ASSURED REFILL CURVE GENERATOR PROGRAM

PROGRAM: ARC.EXE

INTRODUCTION. Assured Refill Curves (ARC's) are required by HYSSR when it operates the river system to meet the load using rule curves in accordance with the Pacific Northwest Coordination Agreement (PNCA). ARC's are computed for cyclical storage projects only. Annual storage projects have ARC's which are equivalent to their first year Critical Rule Curve (CRC1). See Glossary for further definition.

The ARC for each period is an end of period storage content in thousand-acre-feet (KAF) based on the third lowest water conditions for the basin during the sixty-one years of historic record (1928 - 1989). For storage projects in the Columbia River and Snake River basins (projects upstream of Bonneville Dam), ARC calculations are based on natural flows from water year 1931 (1 August 1930 - 31 July 1931). Other storage projects such as projects in the Willamette River basin and Westside projects may require a water year other than 1931. The third lowest water year for these projects should be input on record code 29 and the ARC computed based on that water year.

For each cyclical storage project and each period, the minimum release from the third lowest water year plus any amount of water required for storage by upstream projects are subtracted from the natural flow to give the amount of flow available for storage. This value is converted to a volume and added to the existing project storage to give the end of period storage content.

INPUT. The ARC program executes in batch mode, so it requires a control file named C:\HYSSR\CONFILES\ARC.CON. This control file defines the names of the input data file, the output data file, the Study Characteristics file, the resulting ARC's in standard HYSSR format, and the Base TABOUT (see glossary for a description of Base TABOUT) from a previous HYSSR regulation. A sample control file follows:

```
* C:\HYSSR\CONFILES\ARC.CON
*
* Unit 5 is the input file
* Unit 6 is the printer output file
* Unit 7 is the Study Characteristics file
* Unit 10 is the output file for the resulting ARC's
* Unit 14 is the Base TABOUT file
*
*  FORMAT  T4,I2,T7,A26,T34,A11,T46,A7,T54,A10,T65,I4
*
*_____________________________________________________________________
*UNIT FILE NAME                FORMAT      STATUS  ACCESS     RECL
*_____________________________________________________________________
   5  C:\HYSSR\DATA\ARCDAT.IN  FORMATTED   OLD
   6  C:\HYSSR\DATA\ARC.PRN    FORMATTED   UNKNOWN
   7  C:\REFILL93\STCHAR93.STY UNFORMATTED OLD
  10  C:\HYSSR\DATA\ARC93.DAT  FORMATTED   UNKNOWN
  14  C:\HYSSR\DATA\TABASE.93  UNFORMATTED OLD     DIRECT     104
*_____________________________________________________________________
```

The input data file defines: the program options to be used, which projects are cyclical, the Power Discharge Requirements (PDR's), any changes to project characteristics, the first-year Critical Rule Curve (CRC1) for each project, and the pumping diversions at Grand Coulee. All of this data is input on 80 column records using the standard HYSSR format. A sample of an input file follows the record codes descriptions.

Record Code 11: This record type defines the basic options for the run. The options are as follows:

Identifier	Definition	Default
STY	Depletion year for the study.	None
PUN	Write ARC's to the output file	Not write
DEF	Any deficit in meeting minimum release is not accumulated to the previous period's minimum release requirement.	Accumulate deficits
ECC	The higher of the calculated ARC or CRC1 is used to use the calculated ARC calculate upstream storage.	

Record code 12: This record type defines by external project number which storage projects are to be treated as cyclical projects. One record is required for each cyclical project with the project number appearing in columns 8 - 10.

Record Code 15: This record type defines by external project number the minimum flow in CFS for each period. These minimum flows are called Power Discharge Requirements (PDR's). See the Glossary for further definition of PDR's. The default values for minimum flow values for all periods are the Release Lower Bounds (RLB) values from the Study Characteristics file (STCHAR), unless the RLB values are changed by record code 16, or when a Variable Release Lower Bounds (VRLB) is available for the third lowest water year

from the Base TABOUT file. The minimum flow value used for ARC computations is the highest of the PDR value, the RLB (from STCHAR or record code 16), or the VRLB value from the Base TABOUT file.

