# Water Rights Analysis Package (WRAP) Modeling System Users Manual

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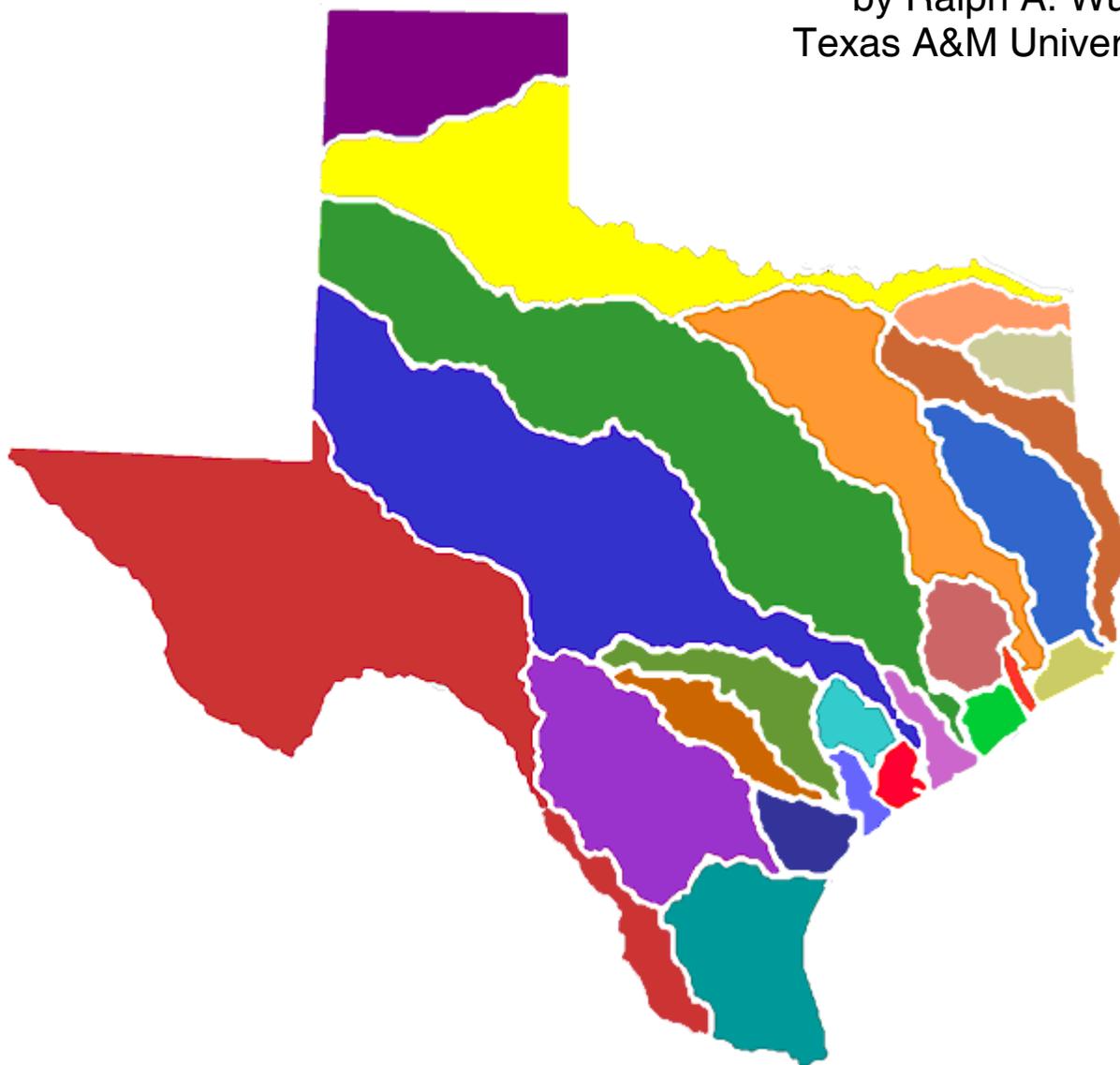
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# Water Rights Analysis Package (WRAP) Modeling System

# Users Manual

by

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Texas Commission on Environmental Quality
Austin, Texas 78711-3087

under

First Edition, August 2003
Second Edition, April 2005
Third Edition, September 2006
Fourth Edition, March 2008

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# WRAP MODELING SYSTEM

The Water Rights Analysis Package (WRAP) is documented by a *Reference Manual* and this *Users Manual*, a *Supplemental Manual* covering additional features, and an introductory *Fundamentals Manual*. The *Reference Manual* explains WRAP capabilities and methodologies. This *Users Manual* provides the operational logistics for applying the model by explaining the organization of input and output files and the content and format of input records. The *Supplemental Manual* documents additional expanded modeling capabilities incorporated in WRAP that are not covered in this basic *Users Manual* and companion *Reference Manual*.

