TOTAL ELAPSED CLOCK TIME FOR:   360 PERIODS:  0:00:03
           ****************************
```

... Continued ...

Table F.15 Printout of Hydropower Optimization Example *(*OPTRY)* - Continued

⑧

```
****************************************************************************************************************************

*OPTRY

ROUTING CYCLE=       2   OPT TRIAL=       1

        ALL. PERC NEGATIVE ERROR=     0.950  POSITIVE ERROR=    0.9500  IND FOR ONE MORE TRY=       0


        AVG. CRITICAL DRAW DOWN RESULTS FROM PER      12  TO      30


     INFLOW      POW-REL      EL-BTW     DRAW-RAT       DIV-Q       EVAP-P     RELEASE     STORAGE        ELEV       EN-REQ
      228.89      449.38       67.04        0.34         0.00        61.90      449.38   838668.06        68.13     1636.79

        AVG. ROUTING PERIOD RESULTS FROM PER       1  TO     360


     INFLOW      POW-REL      HEAD       DRAW-RAT     QSPILL    TAILWATER    RELEASE      H.TOP-C     H-BOT-C
     1781.56     1433.51       71.80        0.10      259.80        1.07     1693.31       73.67       54.17


MIN HEAD=       55.98 CORR EL=       57.06 TW=        1.08 Q=     8104.39 PF=    0.7085    QMXPOW=       6155.

GENERATION     1594.48  SHOULD EXCEED DEMAND     1636.79 RATIO=      0.9742


SX=   338134.94  PSX=   333626.63
GEN LESS DEMAND,NEW ERRORS ARE-,ERROR= 0.026531 ERR=      -8623.     325004.     333627.      8623.
```

... Continued ...

Table F.15 Printout of Hydropower Optimization Example *(*OPTRY)* - Continued

```
  OP TRIAL   ERROR-RAT  ERR-STG   TAR-MIN-STG   MIN-STG   PER-MIN-STG   TOP-STG    LOC.TYP
          1  0.026531    -8623.     658238.    658238.        30       983242.      1.10
************

 AVE ANNUAL PLANT FACTOR(FOR AAE)=     0.264  AVE MONTHLY PLANT FACTOR(FOR FIRM-EN)=     0.083

 ANN DES Q ANN REQ Q ANN DIV Q     INS CAP  ANN FIRM E   AVG ANN E
      0.0      0.00      0.00      28700.      20861.      66470.

   ITYOPT=   1  MULTIPLIER=       0.985387

  CHANGE CAPACITY FROM    28700.  TO    28281.

  ASSUMED   NEXT-ASSUM      PTWO         EST3   ER-IMPROVE   EST-BOUND        BNDMAX        BNDMIN   ERR-BN-MAX   ERR-BN-MIN
  1080.47      1064.68      0.00      1064.68         1.00         0.00      1080.47          0.00     -8622.63         0.00
```

⑨

```
  ==================== Firm Yield Optimization Results =====================
  Location:   1     Optimized Monthly Energy in mW Hours
                     1080.     1333.     1177.      997.     2056.     2565.
                     3777.     3628.     2079.      814.      399.      957.

  New Critical Period=   -11.036     0.050     0.027
```

F.3.2 Output Summary of Conservation Optimization Results (*OPSUM)

A summary of the results of a conservation optimization is printed in the output file anytime a **J7** Record is used in the input data. Table F.16 shows this summary where one line of output for each optimization trial is shown (i.e., optimization results for estimated critical period, check of results with period of record routing, etc.). On each line is shown the following:

Column 1 LOCATION - Identification of Project (from **T1** Record, columns 17 to 26).

Column 2 INS CAP (KW) - Derived installed capacity based on **PR** Record ratios of the firm energy that was dependable for the routing period (length = Col 8, starting date = Col 13) within the allowable storage drawdown error.

Column 3 FIRM ENERGY (MWH) - Annual firm energy which was dependable for the routing period within the allowable storage drawdown error.

Column 4 AVG ANN ENERGY (MWH) - Average annual energy (AAE) for the routing period analyzed. Where the AAE is for the critical period only (plus a few months), a value of -1 is used since this Column has no meaning under these conditions.

Column 5 ERROR RATIO - Drawdown storage error expressed as a ratio. Difference between minimum storage reached in routing and target storage at bottom of conservation pool, expressed as a ratio of total conservation storage. A storage penalty is added when power shortages occur due to the assumed energy being too high.

Column 6 NO. TRIES - Number of iterations (routings) required to determine the firm energy for the routing period selected within the allowable error in drawdown storage.

Column 7 SPILL - The average volume of water in m^3/s (ft^3/s) for the routing period (Col 8) that is passed through the dam without generating energy.

Column 8 NPER - Number of periods of routing for each of the trials.

Column 9	ENERGY RATIO - Factor to adjust monthly power requirements (PR Records) to generate the average annual energy (column 4) with installed capacity shown in column 2. This factor can be entered in the third field of the second PR record (PR.13) to adjust the monthly energy requirements or plant factors.
Column 10	RATIO STG/Q - Ratio of conservation storage to mean annual flow. A value of 1.0 would indicate that there is sufficient power storage to withdraw the reservoir volume over a 12-month period at the same rate as the average annual inflow (ignoring evaporation losses).
Column 11	FIRM ENERGY / PLNT FAC - The ratio of the annual firm energy (Col 3) to the annual energy possible using the installed capacity (Col 2).
Column 12	ASSUMED DEP CAP (kW) - Estimated starting value of Dependable Capacity using power storage and minimum flows available during estimated critical drawdown period.
Column 13	ROUTING/ST PER - Starting year and month of routing (1966.10 indicates October 1966).
Column 14	HEAD - Average head during the routing period (Col 8).
Column 15	DRAW ST PER - Year and month of start of critical drawdown period.
Column 16	DRAW. LENGTH - Length (months) of the critical drawdown period which started at date shown in Col 15.

Table F.16 Summary Printout of Hydropower Optimization Example *(*OPSUM)*

```
*OPSUM
                   T1               BOSWELL  RES. POWER OPT. - PHONEY TW CURVE
                   T2  NATIONAL HYDROPOWER STUDY TEST
                   T3  MUDDY BOGGY CREEK

                   J7  1.10    0.00    0.00    0.00    0.00    0.00    0.00    2.00    6.00    0.05
```

(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*	*(13)*	*(14)*	*(15)*	*(16)*
LOCATION	INS CAP (KW)	FIRM ENERGY (MWH)	AVG ANN ENERGY (MWH)	ERROR RATIO	NO. TRIES	SPILL	NPER	ENERGY RATIO	RATIO STG/Q	FIRM ENERGY PLNT FAC	ASSUMED DEP CAP (KW)	ROUTING ST PER	HEAD	DRAW. ST PER	DRAW. LENGTH
BOSWELL	29613.	21525.	-1.	0.0583	1	305.	34	0.9449	0.2518	0.0830	29613.	1938.10	69.23	1939.09	19.
BOSWELL	28700.	20861.	-1.	0.0265	2	311.	34	0.9742	0.2518	0.0830	28700.	1938.10	69.52	1939.09	19.
BOSWELL	28700.	20861.	66470.	0.0265	1	260.	360	0.9742	0.2518	0.0830	28700.	1938.10	71.80	1939.09	19.

F.4 Output Arranged by Sequence of Control Points (*NORML)

The output from program HEC-5B is preceded by general information that is pertinent to the output results. An example of this information is provided in Table F.17 and described by the following:

FLOOD NUMBER - The basic flood event identifier based on the sequence of events input (**BF**-**EJ** Records), or automatically generated by the program.

NFLRD - The number of flood events read in the input file. This would be the number of **EJ** Records in the input file since each set of time series records requires an **EJ** Record.

IFLRD - The sequence number of the flow series read (NFLRD) which is currently being printed out.

NFLCON - The number of flood ratios to be used (**FC** Record) for the current flood event.

IFLCON - The sequence number of the ratio used (of NFLCON) for the current printout.

Flows Multiplied by - The ratio which is multiplied times all flows on IN Records for current output (**BF** Record, field 4).

Computation Interval in Hours - The simulation time interval (**BF** Record, field 7).

Included alongside the above information is a section showing UNITS OF OUTPUT. All flow and evaporation values are in m^3/s (ft^3/s) and represent the average during each period. Reservoir storage values are in 1000 m^3 (acre-ft). Elevations are in meters (ft). Energy is in 1000 kWh, except when the computation interval is less than 24 hours; then, the energy output is in kWh.

Table F.17 Example Printout of Information for UNITS OF OUTPUT

```
*FLOOD 1
                  UNITS OF OUTPUT:                                                      ***** FLOOD NUMBER  1 *****
          All Flows and Evaporation in m3/s or CFS                                   NFLRD=        1  NFLCON=       0
          Reservoir Storages in 1000 m3 or Acre Feet                                 IFLRD =       1  IFLCON=       1
          Elevations in Meters or Feet
          Energy in 1000 kWh for DAILY-MONTHLY Computations                          Flows Multiplied by    1.000
          Energy in kWh for HOURLY Computations                                      Computation Interval in Hours= 24.00