Record Code 16: This record code defines changes to be made to a project's characteristics by its external project number. These are changes from the values found in the STCHAR file. The project characteristics which may be changed are:

Identifier	Project characteristic
SUB	Storage Upper Bounds (AF)
SLB	Storage Lower Bounds (AF)
RUB	Release Upper Bounds (CFS)
RLB	Release Lower Bounds (CFS)

Record Code 29: This record defines the third lowest water year to be used for that project's ARC computation. The default water year is 1931 (1 August 1930 - 31 July 1931). The format for record code 29 is the external project number in columns 8 - 10 and the water year in columns 19 - 20. If a record code 29 has the project number but no year is specified, that project will use water year 1931 for its ARC computation.

Record Code 41: This record contains input ARCs for a project by period. During periods when the ARC value is input, that value will be used as the ARC and the resultant PDR will be printed to the printer output file. When no ARC is input, the program will calculate the ARC based on the PDR as always. Right now only Steps I and II of the AOP studies will use ARCs as input to the ARC program.

Record Code 42: This record defines each project's CRC1. It will over-ride the CRC1 value obtained from the Base TABOUT file.

Record Code 93: This record contains the Grand Coulee pumping diversions in CFS. These values are added (pumping diversions are negative) to the natural flow values used to calculate the ARC's. The ARC program will only accept pumping diversions for Grand Coulee.

SAMPLE INPUT DATA:

```
11                  DEF         ECC         STY       80PUN
12       1
12       2
12       3
12      10
12      19
16       1          RLB    10000
15       1          JAN     3000FEB     3000MAR    22500AP1    25000
15       1          APR    25000MAY    28000JUN    32000JUL    38000
15      19          JAN    37000FEB    46000MAR    46000AP1    46000
15      19          APR    58000MAY   120000JUN    95000JUL    80000
29     155        44
29     157        44
41       3          AP1   3742.2APR   3471.8MAY   4372.9JUN   5455.6
42      10          JAN   2115.3FEB   1828.4MAR   1731.7AP1   1701.7
42      10          APR   1774.9MAY   2437.4JUN   3056.8JUL   3071.5
42      10          AG1   3071.5AUG   3071.5SEP   2774.0OCT   2797.2
42      10          NOV   2760.5DEC   2669.0
93      19          JUL    -9500AG1    -9650AUG    -6870SEP    -4685
93      19          OCT    -2180MAR     -750AP1    -3330APR    -6180
93      19          MAY    -7240JUN     -8490
```

The data listed here is not complete. It is only a sample of the records needed as input for the ARC program.

OUTPUT. The ARC program produces two output files. One output file contains the resulting ARC's on HYSSR record code 41 (the "PUN" must be among the options on record code 11). There is one set of records for each cyclical storage project. A set contains all the periods in a year as defined in the Study Characteristics file. This output file may be used directly as input to build either the TDDATA or TDMODS files. Sample ARC's on HYSSR record code 41 follows.

SAMPLE OUTPUT:

```
41       3        JAN   3977.0FEB   3874.3MAR   3770.6AP1   3742.2
41       3        APR   3471.8MAY   4372.9JUN   5455.6JUL   5869.4
41       3        AG1   4073.1AUG   4169.5SEP   4239.4OCT   4233.3
41       3        NOV   4177.6DEC   4077.2
```

The other output file provides details of the ARC calculation. It contains a list of the input records and a tabular listing of the data and intermediate values used for the ARC calculation at each storage project. The output for each storage project is described below and a sample follows on page 9.

COLUMN 1: "PERIODS"

These are the periods of the year for which end of period storage is calculated.

COLUMN 2: "NATURAL FLOWS"

These are the natural flows in CFS used to compute the ARC's. Based on the 1928-1989 historical record, natural flows for storage projects in the Columbia and Snake River basins come from water year 1931 (1 August 1930 - 31 July 1931). The program calculates ARC's for Willamette River basin and Westside projects based on the water year input on record code 29. If no record code 29 is available for a project, 1931 water is used.

COLUMN 3: "MINIMUM RELEASE"

These are the minimum releases in CFS. These values are the higher of the PDR's specified on record code 15, the release lower bound (RLB) from either the Study Characteristics file or record code 16, and the variable release lower bound (VRLB) for the water year from the Base TABOUT file.

COLUMN 4: "UPSTREAM STORAGE"

These are the summation of the changes of storage in KAF of storage projects upstream of the current project. The upstream storage value includes storage changes at both annual and cyclical storage projects.