## WRAP Programs

The software package documented by this *Users Manual* and accompanying *Reference Manual* includes the following programs.

*WinWRAP* is a user interface for applying the WRAP modeling system on personal computers with the Microsoft Windows operating system.

*SIM* simulates a river/reservoir water allocation/management/use system for input sequences of monthly naturalized flows and net evaporation rates.

*TABLES* develops frequency relationships, reliability indices, and various user-specified tables for organizing, summarizing, and displaying simulation results.

*HYD* assists in developing monthly naturalized stream flow and reservoir net evaporation less precipitation depth data for *SIM* hydrology input files.

The following programs are not covered in the basic *Reference* and *Users Manuals* but rather are documented by the *Supplemental Manual* covering expanded modeling capabilities.

*SIMD* is an expanded version of *SIM* with additional features for sub-monthly time steps, flow forecasting and routing, and flood control operations.

*DAY* assists in developing sub-monthly (daily) time step hydrology input for *SIMD* including disaggregating monthly flows to sub-monthly time intervals and determining routing parameters.

*SALT* reads a *SIM* or *SIMD* output file and a salinity input file and tracks salt constituents through the river/reservoir/water use system.

The Fortran programs are compiled and executed as separate individual programs, which are listed with the filenames for their executable files as follows.

| *Programs Covered in this Manual* | | *Covered in Supplemental Manual* | |
|---|---|---|---|
| *WRAP-SIM* | SIM.exe | *WRAP-SIMD* | SIMD.exe |
| *WRAP-HYD* | HYD.exe | *WRAP-DAY* | DAY.exe |
| *TABLES* | TAB.exe | *WRAP-SALT* | SALT.exe |
| *WinWRAP* | WinWRAP.exe | | |

*WinWRAP User Interface Program*

Each of the WRAP programs can be executed individually in Microsoft Windows, independently of *WinWRAP*. However, the *WinWRAP* interface facilitates running the WRAP programs within Microsoft Windows in an integrated manner along with use of Microsoft programs to access data files and *HEC-DSSVue* to graph simulation results. *WinWRAP* connects executable programs and data files. The WRAP programs (executable files) should be in the same folder as *WinWRAP*. Program *WinWRAP* can be activated with the conventional Windows options including a mouse click of the executable file, the run window, or a desktop shortcut icon. The other programs are executed from *WinWRAP*, with the user providing the filename root of the input and output data files. The *WinWRAP* menu structure provides the user the options shown in Table 1.1.

Table 1.1  WinWRAP User Interface

| WRAP Files | MS Programs | WRAP Programs | HEC-DSSVue | File Building Aids | Information |
|---|---|---|---|---|---|
| All Files | | | | | |
| All WRAP Files | DOS Editor | SIM-TAB | HEC-DSSVue | TABLES TIN File | WinWRAP Instructions |
| Main Input Files | NotePad | SALT-TAB | HEC Website | SIM DAT Template | WinWRAP Version |
| Main Output Files | WordPad | HYD | | HYD DAT Template | WRAP Documentation |
| Hydrology Files | Word | DAY | | | ------------------------- |
| Special Files | Excel | --------------- | | | TCEQ WAM |
| Message Files | | Terminate | | | TWRI |
| DAT Files | | | | | TAMU WRAP |
| SOU Files | | | | | |
| TIN Files | | | | | |
| TOU Files | | | | | |
| DSS Files | | | | | |

The *WRAP Files* and *MS Programs* pull-down menus in *WinWRAP* are used to activate NotePad, WordPad, Word, and Excel. These programs are distributed by the Microsoft Corporation with its Windows operating system and Office suite of software. WRAP has no graphics, and the *TABLES* TIN file editor is the only editing feature. The Microsoft programs are used to access and edit input and output files for the WRAP programs. Excel may be used to plot simulation results.

The *WRAP Files* pull-down menu provides access to data files through a Microsoft Windows window. Clicking or selecting/opening a data file activates the program such as WordPad or NotePad previously associated through Microsoft Windows with the extension of the file. The Windows operating system provides mechanisms described in Windows Help for designating the program associated with any particular file extension. An extension may be assigned to WordPad, Notepad, or other programs by selecting any file with that extension. A right mouse click or double left click activates a menu that includes an *open with* option that activates a dialog box containing a check-box indicating that the file extension is to always be associated with the selected program.