*****************************************************************************************************************
```

Following the general information, the normal sequential program output is listed (if requested by **J3** Record, field 1 containing a code 8) in the sequence the control points were read (downstream order). An example of the *NORML output is shown in Table F.18 for Reservoir locations and Table F.19 for Non-reservoir locations. Each of the items is shown for all periods using 10 or 12 periods per line of output (depending on the simulation time interval). When the time interval is monthly (e.g., 720 hours), as in conservation analysis, the output is 12 periods per line instead of 10. The average, maximum, and minimum values are also provided for all of the output variables.

All possible output items are shown in the following list along with the order number that they would appear in the *NORML sequential output section. The "**R**" represents output for reservoirs only; the "**C**" represents output for non-reservoir control points only; and "**R, C**" represents output for both reservoirs and non-reservoir control points. An asterisk (*) appears for those items that will be omitted if not given or requested in the input:

R, C (1) `LOC 555  RESERVOIR A`
Location Identification Number (from **CP** Record) and Location Identification Name (from **ID** Record)

R, C `SERVED BY   111, -222, 555`
Shows which upstream reservoirs operate for this location. In this example, there are three reservoirs upstream from Reservoir A (location 555). Reservoir 111 operates for Reservoir A; however, Reservoir 222 does not operate for it (indicated by the negative location number). Since all reservoirs operate for themselves, then 555 is also shown.

R `SERVING   15, 16, 18`
Shows which downstream locations that the reservoir operates for. In this example, Reservoir A (555) operates for locations 15, 16 and 18..

R, C (2) `Local Cumulative` - The cumulative local flow for each period is the flow above the current control point and below all upstream reservoirs that have at least one 1000 m^3 (acre-foot) of flood control storage.

R, C* (3) `Natural Q` - The flow that would occur without any reservoirs in the basin. The calculation and printout of natural flows is an optional program feature (**J3** Record, field 4).

R* (4) `Energy Required` - The firm energy requirements at the reservoir as defined by input. Units of output are 1000 kWh unless the time interval is less than 24 hours.

R* (5) `Energy Generated` - The total energy generated by the reservoir, in 1000 kWh unless time periods are less than 24 hours.

R* (6) `Energy Shortage` - The difference between firm energy required and energy generated. Units of output would be the same as (4) and (5).

R* (7) `Q-Spill-Power` - The flow that could not be used to generate energy.

R* (8) `Peak Capability` - Power plant peaking capability in 1000 kWh.

R, C* (9) `Min Desired Q` - The minimum desired flow at the current control point; i.e., demand to be met as long as reservoirs are above top of buffer pool.

R, C* (10) `Deq-Shortage` - The amount by which regulated flow at the current control point falls short of the minimum desired flow.

R, C* (11) `Min Required Q` - The minimum required flow at the current control point; i.e., demand to be met as long as reservoirs are above level 1.

R, C* (12) `Req-Shortage` - The amount by which regulated flow at the current control point falls short of the minimum required flow.

R, C* (13) `Div Requirement` - The flow demand for diversion from this control point.

R, C* (14) `Diversion Q` - The algebraic sum of all diversions from the control point (positive) or to the control point (negative). The regulated flow at the control point or inflow into the reservoir includes the effects of the diversions both from and to the control point.

R, C* (15) `Div Shortage Q` - The amount by which the diversion falls short of the diversion requirement.

R (16) `Inflow` - The inflow hydrograph to a reservoir. The inflow values are equal to the cumulative local flows plus the routed upstream reservoir releases minus any diversions at the reservoir or upstream points.

C (17) `Qmax-Target Flow` - When channel capacity varies at a control point (**CC** Record is used) the channel capacity is shown for each time period.

C (18) `Flow Regulated` - The calculated regulated flow at a control point based on local inflow, upstream reservoir releases, and diversions from and to the control point.

R (19) `Outflow` - The average reservoir outflow.

R* (20) `Case =Loc.Typ` - The reason for making the reservoir release is shown for each time period as a two-part code such as: `0.03` or `18.03`.

The number to the left of the decimal indicates the downstream controlling location. If the controlling location is the reservoir itself, a zero will be printed to the left of the decimal. <u>When operating for a downstream location</u>, the number to the right of the decimal is the number of future time periods controlling the release. For example, `18.03` indicates that the flow at location `18`, `3` time periods in the future was used to determine the final reservoir release. <u>When operating for itself</u>, there is a zero to the left of the decimal, and the number on the right indicates the following:

`00` Release was for minimum desired flow requirements.

`01` Release was constrained by channel capacity at the reservoir.

`02` The release was governed by the maximum permitted rate-of-change from the preceding release.

`03` The release was calculated to exactly empty flood control storage (e.g., to reach Top-of-Conservation).

`04` The release was made to eliminate or minimize storage of water above the top of the flood control pool.

`05` The release was made to bring the reservoir into balance with a downstream tandem reservoir.

`06` The release was constrained by the outlet capacity.

`07` The release was based on LEVEL 1 limitation (top-of-inactive storage).

`08` Release was governed by minimum required flow.

`09` Release was based on buffer level constraint.

`10` Release was based on firm energy hydropower demand.

`11` Flood control releases cannot be made until highest priority reservoir is releasing (ISCHED = 1 on J2.6). Release only for minimum flow requirements.

`12` Release was based on allocated system energy requirement.

`13` Release was based on hydropower LEAKAGE (**P2** Record, field 1)

`14` Release was limited by hydropower PENSTOCK (**P2** Record, field 2)

`15` Release was limited by hydropower GENERATOR CAPACITY (**P1** Record, field 2 or **PP**/**PS** Records)

`20` Release based on Gate Regulation Curve (**RG** Record), Rising Pool

`21` Release based on Emergency operation: Partial Gate Opening

`22` Release based on Emergency operation: Transition

`23` Release based on Emergency operation: Outflow = Inflow

`24` Release based on Emergency operation: All gates fully open

`29` Release based on Emergency operation: Pre-release option (**J2** Record, field 5)

`99` Release was specified by the user on **QA** Records

R (21) `Level` - The index level for each time period is shown. The index level specified on **J1** Record, field 4 (LEVCON) indicates the top of the conservation pool and the index level from the **J1** Record, field 5 (LEVTFC) indicates the top of the flood control pool. Therefore, a level of 3.750, when

LEVCON and LEVTFC are 3 and 4, respectively, would show that 75% of the flood control storage is being used.

R (22) `Level Equivalent` - The equivalent system level, including all upstream tandem reservoirs, of the current reservoir (omitted when no reservoirs are in tandem).

R* (23) `Evaporation` - The volume of water lost to evaporation in 1000 m^3 (acre-ft) is shown for each time period for routing intervals greater than or equal to 24 hours.

R (24) `EOP Storage` - The end-of-period storage in the reservoir is shown for each time period.

R,C* (25) `EOP Elev/Stage` - When elevation (**RE** Record) is provided at a reservoir or stage data (**EL** Record) is provided at a non-reservoir control point, the end-of-period elevation or stage for each time period is shown. Channel stage is based on the regulated flow while the reservoir elevation is based on the reservoir storage.

C (26) `Q Space Avail.` - The channel capacity minus the regulated flow gives the space available in the channel for additional reservoir releases. Negative values indicate the amount of flooding (in excess of channel capacity). This output is omitted when monthly routings are used.

C (27) `Q by US Res,Divs` - This hydrograph is the result of all upstream reservoir releases and diversion return flows routed to the current control point. It is the difference between regulated flow and cumulative local flow.

C (28) `Fl GT Local Q` - The amount of flooding which could have been prevented, if it had been possible to make no releases from all upstream reservoirs and diversion return flows, for each time period. The total flooding shown in this item does not reflect flooding from the cumulative uncontrolled local flow (Item 2). This output is omitted when a monthly routing is used.

R, C* (29) `Local Incremental` - The intervening flow between a location and its upstream adjacent locations.

R* (30) `Sys En Required` - The system energy requirements, in 1000 KWh unless time periods are less than 24 hours. (System output is only shown at the first reservoir in the system.)

R* (31) `Sys En Useable` - The total system energy generated that can be credited to the system. This value could be less than total generated due to maximum plant factor for system use (PFMAX on **P2** Record, field 4).

R* (32) `Sys En Generated` - The total system energy generated by projects in this system, in 1000 KWh unless time periods are less than 24 hours.

R* (33) `Sys En Shortage` - The difference between system energy required and system energy generated. Units of output are the same as 33, 34, and 35. (Negative shortages or surpluses are ignored.)

R* (34) `Power Head` - The head available for producing hydropower.

R* (35) `Mills / kWh` - The benefit rate in MILLS per kWh for power rule curve operation (**PC**, **PF**, **PB** Records).

R* (36) `Plant Factor` - Ratio of energy generated to maximum generation possible for each time period.

R* (37) `Q-Gate Regulation` - The release from the reservoir based on gate regulation operation (**RG** Record).

R (38) `Pct Storage Norm` - Percentage showing how full the conservation pool is for each time period. 100 indicates the conservation pool is full, 50 indicates the conservation pool is half full, etc.

R (39) `Top Con. Storage` - Storage at the Top of Conservation pool for each time period.

Table F.18 "Normal Sequential" Output for Reservoir Locations *(*NORML)*

```
****************************************************************************************************************************
 *NORML 111

 **** LOC   111 RES 111                          SERVED BY    111
                                                                                        Starting Time=       1
                                                                                        Hour= 0,Day= 1,Mon= 1,Year=1999
                                           SERVING     111   600   800   999
 PER         Local Cumulative

    1   4200.   4300.   5160.   5860.   5980.   6580.  11300.  46500.  63800.  83000.
   11  90200. 112000.  91900.  50300.  48000.  37100.  51300.  55700.  45500.  30600.
   21  19200.  17100.  16800.  32800.  29000.  25400.  22400.  21000.  18300.  16700.

                                                                                        Avg=   35599.332  Max=  112000.000
                                                                                                          Min=    4200.000
 PER         Natural Q

    1   4200.   4300.   5160.   5860.   5980.   6580.  11300.  46500.  63800.  83000.
   11  90200. 112000.  91900.  50300.  48000.  37100.  51300.  55700.  45500.  30600.
   21  19200.  17100.  16800.  32800.  29000.  25400.  22400.  21000.  18300.  16700.

                                                                                        Avg=   35599.332  Max=  112000.000
                                                                                                          Min=    4200.000
 PER         Inflow

    1   4200.   4300.   5160.   5860.   5980.   6580.  11300.  46500.  63800.  83000.
   11  90200. 112000.  91900.  50300.  48000.  37100.  51300.  55700.  45500.  30600.
   21  19200.  17100.  16800.  32800.  29000.  25400.  22400.  21000.  18300.  16700.