COLUMN 5: "STORAGE CHANGE"

Cyclical storage projects begin the ARC calculations full on 31 July. From this 31 July storage content the end of the previous period's ARC is computed by first calculating this period's storage change in KAF, which is calculated as follows:

NATURAL FLOW - MINIMUM RELEASE - UPSTREAM STORAGE - DEFICITS (if deficits are accumulated as determined by the DEF option on record code 11).

For example when the calculated storage change is for July, it is subtracted from the 31 July end of month (EOM) content to yield the EOM content for 30 June (when there are 14 periods per year in the study). The process continues back toward the first half of August.

For annual storage projects, the ARC is set equal to the CRC1 for that period. Storage change for each period is calculated as the difference between this period's ARC (beginning with 31 July) and the previous period's ARC (for 31 July the previous period would be 30 June). Again, the process continues back toward the first half of August.

COLUMN 6: "ACCUM. DRAFT - KAF"

These are the accumulated draft values in KAF. The accumulated draft values for each period are computed as follows:

EOM CONTENT for 31 July - EOM CONTENT for this period

For cyclical storage projects the EOM content for 31 July is full. For annual storage projects the EOM content for 31 July is the CRC1 value for 31 July and may or may not be full.

COLUMN 7: "EOM CONTENT"

These are the end of period storage contents in KAF (the computed ARC's). For cyclical storage projects these end of month (EOM) contents are computed as:

EOM CONTENT (30 June) = EOM CONTENT (31 July) - STORAGE CHANGE (July)

For annual storage projects the EOM Content is the same as the CRC1 for that period.

COLUMN 8: "BASE ECC"

These are the Base Energy Content Curves (BECC's) in KAF which are the higher of the CRC1 or the ARC for that period.

At the bottom of each storage projects table SUB (storage upper bounds) and SLB (storage lower bounds) are printed and are followed by the notes specifying which run options were used. The first note indicates whether deficits were accumulated when minimum release could not be met. The second note indicates whether upstream storage was computed using the ARC or the BECC. The final note is only present if an "*" follows column 7. This note explains that the minimum release for that period could not be met because meeting the required minimum release would force the cyclical project's storage to be above full. The deficit then is the difference between the computed EOM Content and that project's full.

PROGRAM EXECUTION ON THE PC.

To execute the ARC program, have a copy of ARC.EXE in the local C:\HYSSR\PGM subdirectory and the program will execute using the datasets named in ARC.CON. This control file must be in the local C:\HYSSR\CONFILES subdirectory and changed to meet the data file naming conventions being used. The existing format of the confile may not be altered.

INPUT DATA

```
11                DEF         ECC         STY       80PUN
12         1
12         2
12         3
12         5
12        10
12        19
12       155
12       157
12       159
12       163
29       155        44
29       157        44
29       163        44
16         1          SLB       0.          0.          0.          0.          0.
16         1          RLB   10000.          0.          0.          0.          0.
16         3          RLB    4000.          0.          0.          0.          0.
16        10          RLB     145.          0.          0.          0.          0.
15         1          JAN   15000.FEB   20000.MAR   23000.AP1   23000.          0.
15         1          APR   23000.MAY   25000.JUN   28000.JUL   28000.          0.
15         2          JAN    5000.FEB   15000.MAR   18000.AP1   25000.          0.
15         2          APR   30000.MAY   40000.JUN   50000.JUL   50000.          0.
15         5          JAN     100.FEB     500.MAR     500.AP1     500.          0.
15         5          APR    2000.MAY    2000.JUN    2000.JUL    2000.          0.
15         3          JAN    4000.FEB    4000.MAR    4000.AP1    4000.          0.
15         3          APR    6000.MAY    6000.JUN    7000.JUL    7500.          0.
15        10          JAN    2480.FEB    2160.MAR    2500.AP1    5207.          0.
15        10          APR   11242.MAY    5640.JUN    2500.JUL    3500.          0.
15        19          JAN   90000.FEB   96682.MAR   70500.AP1   68400.          0.
15        19          APR   54700.MAY  123275.JUN   41200.JUL   68500.          0.
15        19          AG1   30000.AUG   40000.SEP   40000.OCT   59000.          0.
15        19          NOV   53000.DEC   59000.          0.          0.          0.
15        31          JAN    2000.FEB    2000.MAR    2000.AP1    2000.          0.
15        31          APR    2000.MAY   12000.JUN    2000.JUL    2000.          0.
15       155          DEC    1175.          0.          0.          0.          0.
15       155          JAN    1200.FEB    1200.MAR    1050.AP1    1200.          0.
15       155          APR    1200.MAY    1200.JUN    1100.JUL     750.          0.
15       157          AP1     550.APR     550.MAY     550.JUN     550.          0.
15       157          JUL     550.          0.          0.          0.          0.
15       163          JAN    2000.FEB    2000.MAR    2000.AP1    2800.          0.
15       163          APR    2800.MAY    2800.JUN    2800.JUL    2800.          0.
15       166          AP1      10.APR      10.MAY      10.JUN      10.          0.
15       166          JUL      10.          0.          0.          0.          0.
41         3          AP1   3742.2APR   3471.8MAY   4372.9JUN   5455.6
93        19          JUL   -9500.AG1   -9650.AUG   -6870.SEP   -4685.          0.
93        19          OCT   -2180.NOV       0.DEC       0.JAN       0.          0.
93        19          FEB       0.MAR   -7548.AP1  -10927.APR   -6180.          0.
93        19          MAY   -7240.JUN   -8490.          0.          0.          0.
```