The *MS Programs* pull-down menu is designed for opening the Microsoft programs listed in Table 1.1. A mouse click or select/open button activates the selected program. WRAP data files can then be opened from the Microsoft program. However, the *WRAP Files* menu with pre-assigned filename extensions is a quicker way to edit WRAP data files with Microsoft programs.

The *WRAP Programs* pull-down menu is used to execute the WRAP programs. Clicking a program selection activates a dialog box through which the user enters the root of the filenames for

the input and output files. *TABLES* may be automatically executed along with *SIM*, *SIMD*, or *SALT*. Messages tracking the simulation are written to the monitor as the programs are executed.

*HEC-DSSVue* can be executed from the *HEC-DSSVue* pull-down menu or by clicking a DSS file assuming that the program has been loaded on the computer. Options in the WRAP programs write *SIM*, *SIMD*, and *SALT* simulation results as Hydrologic Engineering Center (HEC) Data Storage System (DSS) files, which can be read and plotted or otherwise manipulated by HEC-DSSVue. *WinWRAP* also provides a link to the Hydrologic Engineering Center website from which the HEC-DSSVue software and documentation are available for download.

The *File Building Aids* menu provides access to optional aids for use in creating input data files. An optional set of interactive dialog boxes may be used to create *TABLES* input files. Copies of text file templates may be accessed to help start the creation of input files for the other programs.

The *Information* menu is divided into two sets of information. The *WinWRAP Instructions*, *WinWRAP Version*, and *WRAP Documentation* selections provide instructions for using *WinWRAP*, the date of the version being used, and a list of the WRAP manuals. The *TCEQ WAM*, *TWRI*, and *TAMU WRAP* selections activate websites for The Texas Commission on Environmental Quality (TCEQ) Water Availability Modeling (WAM) System, Texas Water Resources Institute (TWRI), and latest WRAP software and documentation available at Texas A&M University (TAMU).

## WRAP-SIM Simulation Program

*WRAP-SIM* is a river/reservoir system water allocation simulation model that provides an accounting system for tracking river flow sequences, subject to reservoir storage capacities, net reservoir evaporation-precipitation and channel losses, and specified diversion, instream flow, and hydroelectric power requirements. Water balance computations are performed for each month of the hydrologic simulation period. Flexibility is provided for adaptation to a broad range of modeling approaches. Typically, a simulation will be based on the following premises.

- River basin hydrology is represented by historical sequences of naturalized stream flows and reservoir net evaporation less precipitation rates.

- Annual water use requirements, distributed over the 12 months of the year, are met as long as water is available from stream flow and/or reservoir storage. Water use targets may also vary as a function of storage or stream flow.

The *SIM* model simulates capabilities for meeting water management and use requirements (water rights) during a hypothetical repetition of historical natural hydrology. For example, a simulation might be concerned with assessing reliabilities in meeting a specified set of annual water use requirements (with seasonal variations over the 12 months of the year) during a repeat of historical hydrology represented by sequences of naturalized stream flows and reservoir net evaporation rates for each month of the 804-month 1940-2006 hydrologic period-of-analysis. The historical naturalized stream flows and net evaporation rates are assumed to be statistically representative of future river basin hydrology. The annual water supply diversions, environmental instream flow requirements, and hydroelectric energy demands have a specified seasonal distribution. They also may vary with reservoir storage content and/or stream flow.

Chapters 3 and 4 of the *Reference Manual* describe the component features of the *SIM* simulation model, which are organized in two categories.

- *River basin hydrology* includes naturalized river flows, reservoir net evaporation less precipitation, and channel losses (Chapter 3 of the *Reference Manual*).

- *Water rights* include all aspects of water resources development, allocation, use, and management including water supply diversions, return flows, environmental instream flow requirements, hydroelectric energy generation, reservoir storage, multiple-reservoir/river system operations, off-channel storage, and intrabasin and interbasin conveyance (Chapter 4 of the *Reference Manual*).

The model-user must create or obtain previously created files describing the hydrology and water rights for the river basin or region of concern. This *Users Manual* provides instructions for developing and modifying sets of records for the input files. Input files may be developed following the instructions provided in this manual using the previously cited Microsoft programs activated from *WinWRAP* or any other editor, spreadsheet, or other software.

## TABLES Post-Simulation Program

The program *TABLES* provides an array of tables and data tabulations in user-specified formats for organizing, summarizing, analyzing, and displaying simulation results from *SIM*, *SIMD*, and *SALT*. Many of the options provided by *TABLES* involve rearranging simulation results as (1) convenient tables in a text file for reports and analyses, (2) tabulations in a text file to be read by Microsoft Excel, or (3) records in a binary file to be read by HEC-DSSVue. *TABLES* also provides a variety of computational options for developing tables of water supply reliability indices and stream flow and reservoir storage frequency relationships. *TABLES* is covered in Chapter 5 of the *Reference Manual* and Chapter 4 of this *Users Manual*.