                                                                                        Avg=   35599.332  Max=   12000.000
                                                                                                          Min=    4200.000
```

... Continued ...

Table F.18 "Normal Sequential" Output for Reservoir Locations *(*NORML)* - Continued

```
PER        QMax-Target Flow

   1  12000.  12000.  12000.  12000.  12000.  12000.  12000.  12000.  12000.  26000.
  11  40000.  40000.  61805.  66412.  64023.  61581.  60309.  65483.  73367.  79332.
  21  83269.  85722.  87858.  87153.  90000.  89963.  89661.  90000.  90000.  90000.
                                                                                      Avg=   54331.289  Max=   90000.047
                                                                                                        Min=   12000.040
PER        Outflow

   1   4200.   4300.   5160.   5860.   5980.   6580.   8992.   7602.  12000.  26000.
  11  33303.  40000.  61215.  66412.  64023.  45270.  17305.      0.      0.      0.
  21      0.      0.  22480.      0.  38877.  27890.  15603.  15302.  14028.  14093.
                                                                                      Avg=   18749.121  Max=   66411.906
                                                                                                        Min=       0.000
PER        Case    =Loc.Typ

   1    0.03    0.03    0.03    0.03    0.03    0.03  999.00  999.00  999.00    0.00
  11    0.00    0.00    0.00    0.00    0.00    0.00    0.00  600.00  600.00  600.00
  21  600.00  600.00    0.00  600.00    0.00    0.00    0.00    0.00    0.00    0.00
                                                                                      Avg=     219.906  Max=     999.000
                                                                                                        Min=       0.000
PER        Level

   1   3.000   3.000   3.000   3.000   3.000   3.000   3.004   3.069   3.156   3.252
  11   3.348   3.469   3.521   3.493   3.467   3.453   3.510   3.604   3.680   3.732
  21   3.764   3.793   3.783   3.838   3.822   3.817   3.829   3.838   3.846   3.850
                                                                                      Avg=       3.465  Max=       3.850
                                                                                                        Min=       3.000
PER        Pct Storage Norm

   1    0.00    0.00    0.00    0.00    0.00    0.00    0.39    6.93   15.64   25.22
  11   34.79   46.90   52.06   49.35   46.65   45.28   51.00   60.36   68.01   73.16
  21   76.39   79.26   78.31   83.82   82.16   81.74   82.89   83.84   84.56   85.00
                                                                                      Avg=      46.457  Max=      85.000
                                                                                                        Min=       0.000
```

... Continued ...

Table F.18 "Normal Sequential" Output for Reservoir Locations *(*NORML)* - Continued

```
PER         Top Con. Storage

    1 558000. 558000. 558000. 558000. 558000. 558000. 558000. 558000. 558000. 558000.
   11 558000. 558000. 558000. 558000. 558000. 558000. 558000. 558000. 558000. 558000.
   21 558000. 558000. 558000. 558000. 558000. 558000. 558000. 558000. 558000. 558000.

                                                                                            Avg=  558000.000  Max=  558000.000
                                                                                                              Min=  558000.000
PER         EOP Storage

    1 558000. 558000. 558000. 558000. 558000. 558000. 562578. 639732. 742478. 855538.
   11 968393.1111205.1172069.1140111.1108330.1092125.1159554.1270035.1360285.1420980.
   211459063.1492981.1481715.1546773.1527182.1522244.1535725.1547027.1555501.1560672.

                                                                                            Avg= 1106009.880  Max= 1560672.000
                                                                                                              Min=  558000.000
PER         EOP Elev/Stage

    1  723.02  723.02  723.02  723.02  723.02  723.02  723.19  726.16  729.78  733.43
   11  736.65  740.54  741.97  741.22  740.47  740.09  741.67  744.27  746.38  747.69
   21  748.45  749.12  748.90  750.19  749.80  749.71  749.97  750.20  750.37  750.47

                                                                                            Avg=     738.960  Max=     750.470
                                                                                                              Min=     723.020
PER         Q-Gate Regulatio

    1      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
   11      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
   21      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.

                                                                                            Avg=       0.000  Max=       0.000
                                                                                                              Min=       0.000
*******************************************************************************************************************************
```

Table F.19 “Normal Sequential” Output for Non-reservoir Locations *(*NORML)*

```
************************************************************************************************************************
*
 *NORML 999

 **** LOC   999 CP999                            SERVED BY    111    222    333

 PER        Local Cumulative

     1   1260.   1290.   1548.   1758.   1794.   1974.   3390.  13950.  19140.  24900.
    11  27060.  33600.  27570.  15090.  14400.  11130.  15390.  16710.  13650.   9180.
    21   5760.   5130.   5040.   9840.   8700.   7620.   6720.   6300.   5490.   5010.
                                                                                        Avg=   10679.800  Max=   33600.000
                                                                                                          Min=    1260.000
 PER        Natural Q

     1  13976.  14206.  14564.  14678.  17374.  18784.  26370.  76930. 112200. 143680.
    11 152190. 189600. 177270. 141290. 145500. 135730. 254390. 235510. 173650. 125460.
    21 102810.  95530. 101340. 116040.  96300.  93320.  97020.  93800.  89500.  84720.
                                                                                        Avg=  105124.398  Max=  254390.000
                                                                                                          Min=   13976.000
 PER        QMax-Target Flow

     1  20000.  20000.  20000.  20000.  20000.  20000.  20000.  21552.  36818. 150000.
    11 150000. 150000. 150000. 150000. 150000. 250000. 250000. 250000. 250000. 250000.
    21 250000. 250000. 250000. 250000. 250000. 250000. 250000. 250000. 250000. 250000.
                                                                                        Avg=  161612.359  Max=  250000.063
                                                                                                          Min=   20000.039
 PER        Flow Regulated

     1  13976.  14206.  14564.  14678.  17374.  18784.  20000.  21552.  36818.  56134.
    11  60363.  91800.  88785.  82545.  82200.  80565.  82695.  83355.  77718.  69182.
    21  62904.  57839.  80587.  56478.  79350.  78810.  78360.  78150.  77745.  77505.
                                                                                        Avg=   58500.707  Max=   91799.828
                                                                                                          Min=   13976.000
```

... Continued ...

Table F.19 "Normal Sequential" Output for Non-reservoir Locations *(*NORML)* - Continued

```
PER        Q Space Avail.

    1   6024.   5794.   5436.   5322.   2626.   1216.      0.      0.      0.  93866.
   11  89637.  58200.  61215.  67455.  67800. 169435. 167305. 166645. 172282. 180818.
   21 187096. 192161. 169413. 193522. 170650. 171190. 171640. 171850. 172255. 172495.

                                                                                    Avg=  103111.664  Max=  193521.719
                                                                                                      Min=       0.050
PER        Q by US Res,Divs

    1  12716.  12916.  13016.  12920.  15580.  16810.  16610.   7602.  17678.  31234.
   11  33303.  58200.  61215.  67455.  67800.  69435.  67305.  66645.  64068.  60002.
   21  57144.  52709.  75547.  46638.  70650.  71190.  71640.  71850.  72255.  72495.

                                                                                    Avg=   47820.914  Max=   75546.672
                                                                                                      Min=    7601.880
PER        Fl GT Local Q

    1      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
   11      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.
   21      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.

                                                                                    Avg=       0.000  Max=       0.000
                                                                                                      Min=       0.000
*************************************************************************************************************************
```

F.5 Reservoir Operation Summary and Control Point Summary by Sequence of Time Period (*ROPER).

When requested (**J3** Record, field 1 contains 16), the following items are shown for all reservoirs for each time period:

(1) `Res No` - The identification number of the reservoir.

(2) `TITLE` - The alphanumeric name for the **ID** Record.

(3) `Inflow` - The reservoir inflow.

(4) `Outflow` - The reservoir outflow.

(5) `EOP Stor` - The end of period reservoir storage in 1000 m^3 (acre-ft).

(6) `Elev` - The elevation corresponding to the average reservoir storage.

(7) `Case` - The controlling criteria (LOC.TYP) for determining the reservoir release.

(8) `Level` - The reservoir index level.

(9) `Pct FC` - The percent of Flood Control storage

(10) `EQ Level` - Equivalent level of tandem reservoirs.

Table F.20 shows an example of the *ROPER output.

Table F.20 Example of Reservoir Operation by Period *(*ROPER)*

```
 ********************************************

 Reservoir Operation by Period

             Cum Time=      1
 *ROPER 1

  Res No=       111     222     333
  TITLE=     RES 11  RES 22  RES 33
  Inflow      4200.    356.   8160.
  Outflow     4200.    356.   8160.
  EOP Stor  558000. 553000.1087000.
  Elev         723.    638.    730.
  Case=       0.030   0.030   0.030
  Level       3.000   3.000   3.000
  Pct FC       0.00    0.00    0.00
  Eq Level    3.000   3.000   3.000


    ... Periods 2 through 29 not shown ...

             Cum Time=     30
  *ROPER 30

  Res No=       111     222     333
  TITLE=     RES 11  RES 22  RES 33
  Inflow     16700.  20810.  42200.
  Outflow    14093.  18656.  39747.
  EOP Stor 1560672.1381160.2030512.
  Elev         750.    658.    752.
  Case=       0.000   0.000   0.000
  Level       3.850   3.850   3.850
  Pct FC      85.00   85.00   85.00
  Eq Level    3.850   3.850   3.850
```

F.6 Results by Time Period

F.6.1 Reservoir Releases by Period (*RRPER) and Regulated Flows at Control Points (*RQPER)

When requested (**J3** Record, field 1 contains 32), the following items are shown for all reservoirs (see Table F.21, *RRPER output) and for all non-reservoirs (see Table F.22, *RQPER output) for each time period:

`Res No` / `C.P. No.` - The identification number of reservoir or control point.

`Location` - Alphanumeric name from the **ID** Record.

`Chan Cap` - The non-damaging channel capacity in m^3/s (ft^3/s) at the reservoir or control point. A "`-1`" indicates that the channel capacity varies each time period.

`Min Des Q` - Minimum desired flow at the specified location (-1 if not input).

`Min Req Q` - Minimum required flow at the specified location (-1 if not input).

Reservoir releases or regulated flows for each time period, at all reservoirs and control points, are in m^3/s (ft^3/s).

The Sum, Maximum value, Minimum value, Period number (PMax) of the maximum value, the Average value (Avg), and the Period number (PMin) of the minimum value for each reservoir and control point are also shown.

Table F.21 Example of Reservoir Release by Period *(*RRPER)*

```
*RRPER     Reservoir Release by Period

Res No         111     222     333
Location   RES 111 RES 222 RES 333
Chan Cap       -1.     -1.     -1.
Min Des Q      -1.     -1.     -1.
Min Req Q      -1.     -1.     -1.
 Period
    1        4200.    356.   8160.
    2        4300.    356.   8260.
    3        5160.    636.   7220.
    4        5860.   1240.   5820.
    5        5980.   1800.   7800.
    6        6580.   2260.   7970.
    7        8992.   1670.   5948.
    8        7602.      0.      0.
    9       12000.   3438.   2241.
   10       26000.   3532.   1703.