DEPLETION YEAR 1980

PERIOD	1944 FLOW CFS	MINIMUM RELEASE CFS	UPSTREAM STORAGE KAF	STORAGE CHANGE KAF	ACCUM. DRAFT (PERIOD - 31 JUL)	EOM CONTENT KAF	BASE-ECC KAF
AG1	109.	100.			197.6	174.5	368.1
AUG	109.	100.	0.0	0.3	197.3	174.8	368.1
SEP	89.	100.	0.0	-0.7	198.0	174.1	331.6
OCT	503.	100.	0.0	24.8	173.2	198.9	300.3
NOV	446.	100.	0.0	20.6	152.6	219.5	219.5
DEC	794.	100.	0.0	42.7	110.0	262.1	262.1
JAN	1094.	100.	0.0	61.1	48.8	323.3	323.3
FEB	593.	100.	0.0	27.4	21.4	350.7	350.7
MAR	448.	100.	0.0	21.4	0.0	372.1	372.1
AP1	485.	550.	0.0	0.0	0.0	372.1 *	372.1
APR	537.	550.	0.0	0.0	0.0	372.1 *	372.1
MAY	510.	550.	0.0	0.0	0.0	372.1 *	372.1
JUN	377.	550.	0.0	0.0	0.0	372.1 *	372.1
JUL	151.	550.	0.0	0.0	0.0	372.1 *	372.1

SUB 372.1 KAF
SLB 0.0 KAF

NOTES:
DEFICITS FOR MINIMUM RELEASE WERE NOT ACCUMULATED DURING PERIODS THAT PROJECT WAS AT SUB
UPSTREAM STORAGE WAS COMPUTED FROM BASE ECC FOR UP STREAM PROJECTS
"*" INDICATES THAT MINIMUM RELEASE COULD NOT BE SATISFIED

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DEPLETION YEAR 1980

PERIOD	1931 FLOW CFS	MINIMUM RELEASE CFS	UPSTREAM STORAGE KAF	STORAGE CHANGE KAF	ACCUM. DRAFT (PERIOD - 31 JUL)	EOM CONTENT KAF	BASE-ECC KAF
AG1	9271.	4000.			1796.3	4073.1	5869.4
AUG	7038.	4000.	0.0	96.4	1699.9	4169.5	5869.4
SEP	5174.	4000.	0.0	69.9	1630.0	4239.4	5828.5
OCT	3901.	4000.	0.0	-6.1	1636.1	4233.3	5869.4
NOV	3064.	4000.	0.0	-55.7	1691.8	4177.6	5369.4
DEC	2367.	4000.	0.0	-100.4	1792.2	4077.2	4077.2
JAN	2370.	4000.	0.0	-100.2	1892.4	3977.0	3977.0
FEB	2151.	4000.	0.0	-102.7	1995.1	3874.3	3874.3
MAR	2313.	4000.	0.0	-103.7	2098.8	3770.6	3770.6
AP1	3046.	4000.	0.0	-28.4	2127.2	3742.2 I	3742.2
APR	3821.	12909.	0.0	-270.4	2397.6	3471.8 I	3471.8
MAY	18654.	3999.	0.0	901.1	1496.5	4372.9 I	4372.9
JUN	22197.	4002.	0.0	1082.7	413.8	5455.6 I	5869.4
JUL	10729.	3999.	0.0	413.8	0.0	5869.4	5869.4

SUB 5869.4 KAF
SLB 889.9 KAF

NOTES:
DEFICITS FOR MINIMUM RELEASE WERE NOT ACCUMULATED DURING PERIODS THAT PROJECT WAS AT SUB
UPSTREAM STORAGE WAS COMPUTED FROM BASE ECC FOR UP STREAM PROJECTS
“I” INDICATES THAT EOM STORAGE CONTENT WAS INPUT AS ARC PN CC 41

SAMPLE OUTPUT (cont.)