...  Periods 11 through 28 not shown ...

   29       14028.  17647.  40580.
   30       14093.  18656.  39747.

     Sum = 562474. 109294. 762860.
     Max =  66412.  19732.  66645.
     Min =      0.      0.      0.
     PMax=     14.     27.     18.
     Avg =  18749.   3643.  25429.
     PMin=     18.      8.      8.
```

Table F.22 Example of Regulated Flows by Period *(*RQPER)*

```
*RQPER   Regulated Flows at Control Points by Period
         (Non-Reservoir Locations)

 C.P. No.        600     800     999
 Location    CP 600  CP 800  CP 999
 Chan Cap        -1.     -1.     -1.
 Min Des Q       -1.     -1.     -1.
 Min Req Q       -1.     -1.     -1.
 Period
     1       13346.  13766.  13976.
     2       13561.  13991.  14206.
     3       13790.  14306.  14564.
     4       13799.  14385.  14678.
     5       16477.  17075.  17374.
     6       17797.  18455.  18784.
     7       18305.  19435.  20000.
     8       14577.  19227.  21552.
     9       27248.  33628.  36818.
    10       43684.  51984.  56134.

 ...  Periods 11 through 28 not shown ...

    29       75000.  76830.  77745.
    30       75000.  76670.  77505.

      Sum =1594824.1701622.1755021.
      Max =  78067.  86200.  91800.
      Min =  13346.  13766.  13976.
      PMax=     23.     12.     12.
      Avg =  53161.  56721.  58501.
      PMin=      1.      1.      1.
```

F.6.2 Diversion Flows and Shortages by Time Period (*DVPER, *DVSHORT)

When diversions are input, a summary of diversion flows and shortages for each time period, for all locations, can be requested by including a 32 in the value specified in field 1 of the **J3** Record. Table F.23 shows an example of the diversion flows (*DVPER) output and Table F.24 shows an example of the diversion shortages (*DVSHORT) output.

Table F.23 Example of Diversion Flows by Period *(*DVPER)*

*DVPER Diversion Flows at Control Points by Period (All Locations)

C.P. No.	55	40	39	30	20	10
Location	ADAM R	BAKERV	RETURN	CONWAY	DAVISV	WILLEY
Period						
1	80.	75.	-53.	5.	-2.	0.
2	80.	75.	-53.	5.	-2.	0.
3	80.	75.	-53.	5.	-2.	0.
4	80.	75.	-53.	5.	-2.	0.
5	80.	75.	-53.	5.	-2.	0.
6	80.	75.	-53.	5.	-2.	0.
7	80.	75.	-53.	5.	-2.	0.
8	80.	75.	-53.	5.	-2.	0.
9	80.	75.	-53.	5.	-2.	0.
10	80.	75.	-53.	5.	-2.	0.
Sum =	800.	750.	-525.	53.	-21.	0.
Max =	80.	75.	-53.	5.	-2.	0.
Min =	80.	75.	-53.	5.	-2.	0.
PMax=	1.	1.	1.	1.	1.	1.
Avg =	80.	75.	-53.	5.	-2.	0.
PMin=	1.	1.	1.	1.	1.	1.

Table F.24 Example of Diversion Shortages by Period *(*DVSHORT)*

*DVSHORT Diversion Shortages at Control Points by Period (All Locations)

C.P. No.	55	40	39	30	20	10
Location	ADAM R	BAKERV	RETURN	CONWAY	DAVISV	WILLEY
Period						
1	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.
Sum =	0.	0.	0.	0.	0.	0.
Max =	0.	0.	0.	0.	0.	0.
Min =	0.	0.	0.	0.	0.	0.
PMax=	1.	1.	1.	1.	1.	1.
Avg =	0.	0.	0.	0.	0.	0.
PMin=	1.	1.	1.	1.	1.	1.

F.6.3 Percent Flood Control Storage by Time Period (*FCPCT)

To assist in the analysis of a flood control system, a summary of percent flood control storage used by each reservoir can be requested by including a 32 in the value specified in field 1 of the **J3** Record. By reviewing this output, you can see how much flood storage was used by each reservoir throughout the system. Table F.25 shows an example of the *FCPCT output summary.

Table F.25 Example of Percent Flood Control Storage by Period *(*FCPCT)*

```
*FCPCT     Percent Flood Control Storage Used by Reservoir and by Period


Res No          3       2       5
Location      RES C   RES B   RES A
 Period
    1          0.      0.      0.
    2          0.      0.      0.
    3          0.      0.      4.
    4         12.      0.     16.
    5         43.      5.     39.
    6         78.     15.     55.
    7        100.     34.     67.
    8        100.     54.     75.
    9        100.     69.     83.
   10        100.     80.     89.
   11         99.     88.     94.
   12         93.     93.     94.
   13         93.     94.     94.
   14         93.     95.     94.
   15         93.     97.     92.
   16         93.     93.     90.
   17         93.     90.     90.

     Sum =   1190.    907.   1075.
     Max =    100.     97.     94.
     Min =      0.      0.      0.
     PMax=      7.     15.     11.
     Avg =     70.     53.     63.
     PMin=      1.      1.      1.
```

F.7 User Designed Output (*USERS)

Tables of output can be designed by using up to 80 different **J8** Records (see Appendix G, Input Description). Output can be time distributed variables or summary data at any control point or reservoir. Table F.26 shows an example of a User Designed Output table requested by a **J8** Record.

Useful items to include in a *USER table for a reservoir location include the following (shown with with the **J8** Record "code" that would be input with the "X" value being the location identification number):

Inflow	(X.09)	-	Net Inflow at the reservoir (values shown account for Evaporation and Diversions).
Outflow	(X.10)	-	Releases from the reservoir.
Case	(X.12)	-	The "reason" for the reservoir's release. A description of Cases are shown at the end of the output file (*CASES).
Level	(X.13)	-	The level number at the end of the time period (see the **J1** Record for user definition of the level numbers).
EOP Stor	(X.11)	-	End-of-period Storage values.
EOP Elev	(X.22)	-	End-of-period Elevation values (if **RE** Records are input).
Flow Reg	(X.04)	-	Regulated Flow at the Downstream location that the reservoir operates for (**RO** Record).

For non-reservoir locations, there are several items available to analyze the performance of a system. In addition to the Regulated Flow (X.04), the following items might be requested for a location where there is a Water Supply demand:

Min Des	(X.05)	Minimum Desired flow.
Min Req	(X.07)	Minimum Required flow.
Min Des Sh	(X.06)	Minimum Desired Shortage.
Min Req Sh	(X.08)	Minimum Required Shortage.
Div	(X.03)	Diversion.
Div Req	(X.30)	Diversion Requirement.
Div Sh	(X.31)	Diversion Shortage

The following items might be useful for a location where there is a limiting Channel Capacity (e.g., Flood Control Operation):

Qmax-Tar	(X.17)	Channel Capacity
Q Space	(X.18)	Space Available (e.g., Channel Capacity - Regulated Flow)
Local Cu	(X.01)	Cumulative Local Flow (e.g., sum of all upstream routed uncontrolled local flows)
Q By Res	(X.19)	Flows from reservoirs & diversions

Table F.26 Example of a User Designed Output Table *(*USERS)*

*USERS. 1 User Designed Output (Dates shown are for END-of-Period)
Summary by Period Flood= 1

Per	Date:	Hr	Day	BISHOP DA Inflow	BISHOP DA Outflow	BISHOP DA Case	BISHOP DA Level	BISHOP DA EOP Stor	BISHOP DA EOP Elev	ZELMA Flow Reg	ZELMA QMax-Tar	ZELMA Q Space	ZELMA Local Cu
Location No=				44.	44.	44.	44.	44.	44.	40.	40.	40.	40.
J8/JZ Codes=				44.090	44.100	44.120	44.130	44.110	44.220	40.040	40.170	40.180	40.010
1	9Nov73	9	Fri	67.00	80.00	0.00	2.99	146340.00	251.49	132.00	450.00	318.00	52.00
2	9Nov73	12	Fri	78.00	29.00	0.02	3.00	146869.00	251.54	133.50	450.00	316.50	62.00
3	9Nov73	15	Fri	159.00	0.00	40.04	3.01	148586.00	251.71	109.25	450.00	340.75	78.00
4	9Nov73	18	Fri	215.00	0.00	40.03	3.01	150908.00	251.94	202.21	450.00	247.79	197.00
5	9Nov73	21	Fri	309.00	0.00	40.04	3.02	154245.00	252.27	231.87	450.00	218.13	231.00
6	9Nov73	24	Fri	473.00	0.00	40.04	3.03	159354.00	252.77	289.15	450.00	160.85	289.00
7	10Nov73	3	Sat	605.00	0.00	40.04	3.05	165888.00	253.42	473.03	450.00	-23.03	473.00
8	10Nov73	6	Sat	704.00	0.00	40.04	3.06	173491.00	254.17	460.01	450.00	-10.01	460.00
9	10Nov73	9	Sat	960.00	0.00	40.04	3.09	183859.00	255.20	509.00	450.00	-59.00	509.00
10	10Nov73	12	Sat	1022.00	0.00	40.03	3.12	194896.00	256.29	608.00	450.00	-158.00	608.00
11	10Nov73	15	Sat	1133.00	0.00	40.02	3.15	207133.00	257.50	756.00	450.00	-306.00	756.00
12	10Nov73	18	Sat	1378.00	0.00	40.01	3.18	222015.00	258.97	934.00	450.00	-484.00	934.00
13	10Nov73	21	Sat	1696.00	0.00	40.00	3.23	240332.00	260.78	1036.00	450.00	-586.00	1036.00
14	10Nov73	24	Sat	1787.00	0.00	40.00	3.27	259631.00	262.57	882.00	450.00	-432.00	882.00
15	11Nov73	3	Sun	2405.00	0.00	40.00	3.33	285605.00	264.58	715.00	450.00	-265.00	715.00
16	11Nov73	6	Sun	2616.00	0.00	40.00	3.40	313858.00	266.77	529.00	450.00	-79.00	529.00
17	11Nov73	9	Sun	2150.00	0.00	40.00	3.46	337078.00	268.57	374.00	450.00	76.00	374.00
18	11Nov73	12	Sun	1974.00	51.00	0.02	3.51	357847.00	270.18	334.50	450.00	115.50	326.00
... Periods 19 through 31 not shown ...													
32	13Nov73	6	Tue	197.00	346.89	40.00	3.67	424140.00	274.72	438.60	450.00	11.40	57.00
			Sum =	30179.00	4469.73	880.53	108.10	9721559.00	8482.33	13873.92	14400.00	526.08	9678.00
			Max =	2616.00	395.73	40.04	3.69	433131.00	275.31	1036.00	450.00	340.75	1036.00
			Min =	67.00	0.00	0.00	2.99	146340.00	251.49	109.25	450.00	-586.00	52.00
			PMax=	16.00	31.00	3.00	27.00	27.00	27.00	13.00	1.00	3.00	13.00
			Avg =	943.09	139.68	27.52	3.38	303798.72	265.07	433.56	450.00	16.44	302.44
			PMin=	1.00	3.00	1.00	1.00	1.00	1.00	3.00	1.00	13.00	1.00

F.8 Single Flood Summary

A single flood summary of maximums for reservoirs and non-reservoirs for each flood event (where the time interval is Daily or less) can be requested by including a 1 in the value input in field 1 of the **J3** Record. If requested, the following information will be displayed for Reservoir locations and for Control Point locations:

Reservoirs: For each reservoir, the following is displayed as shown in Table F.27:

(1) STOR1 - The starting reservoir storage.
(2) MAX LEVEL - The maximum reservoir level during the flood.
(3) MAX INFLOW - The maximum reservoir inflow.
(4) MAX REL. - The maximum reservoir release.
(5) CHAN CAP. - The channel capacity at the reservoir.

The maximum system storage is printed at the end of the summary table.

Table F.27. Summary of Maximums for Reservoirs (for Daily or Less Time Interval)