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DEPLETION YEAR 1980

PERIOD	1931 FLOW CFS	MINIMUM RELEASE CFS	UPSTREAM STORAGE KAF	STORAGE CHANGE KAF	ACCUM. DRAFT (PERIOD - 31 JUL)	EOM CONTENT KAF	BASE-ECC KAF
AG1	7586.	4000.			0.0	1493.8	1493.8
AUG	5056.	4000.	-30.7	0.0	0.0	1493.8	1493.8
SEP	5945.	4000.	0.0	-185.3	185.3	1308.5	1308.5
OCT	7957.	4000.	-103.7	-546.0	731.3	762.5	762.5
NOV	7928.	4000.	-303.0	-263.4	994.7	499.1	499.1
DEC	6266.	4000.	-100.0	0.0	994.7	499.1	499.1
JAN	6872.	4000.	-118.3	0.0	994.7	499.1	499.1
FEB	8116.	4000.	-471.1	0.0	994.7	499.1	499.1
MAR	11417.	4000.	-331.8	0.0	994.7	499.1	499.1
AP1	19401.	4000.	3.2	0.0	994.7	499.1	499.1
APR	23069.	4000.	44.2	263.4	731.3	762.5	762.5
MAY	56264.	4000.	848.1	268.3	463.0	1030.8	1030.8
JUN	30340.	4000.	563.0	463.0	0.0	1493.8	1493.8
JUL	9341.	4000.	0.0	0.0	0.0	1493.8	1493.8

SUB 1540.0 KAF
SLB 384.8 KAF

NOTES:
DEFICITS FOR MINIMUM RELEASE WERE NOT ACCUMULATED DURING PERIODS THAT PROJECT WAS AT SUB
UPSTREAM STORAGE WAS COMPUTED FROM BASE ECC FOR UP STREAM PROJECTS

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DEPLETION YEAR 1980

PERIOD	1931 FLOW CFS	MINIMUM RELEASE CFS	UPSTREAM STORAGE KAF	STORAGE CHANGE KAF	ACCUM. DRAFT (PERIOD - 31 JUL)	EOM CONTENT KAF	BASE-ECC KAF
AG1	108376.	30000.			3859.8	5247.6	9098.1
AUG	82661.	40000.	-152.7	1506.6	2353.3	6754.1	8953.3
SEP	57761.	40000.	-393.0	1449.9	903.4	8204.0	8953.3
OCT	33624.	59000.	-1928.8	368.5	534.9	8572.5	8953.3
NOV	28587.	53000.	-1987.6	534.9	0.0	9107.4	9107.4
DEC	21984.	59000.	-1699.4	0.0	0.0	9107.4 *	9107.4
JAN	23059.	90000.	-2947.5	-1057.0	1057.0	8050.4 *	8368.0
FEB	24932.	96682.	-1188.6	-2796.2	3853.2	5254.2	7882.6
MAR	29669.	70500.	-1396.4	-1114.2	4967.3	4140.1	5918.4
AP1	53633.	68400.	-221.2	-218.2	5185.5	3921.9	6413.5
APR	69272.	54700.	174.2	0.0	5185.5	3921.9	7386.9
MAY	198260.	123275.	3867.9	425.4	4760.1	4347.3	7264.6
JUN	210700.	41200.	6519.1	3566.8	1193.2	7914.2	9107.0
JUL	130941.	68500.	2646.1	1193.2	0.0	9107.4	9107.4

SUB 9107.4 KAF
SLB 3921.9 KAF

NOTES:
DEFICITS FOR MINIMUM RELEASE WERE NOT ACCUMULATED DURING PERIODS THAT PROJECT WAS AT SUB
UPSTREAM STORAGE WAS COMPUTED FROM BASE ECC FOR UP STREAM PROJECTS
"*" INDICATES THAT MINIMUM RELEASE COULD NOT BE SATISFIED