```
                                          --------------
                 Summary of Maximums for    RESERVOIRS
                            --------      --------------

      HEC-5 Example 1, Basic Flood Regulation   (EXAMPLE1.DAT)
      SI Units, 24 Hrs Foresight with 20% Contingency
      Rocky River, Bishop Dam Site to Zelma, 9-13 Nov 1973 Flood

           -------------------------------------------------------

           Period of Analysis:  STARTING :  09NOV73 - 0600 Hrs
                                ENDING   :  13NOV73 - 0600 Hrs
                                DURATION :  4 Days,  0 Hrs,  0 Min

                Time Interval:    3 Hours,  0 Minutes

           -------------------------------------------------------

******************************************************************************
*    Reservoir    *     Max     *     Max     *    Max             *     Max    *
*                 *   Inflow    *   Outflow   *  Storage    Elev   *    HEC-5   *
*  ID    Name     *   (m3/s)    *   (m3/s)    * (1000m3)  (Meters)*    Levels  *
*                 *             *             *                    *            *
******************************************************************************
*                 *             *             *                    *            *
*  44 BISHOP DAM  *        2616 *         425 *   351464   269.68 *      3.493 *
*                 * 11NOV-0600 * 10NOV-0300 *    12NOV-1200      * 12NOV-1200 *
*                 *             *             *                    *            *
******************************************************************************


           Maximum System Storage Used =   351464.  (12NOV-1200)
```

Control Points: For each control point location, the following is displayed (as shown in Table F.28):

(1) Max Reg Flow - Maximum regulated flow at control point..
(2) Max Nat - Maximum unregulated (natural) discharge.
(3) MAX UNC - Maximum discharge from the uncontrolled drainage area below all reservoirs which have flood control storage.
(4) Q BY RES - The difference between the MAX REG Q and MAX UNC which shows the remaining possible reduction in peak discharge if all reservoirs had unlimited flood control storage.
(5) CH CAP - Channel capacity.

Table F.28. Summary of Maximums for Control Points (for Daily or Less Time Interval)

```
                                   ------------------------------------
         Summary of Maximums for    CHANNEL CONTROL POINT LOCATIONS
                    --------       ------------------------------------


      HEC-5 Example 1, Basic Flood Regulation   (EXAMPLE1.DAT)
      SI Units, 24 Hrs Foresight with 20% Contingency
      Rocky River, Bishop Dam Site to Zelma, 9-13 Nov 1973 Flood

           -------------------------------------------------------

           Period of Analysis:  STARTING :  09NOV73 - 0600 Hrs
                                ENDING   :  13NOV73 - 0600 Hrs
                                DURATION :  4 Days,  0 Hrs,  0 Min

                Time Interval:    3 Hours,  0 Minutes

           -------------------------------------------------------

******************************************************************************
*  Channel Location  *  Channel     Max     Q from *  Max Cum.  *    Max     *
*                    * Capacity  Reg. Flow    Res. *  Local Q   * Natural Q  *
*  ID    Name        *  (m3/s)    (m3/s)    (m3/s) *  (m3/s)    *  (m3/s)    *
******************************************************************************
*                    *                             *            *            *
*  44 BISHOP DAM     *     425        425        0 *     2616   *      2616  *
*                    *          10NOV-0300         * 11NOV-0600 * 11NOV-0600 *
*                    *                             *            *            *
*  40 ZELMA          *     650        529      425 *      104   *      2532  *
*                    *          10NOV-2100         * 10NOV-2100 * 11NOV-0900 *
*                    *                             *            *            *
******************************************************************************
```

F.9 Multi-flood Summaries: Flood Control (*SUMFS) and Conservation (*SUMPO)

The *SUMFS summary shown in Table F.29 and described below is done for each flood event in turn (FLOOD SUMMARY - EACH FLOOD) and then the maximums and minimums for all flood events are shown (MAX VALUES FOR MULTI-FLOODS). The Multi-flood summary is a summary of the significant features of each event. For each control point, the maximum regulated flow (MAX REG Q), the maximum natural flow (MAX NAT Q) and the maximum cumulative local flow (MAX LOCAL Q) are presented. Also, listed for each control point is the total contribution of upstream reservoirs to the maximum regulated flow at the control point (Q BY RES). For each reservoir, the minimum storage (MIN STG), minimum level (MIN LEVEL), maximum storage (MAX STG), maximum level (MAX LEVEL) and the maximum release (MAX REL) are listed. Finally, the minimum combined storage (MIN SYSTEM STG) and the maximum combined storage (MAX SYSTEM STG) that were reached by the system reservoirs during the flood event are listed.

The flood summary for all floods (MAX VALUES FOR MULTY FLOODS) is presented with the same format as the individual flood summaries.

Table F.29. Summary of Multiple Flood Events *(*SUMFS)*

```
FLOOD SUMMARY-EACH FLOOD  COPY=   1

       HYDROPOWER RESERVOIR WITH MIN FLOW, AND DIVERSION        TEST 5
       MIXED MONTHLY AND 6 HOUR TIME INTERVALS             1982 INPUT FORMAT
       BROKEN BOW DAM
*SUMFS 1
                                           ***** FLOOD NUMBER  1 *****

                               MAX REG Q   MAX NAT Q   MAX LOC Q  Q BY RES
LOC    44 EAGLETOWN                 3612.       3579.          0.       3612.


        RESERVOIRS            MIN STG   MIN LEVEL  MAX STG   MAX LEVEL  MAX REL
LOC    25 BROKEN BOW DAM         530185.    1.173   918800.   2.000     3556.

                          MIN SYSTEM STG=    530185.   MAX SYSTEM STG=    918800.

*SUMFS 2
                                           ***** FLOOD NUMBER  2 *****

                               MAX REG Q   MAX NAT Q   MAX LOC Q  Q BY RES
LOC    44 EAGLETOWN                 8068.     152000.          0.       8068.


        RESERVOIRS            MIN STG   MIN LEVEL  MAX STG   MAX LEVEL  MAX REL
LOC    25 BROKEN BOW DAM         659135.    1.448  1042448.   2.275     8000.

                          MIN SYSTEM STG=    659135.   MAX SYSTEM STG=   1042448.

                                                               COPY=       1

                                      ***** MAX VALUES FOR MULTY FLOODS *****

                               MAX REG Q   MAX NAT Q   MAX LOC Q  Q BY RES
LOC    44 EAGLETOWN                 8068.     152000.          0.       8068.

        RESERVOIRS            MIN STG   MIN LEVEL  MAX STG   MAX LEVEL  MAX REL
LOC    25 BROKEN BOW DAM         530185.    1.173  1042448.   2.275     8000.
```

For events with a monthly time interval, the MINIMUM VALUES AND SHORTAGES FOR CONSERVATION OPERATION - ALL FLOODS table (as shown in Table F.30) provides conservation based results (*SUMPO). For control points including reservoirs, the shortage periods, shortage volume (in month-discharge units), and shortage index are provided for both desired flow and required flow. In the event no minimum flow requirement is defined at a location, the shortage volume value -1 is printed. The shortage index is defined as the sum of the squares of annual shortages prorated to a 100-year period where annual shortages are expressed as a decimal fraction of the demand. For each reservoir, the time period 1 (FLD. PER), the minimum storage (MIN STG), and the minimum level (MIN LEVEL) are printed.

Table F.30. Example Summary Output for Monthly Conservation *(*SUMPO)*

```
*SUMPO
 MINIMUM VALUES AND SHORTAGES FOR CONSERVATION OPERATION-ALL FLOODS
                            ***** DESIRED FLOW ****    **** REQUIRED FLOW ****
                            SHORTAGE SHORTAGE SHORTAGE SHORTAGE SHORTAGE
SHORTAGE
    LOC                     PERIODS  VOLUME   INDEX    PERIODS  VOLUME   INDEX
     20 ALLEN RES               2.       11.     0.01       0.        0.     0.00
     15 BRENDA                  0.       -1.     0.00       0.       -1.     0.00
     10 CHARLES LAKE            0.        0.     0.00       0.        0.     0.00
      5 JAMESTOWN               0.       -1.     0.00       0.        0.     0.00
      NOTE@  -1. INDICATES THAT DESIRED AND/OR REQUIRED FLOWS WERE NOT SPECIFIED
                   FOR GIVEN CONTROL POINT

          RESERVOIRS               FLD.PER    MIN STG   MIN LEVEL
 LOC    20 ALLEN RES               1.04000      8883.     1.692
 LOC    10 CHARLES LAKE            1.04000     24878.     2.352
```

d. If there are power reservoirs in the system, the SUMMARY OF AT SITE ENERGY PRODUCTION (see Table F.31) and the SUMMARY OF AT SITE POWER BENEFITS (see Table F.32) are printed for each event and for the sum for all events. These summaries represent totals for all power reservoirs regardless of whether the projects are operated as one or more power systems (see **SM** Record). The energy production table provides the total primary, secondary, and total energy for each power reservoir based on at-site energy requirements. Also printed are the total shortage, the minimum peaking capability and the installed capacity. Totals of system energy production and shortages are provided for each flood, and a grand total table is provided under the heading ALL FLOODS. The power benefits table shows the energy benefit data (input on **J4** Record) and the total benefits for primary and secondary energy, the cost of purchase energy (based on shortage) and the net total energy value. The capacity value is based on the minimum capability. The benefits table is printed for each flood and the grand total is shown for ALL FLOODS.

Table F.31. Summary of At-Site Energy Production

SUMMARY OF AT-SITE ENERGY PRODUCTIONS ** 1000 KWH ** CAPACITIES ** KW **

***** FLOOD NUMBER 1 *****

LOC=	PROJECT	PRIMARY	SECONDARY	SHORTAGE	TOTAL	MIN PEAK CAP	INSTALLED CAP
1	HARTWELL	4435.	35417.	0.	39853.	299007.	264000.
99	PUMP-BACK	-102231.	0.	0.	-102231.	300000.	-300000.
2	R RUSSELL	10080.	99894.	0.	109974.	622341.	600000.
3	CLRK HILL	4704.	76109.	0.	80813.	312742.	280000.
	TOTALS OF AT-SITE ENERGY PRODUCTIONS						
		-83012.	211421.	0.	128409.		

***** ALL FLOODS *****

LOC=	PROJECT	PRIMARY	SECONDARY	SHORTAGE	TOTAL	MIN PEAK CAP	INSTALLED CAP
1	HARTWELL	4435.	35417.	0.	39853.	299007.	264000.
99	PUMP-BACK	-102231.	0.	0.	-102231.	300000.	-300000.
2	R RUSSELL	10080.	99894.	0.	109974.	622341.	600000.
3	CLRK HILL	4704.	76109.	0.	80813.	312742.	280000.
	TOTALS OF AT-SITE ENERGY PRODUCTIONS						
		-83012.	211421.	0.	128409.		

Table F.32. Summary of At-Site Energy Benefits

SUMMARY OF AT-SITE POWER BENEFITS ** DOLLARS **

***** FLOOD NUMBER 1 *****

LOC=	PROJECT	BENEFIT RATES PRI	SEC	PUR	CAP	ENERGY VALUE PRIMARY	SECONDARY	PURCHASE	TOTAL ENERGY VALUE	CAPACITY VALUE
1	HARTWELL	1.20	0.80	2.40	20.00	5322.	28334.	0.	33656.	5280000.
99	PUMP-BACK	1.20	0.80	2.40	20.00	0.	0.	0.	0.	0.
2	R RUSSELL	1.20	0.80	2.40	20.00	12096.	79915.	0.	92011.	12000000.
3	CLRK HILL	1.20	0.80	2.40	20.00	5645.	60888.	0.	66532.	5600000.
	TOTALS OF AT-SITE POWER BENEFITS					23063.	169137.	0.	192200.	22880000.

***** ALL FLOODS *****

LOC=	PROJECT	PRIMARY	SECONDARY	PURCHASE	TOTAL ENERGY VALUE	CAPACITY VALUE
1	HARTWELL	5322.	28334.	0.	33656.	
99	PUMP-BACK	0.	0.	0.	0.	
2	R RUSSELL	12096.	79915.	0.	92011.	
3	CLRK HILL	5645.	60888.	0.	66532.	
	TOTALS OF AT-SITE POWER BENEFITS	23063.	169137.	0.	192200.	22880000.

F.10 Damage Computation Data (*ECDAM)

An example of input records and corresponding output for flood frequency and damage data are shown in Table F.33. This is a compilation of flood flow-frequency-damage data for the system and consists of the following:

a. Data Printout. The exceedence frequency, peak flow, and damage data for base conditions, provided as input to the program, is listed in order of increasing flood peaks:

Column 1	Probabilities of exceedence corresponding to each input flood peak in Column 2.
Column 2	Input peak flows corresponding to exceedence probabilities in Column 1.
Column 3	The sum of the damages for all types corresponding to flood peaks in Column 2. Damages are listed in the same units as input to the program (e.g., dollars, thousands of dollars, etc.) and multiplied by escalation factor ECFCT (J4.2).
Columns 4 - 12	Damages for up to 9 types (**DA** Record, field 1); e.g., urban, rural transportation, times ECFCT. Damage types are in the same order as the **DC** Records from which the data are read.

b. Expected Annual Damages. If expected annual damages are computed (**J4** Record, field 1 is positive), they are based on the input discharge-frequency damage data and the results are printed on the line labeled BASE COND-COMPUTED. If expected annual damages for base conditions have been input (**DA** Record), these values are listed as BASE COND-INPUT. If expected annual damages for the existing system have been input (**DB** Record), these values are listed as EXISTING SYSTEM-INPUT.

c. Base Condition Flood Damages. This output includes the flood event number with the unregulated peak flow and the exceedence frequency, probability interval and damage values associated with that event. The unregulated peak flows have been arranged from smallest to largest. The exceedence frequency for the event is determined by logarithmic interpolation of the input flow-frequency data. The probability interval for the event represents the probability between the midpoints of adjacent events. If expected annual damages are computed (**J4** Record, field 1 is positive), the damage values represent the incremental portion between adjacent events. If damages only are computed (**J4** Record, field 1 is negative), the values are the damages for the event interpolated from the input discharge-damage relation and the probability interval is set to 1.0.

d. Modified Conditions Flow-Damage Data. If a design discharge, DESQ (**C$** Record, field1), is provided for a local project or second set of **DC** Records is input, the modified flow-frequency-damage data are listed.

e. Modified Conditions Flood Damages. Modified conditions refer to the system with all reservoirs and local projects in operation. This output has the same format as for the base conditions output except that there is an additional line of output showing damage reduction (the amount by which damages are reduced from the existing system damages).

f. Uncontrolled Local Flow Flood Damages. Uncontrolled local flows refer to those flows which reach the control point without passing through a reservoir; that is, flows for which there are no available controls. Damages with total control at projects refer to the damages that would occur if all upstream reservoirs had sufficient capacity to prevent releases contributing to peak flows downstream. Thus, damages with total control are equivalent to damages from uncontrolled local flow. RESIDUAL DAMAGES is the amount by which damages could be further reduced in the existing system if all reservoirs had sufficient capacity.

Table F.33. Printout of Flood Frequency and Damage Data *(*ECDAM)*

Example Input Records:

```
'
.
.
J4      1      999             .03       .1
.
.
.
CP      4    40000
ID CP 4
C2 0.025       2.5
RT      4
QS      9    10000    20000    30000    40000   100000   300000   500000   700000   900000
EL      9      300      350      450      500      550      600      625      650      700
C$ 40000      2000     4000     5000     6000
DA      2
DB      2      500     1000
DF     17     .999     .900     .800     .700     .600     .500     .400     .300     .250
DF   .200     .150     .100     .050     .020     .010     .005     .002
DQ     17    28800    35000    42000    50500    60500    73000    90000   114000   130000
DQ150000    180000   230000   323000   490000   640000   840000  1000000
DC      1      .05      .08      .10      .11      .14      .19      .29      .38      .48
DC    .60      .80     1.21     2.20     4.20     5.38     6.12     6.50
DC      2      .10      .17      .22      .30      .40      .52      .75     1.10     1.45
DC   1.90     2.80     4.90     9.80    12.20    13.32    14.17    14.66
ED
BF      0       18        0       057060610        0        6
FC     .3        1      1.5        2        3        4
.
.
.
EJ
ER
```

Example Output:

```
*ECDAM 4
                  BASE CONDITION FREQUENCY-FLOW-DAMAGE DATA
    FREQ       PEAK           SUM     TYPE 1    TYPE 2
  0.9990     28800.        149.85      49.95     99.90
  0.9000     35000.        249.75      79.92    169.83
  0.8000     42000.        319.68      99.90    219.78
  0.7000     50500.        409.59     109.89    299.70
  0.6000     60500.        539.46     139.86    399.60
  0.5000     73000.        709.29     189.81    519.48
  0.4000     90000.       1038.96     289.71    749.25
  0.3000    114000.       1478.52     379.62   1098.90
  0.2500    130000.       1928.07     479.52   1448.55
  0.2000    150000.       2497.50     599.40   1898.10
  0.1500    180000.       3596.40     799.20   2797.20
  0.1000    230000.       6103.89    1208.79   4895.10
  0.0500    323000.      11988.00    2197.80   9790.20
  0.0200    490000.      16383.60    4195.80  12187.80
  0.0100    640000.      18681.30    5374.62  13306.68
  0.0050    840000.      20269.71    6113.88  14155.83
  0.0020   1000000.      21138.84    6493.50  14645.34

EXPECTED ANNUAL DAMAGES
   BASE COND-COMPUTED   2206.91     523.61   1683.30
   BASE COND-   INPUT      0.00       0.00      0.00
   EXIST SYSTEM-INPUT   1500.00     500.00   1000.00
```

... Continued ...

Table F.33. Printout of Flood Frequency and Damage Data *(*ECDAM)* - Continued

```
                                BASE CONDITION FLOOD DAMAGES
            EXCD  PROB
NO.  FLOW  FREQ   INT        SUM     TYPE 1     TYPE 2
 1  61200.0.594 0.642     326.82      91.11     235.71
 2 204000.0.123 0.269     728.27     165.94     562.33
 3 306000.0.056 0.046     443.59      83.55     360.04
 4 408000.0.031 0.022     316.22      70.92     245.30
 5 612000.0.011 0.013     219.25      59.74     159.50
 6 816000.0.006 0.008     172.76      52.33     120.43

    BASE COND DAMAGES    2206.91     523.61    1683.30
    EXST SYST DAMAGES    1500.00     500.00    1000.00


                             MODIFIED CONDITIONS FLOW-DAMAGE DATA
    FREQ       PEAK          SUM     TYPE 1     TYPE 2
  0.9990    28800.          0.00       0.00       0.00
  0.8268    40000.        299.70      94.19     205.51
  0.8000    42000.        319.68      99.90     219.78
  0.7000    50500.        409.59     109.89     299.70
  0.6000    60500.        539.46     139.86     399.60
  0.5000    73000.        709.29     189.81     519.48
  0.4000    90000.       1038.96     289.71     749.25
  0.3000   114000.       1478.52     379.62    1098.90
  0.2500   130000.       1928.07     479.52    1448.55
  0.2000   150000.       2497.50     599.40    1898.10
  0.1500   180000.       3596.40     799.20    2797.20
  0.1000   230000.       6103.89    1208.79    4895.10
  0.0500   323000.      11988.00    2197.80    9790.20
  0.0200   490000.      16383.60    4195.80   12187.80
  0.0100   640000.      18681.30    5374.62   13306.68
  0.0050   840000.      20269.71    6113.88   14155.83
  0.0020  1000000.      21138.84    6493.50   14645.34


                              MODIFIED CONDITIONS FLOOD DAMAGES
            EXCD  PROB
NO.  FLOW  FREQ   INT        SUM     TYPE 1     TYPE 2
 1  40000.0.594 0.642      86.68      24.91      61.77
 2  85000.0.123 0.269     184.29      49.29     135.00
 3 127500.0.056 0.046      76.39      19.35      57.04
 4 170000.0.031 0.022      75.70      16.88      58.81
 5 312760.0.011 0.013     111.97      21.61      90.36
 6 463262.0.006 0.008     148.35      40.64     107.71

     MODIFIED DAMAGES     683.37     172.69     510.68
     DAMAGE REDUCTION     816.63     327.31     489.32


                             UNCONTROLLED LOCAL FLOW FLOOD DAMAGES
            EXCD  PROB
NO.  FLOW  FREQ   INT        SUM     TYPE 1     TYPE 2
 1  25500.0.594 0.642       5.06       1.59       3.47
 2  85000.0.123 0.269     157.62      42.96     114.66
 3 127500.0.056 0.046      76.39      19.35      57.04
 4 170000.0.031 0.022      71.92      16.26      55.66
 5 255000.0.011 0.013      81.93      16.09      65.85
 6 340000.0.006 0.008     111.08      23.80      87.29
     DAMAGES W/ TOTAL
  CONTROL AT PROJECTS     504.00     120.04     383.96

   REDUCTION POSSIBLE
   W/ TOTAL CONTROL       996.00     379.96     616.04

     RESIDUAL DAMAGES     179.37      52.65     126.72
```

F.11 Flood Frequency Plots (*EPLOT)

The input exceedence frequency-discharge data, the peak flows for input flood events under base conditions, and the reduced flows resulting from modified conditions are plotted on the exceedence frequency curve (see Figure F.1). An expected annual damages summary is also printed out on the plot. If a single flood event is input to the program the damage values for the modified system are for the single event.

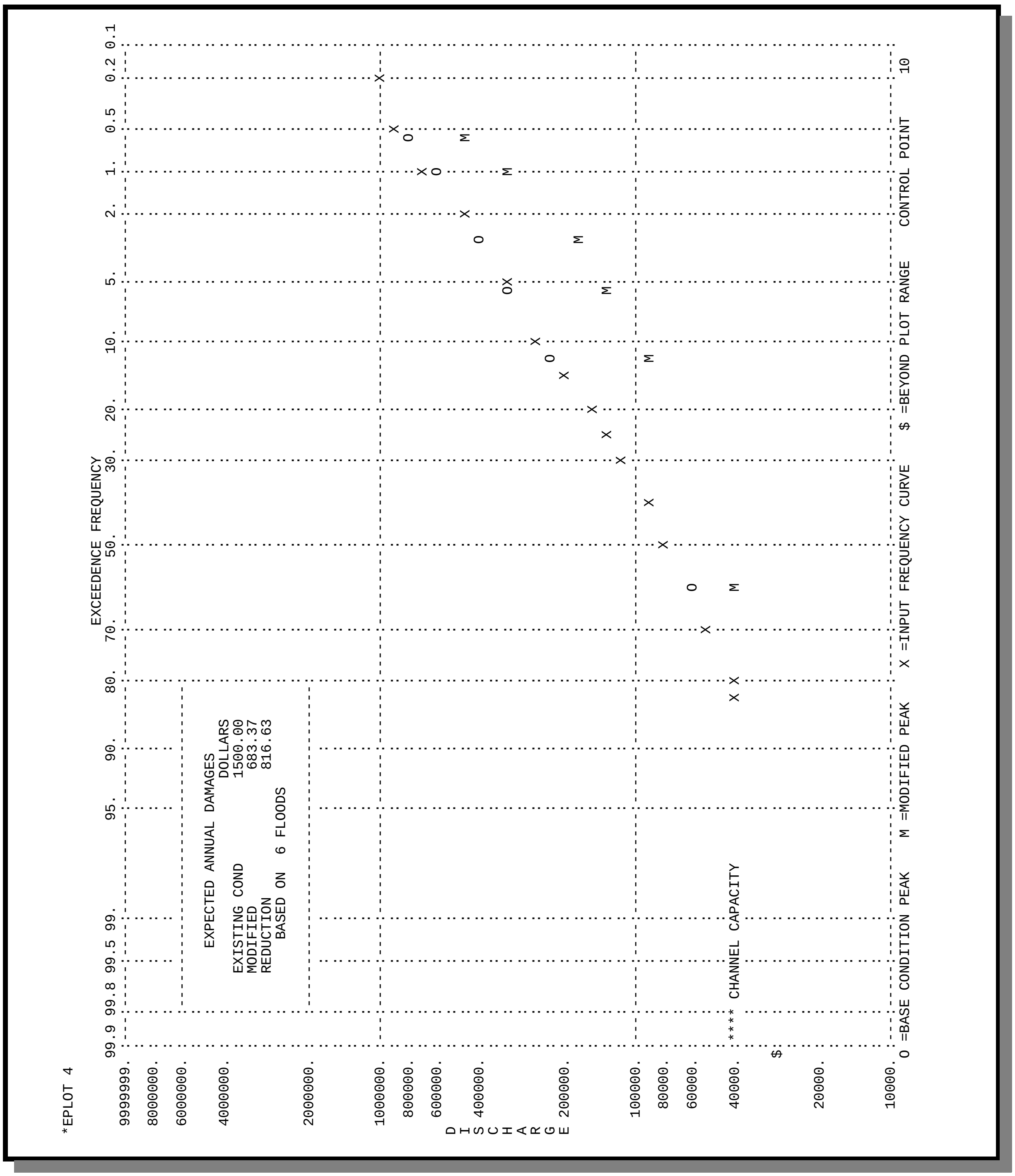

Figure F.1. Example of Flood Frequency Plot *(*EPLOT)*

F.12 Summary of Damages or Average Annual Damages, System Costs and Net Benefits

F.12.1 Summary of Damages and Damage Reductions (*ESUMD)

For each damage control point, the total damages for base conditions, modified conditions and uncontrolled local flows, the damage reductions expected from modified conditions and from total control at projects, and residual damages are summarized. If multiple floods are input to the program, the printout values are either damages for those specific floods (**DA** Record, field 1 is negative) or are expected annual damages (**DA** Record, field 1 is positive). If a single flood event is input, the values are damages for the single event. An example printout of this summary information is shown in Table F.34.

Table F.34. Expected Annual Flood Damage Summary *(*ESUMD)*

```
*ESUMD
                  SUMMARY OF SYSTEM"S EXPECTED ANNUAL FLOOD DAMAGES

                    DAMAGES                           DAMAGE REDUCTION
    CP      BASE COND   MOD COND   LOC COND   MOD COND   LOC COND   RESIDUAL
         4    1500.00     683.37     504.00     816.63     996.00     179.37

   TOTALS     1500.00     683.37     504.00     816.63     996.00     179.37
```

F.12.2 Summary of System Costs (*ESUMC)

For each control point for which a project is being considered, the project type and project costs are listed. The project type will be indicated as either a reservoir or a local protection work. Costs include initial (capital) costs and annual (operation, maintenance and replacement) costs. An example of this summary information is shown in Table F.35.

Table F.35. System Costs Summary *(*ESUMC)*

```
*ESUMC

                              SUMMARY OF SYSTEM COSTS
                              -----------------------
         *************************************************************
         *         *           *           *   ANNUAL   *   TOTAL    *
         * CONTROL *  PROJECT  *  CAPITAL  *   O,M, R   *   ANNUAL   *
         *  POINT  *   TYPE    *   COST    *    COST    *    COST    *
         *************************************************************
         *         *           *           *            *            *
         *     1.  * RESERVOR  *   7600.00 *     152.00 *     380.00 *
         *     4.  * LOCAL     *    600.00 *      15.00 *      30.00 *
         *************************************************************
```

F.12.3 System Economic Cost and Performance Summary (*ESUMB)

Total capital and annual costs include the combined costs of all proposed projects. EXPECTED ANNUAL DAMAGES - EXISTING SYSTEM are the expected annual damages of the system in the base condition, computed from the discharge-frequency curve. Alternatively, the EXPECTED ANNUAL DAMAGES for the existing system may be the sum of the input values by means of base damage records (**DB** Records). EXPECTED ANNUAL DAMAGE - PROPOSED SYSTEM is based on a modified discharge-frequency curve which is derived from flows computed for multiple input flood events. The total system annual costs and expected annual damage reduction is summarized and the net damage reduction benefits computed. If a single flood event is input to the program this portion of the output is deleted. An example of this summary information is shown in Table F.36.

Table F.36. System Economic Summary *(*ESUMB)*

```
*ESUMB
              SYSTEM ECONOMIC COST AND PERFORMANCE SUMMARY
                  (EXCLUSIVE OF EXISTING SYSTEM COSTS)

       TOTAL SYSTEM CAPITAL COST * * * * * * *        8200.00

       TOTAL SYSTEM ANNUAL OPERATING
          MAINTENANCE, AND REPAIR COST * * * *         167.00

       TOTAL SYSTEM ANNUAL COST  * * * * * * *                     410.00


       EXPECTED ANNUAL DAMAGES - EXISTING SYSTEM      1500.00

       EXPECTED ANNUAL DAMAGES - PROPOSED SYSTEM       683.37
```

F.13 Hydrologic Efficiencies (*HYEFF)

The reduction in discharge and stage at each control point as a result of reservoir operation is tabulated in the output as shown in Table F.37. Differences are taken between natural and regulated values.

Table F.37. Example Output of Hydrologic Efficiencies *(*HYEFF)*

```
*HYEFF

HYDROLOGIC EFFICIENCIES

  LOCATION         PEAK DISCHARGE REDUCTION      MAX STAGE REDUCTION
                   NAT Q     REG Q    DIFF Q   NAT STG  REG STG  DIF STG

************************************************************************

 SAVANNAH R. BEL    22936.    18146.    4789.      0.00     0.00     0.00

************************************************************************
```

F.14 Computer Check for Possible Errors (*ERROR)

Results of program operation are scanned for possible reservoir operation errors. If no operation errors are detected, then the output will look like that shown in Table F.38. If a constraint is violated, an error message is printed out (as shown in Table F.39). The basic message has the form "POSSIBLE ERROR: Loc No=, Per=, Act Q=, Min Q=, Res No=, Level=, (Above Level=)". The message states that a possible error was found at a control point (Loc No) for a particular time period (Per). The actual flow (Act Q) and minimum desired or required flow (Min Q) are listed for that control point at that time period. The remaining items identify the reservoir (Res No=) that was the source of the possible erroneous release, the level (Level=) of the reservoir at the end of the period and the next lower integer level (Above Level=). Additional messages are also printed:

a. "MINIMUM FLOW NOT SUPPLIED." The desired or required flow at the current control point was not satisfied and one or more reservoirs had storage that could have eliminated or reduced the shortage.

b. "FLOODING CAUSED BY RESERVOIR." Flooding at the current control point was caused at least in part by nonessential releases from an upstream reservoir.

c. "RESERVOIR RELEASE INCORRECTLY BASED ON D.S. FLOW." Reservoir release (Rel=) was made to provide a target flow at the downstream control point as indicated by the "Case=" and "D.S.Loc=". The downstream flow is either larger than or less than the target flow considering the contingency factor and a 5% allowable departure. When the reservoir is in flood control operation, the downstream flow "D.S. Flow=" should be at channel capacity "CCap=" (allowing for a contingency factor). If the reservoir is in conservation operation, the downstream flows should satisfy minimum desired or required flows.

Table F.38. Example where "No Operation Errors" Detected *(*ERROR)*

```
*****************************************************************************
 *ERROR
              Computer Check for POSSIBLE ERRORS
                            ***** Flood Number  1 *****

     Possible ERRORS Found=       0 Allowable ERROR CHECK=      50


*****************************************************************************
```

Table F.39. Example where "Operation Errors" are Detected *(*ERROR)*

```
 ************************************************************************************************************************
 *ERROR
                   Computer Check for POSSIBLE ERRORS
                       ***** Flood Number  1 *****
         RESERVOIR RELEASE INCORRECTLY BASED ON D.S. FLOW
POSSIBLE ERROR:  Res=  20, Per=  2, Rel=  106.3, Case=  50.00, Level= 2.62, D.S.Loc=  50, D.S.Flow=  106.3, CCap= 4000.0

        MINIMUM FLOW NOT SUPPLIED
 POSSIBLE ERROR:  Loc No=   50, Per=   2, Act Q=   106.3, Min Q=   555.0, Res No=   20, Level= 2.62 (Above Level= 2.00)

 Possible ERRORS Found=     2   Allowable ERROR CHECK=      50
 ************************************************************************************************************************
```

F.15 Case Definitions (*CASES)

A brief table is presented at the end of the output file defining the Case designations used by the program. Table F-40 provides a description of the different case values that show "why" the reservoir made the release it did.

Table F.40. Case Designations for Reservoir Releases *(*CASES)*

```
*CASES

     CASES for  PROGRAM DETERMINED Releases
                ---------------------------

** CASE =  X.Y, Where:  X = Controlling LOCATION
                        Y = NUMBER of Future Period Controlling

EXCEPT When X=0
THEN, TYPE of Release is Based on RESERVOIR REQUIREMENTS,  Y =

     Y=00 Minimum DESIRED FLOW at Dam Site
     Y=01 Operational CHANNEL CAPACITY at Dam Site
     Y=02 Based on MAX RATE of CHANGE of Reservoir Release
     Y=03 Release to Reach TOP of CONSERVATION  POOL
     Y=04 Release to Reach TOP of FLOOD CONTROL POOL
     Y=05 Release to BALANCE TANDEM Reservoirs
     Y=06 Based on MAX RELEASE Due to OUTLET CAPACITY
     Y=07 Based on NOT DRAWING BELOW LEVEL 1
     Y=08 Minimum REQUIRED FLOW at Dam Site
     Y=09 Release to Reach TOP of BUFFER LEVEL
     Y=10 Based on POWER: AT-SITE Demand
     Y=11 MIN FLOW Since Highest Res CANNOT Release
     Y=12 Based on SYSTEM POWER Demand
     Y=13 Based on POWER: LEAKAGE
     Y=14 Based on POWER: PENSTOCK Limit
     Y=15 Based on POWER: GENERATOR CAPACITY
     Y=20 Based on GATE REGULATION CURVE - RISING POOL
     Y=21 Based on EMERGENCY Release: PARTIAL GATE OPENING
     Y=22 Based on EMERGENCY Release: TRANSITION
     Y=23 Based on EMERGENCY Release: OUTFLOW=INFLOW
     Y=24 Based on EMERGENCY Release: ALL GATES FULLY OPEN
     Y=29 Based on EMERGENCY Release: PRE-RELEASE


     CASES for  USER SPECIFIED Release Criteria  (QA Records)
                -------------------------------

** CASE = -X.Y, Where:  X = RELEASE (CFS) or  Release CRITERIA (If Any)
                        Y = CODE that was Input on QA Record
                            (or REPEATED from Previous Period)

     Y=00  X RELEASE Specified by USER
     Y=01  Release SAME as Previous Period's RELEASE
     Y=02  INTERPOLATED Release Between Two USER Supplied Release VALUES
     Y=03  PREVIOUS Period Release  +  X PERCENT
     Y=04  PREVIOUS Period Release  -  X PERCENT
     Y=10  PREVIOUS Period Release  +  X CONSTANT
     Y=20  PREVIOUS Period Release  -  X CONSTANT
     Y=22  Release from GATE REGULATION CURVE
     Y=23  Release to Reach TOP of FLOOD CONTROL POOL
     Y=24  Release for DAM SITE Operational CHANNEL CAPACITY
     Y=25  Release for MAXIMUM OUTLET CAPACITY
     Y=26  Release to REACH TOP of CONSERVATION POOL
     Y=27  Based on MAXIMUM RATE of CHANGE of Reservoir RELEASE (RISING)
     Y=28  Based on MAXIMUM RATE of CHANGE of Reservoir RELEASE (FALLING)
     Y=29  Release to REACH TOP of BUFFER POOL
     Y=30  Release to REACH LEVEL 1 POOL
     Y=31  Based on FIRM ENERGY DEMAND
     Y=32  Based on Allocated SYSTEM POWER ENERGY
     Y=33  Release to BALANCE TANDEM RESERVOIRS
     Y=34  Based on Reservoir LOW FLOW REQUIREMENTS (DESIRED Q)
     Y=35  Based on Reservoir LOW FLOW REQUIREMENTS (REQUIRED Q)
     Y=36  Based on D.S. FLOOD CONTROL Limitations
     Y=37  Based on D.S. LOW FLOW Requirements
     Y=41  OUTFLOW Equal INFLOW
     Y=42  Based on PREVIOUS Period GATE SETTING
     Y=43  Release to REACH  X LEVEL     (At End of CURRENT PERIOD)
     Y=44  Release to REACH  X STORAGE   (At End of CURRENT PERIOD)
     Y=45  Release to REACH  X ELEVATION (At End of CURRENT PERIOD)
     Y=50  MINIMUM Release Made IF D.S. TANDEM RES. is RISING  AND
                                   D.S. Release is LESS than Value X
```