## WRAP-HYD Pre-Simulation Program

The program *WRAP-HYD* facilitates developing *SIM* hydrology input files. *HYD* is a set of computational options designed to provide assistance in developing sequences of monthly naturalized stream flows (*IN* records) and reservoir net evaporation-precipitation rates (*EV* records) for *SIM* input files. *HYD* output files are read by *SIM* as input files. *HYD* also includes options for reading and writing stream flow and evaporation-precipitation data as a DSS file or as columns in a table for transport from and to spreadsheet programs such as Microsoft Excel. *HYD* is covered in Chapters 3 and 6 of the *Reference Manual* and Chapter 5 of this *Users Manual*.

## Programs SIMD, DAY, and SALT

The WRAP programs *SIMD*, *DAY*, and *SALT* provide expanded modeling capabilities related to sub-monthly time steps, flow forecasting and routing, flood control operations, and salinity that are not covered in this *Users Manual*. The *SIMD*, *DAY*, and *SALT* programs are introduced in Chapter 1 of the *Reference Manual* and documented in detail in the *Supplemental Manual*. Conditional reliability modeling is also covered in the *Supplemental Manual*. *SIM* and *SIMD* provide the same simulation capabilities for conditional reliability modeling, with frequency and reliability analyses of simulation results being performed by routines in *TABLES*.

**Auxiliary Software**

The WRAP programs provide comprehensive computational capabilities but have no editing or graphics capabilities. The user's choice of auxiliary editing and graphics software may be adopted for use with WRAP. The only required auxiliary software is an editor such as Microsoft WordPad. However, WRAP modeling and analysis capabilities are enhanced by use of other supporting software for developing input datasets and plotting simulation results, such as Microsoft Excel, HEC-DSSVue, and ArcGIS.

The WRAP programs *SIM*, *SIMD*, *SALT* and *HYD* have options for storing hydrology data and simulation results as either text files or HEC-DSS binary files. The post-simulation program *TABLES* also includes options for writing the time series variables from the *SIM*, *SIMD*, or *SALT* simulation results as either text files or HEC-DSS files. The *TABLES* time series records described in Chapter 4 include options for writing *SIM* results in the following alternative formats.

1. A text file may be created that displays the simulation results in easy-to-read tables to be printed for analysis or exported to Microsoft Word for inclusion in a report.

2. A text file may be created that tabulates simulation results in columns for export to Microsoft Excel or other spreadsheet programs for plotting or other manipulations.

3. A HEC-DSS file may be created to be read by HEC-DSSVue for graphing time series plots or other data management or computation purposes.

*Microsoft Programs*

Programs distributed by the Microsoft Corporation with its Windows and Office Systems are routinely used on personal computers for an array of applications in offices and homes throughout the world. As previously discussed, Microsoft Excel, WordPad, Notepad, Word, and the DOS Editor may be activated directly from *WinWRAP* for use in editing WRAP input files and viewing simulation results. Excel provides both graphics and computational capabilities. *TABLES* has options for tabulating essentially any of the time series variables included in the *SIM*, *SIMD*, and *SALT* simulation results in a format designed to be conveniently read by Microsoft Excel for plotting or other purposes. Microsoft programs are described in detail by online documentation as well as by books published by Microsoft Press and other publishers.

*HEC-DSSVue*

The HEC-DSS (Data Storage System) is combined routinely with the widely-applied suite of generalized hydrologic, hydraulic, and water management simulation models developed by the Hydrologic Engineering Center (HEC) of the U.S. Army Corps of Engineers. HEC-DSS is used with other non-HEC modeling systems as well. The graphics and data management capabilities provided by the HEC-DSS are shared by multiple simulation models. The original development of the HEC-DSS by the Hydrologic Engineering Center dates back to 1979. The HEC-DSS Visual Utility Engine (HEC-DSSVue) is a recently developed graphical user interface program for viewing, editing, and manipulating data in HEC-DSS files. HEC-DSS references are cited in the WRAP *Reference Manual*. A Microsoft Excel add-in for data exchange with HEC-DSS is also available from the HEC.

HEC-DSSVue provides capabilities for graphical displays of WRAP simulation results and computational routines that may also be pertinent to analysis of WRAP simulation results. The public domain HEC-DSSVue software and documentation may be downloaded from the Hydrologic Engineering Center website:     http://www.hec.usace.army.mil/

A HEC-DSS file is a direct access binary file that can be read only by HEC-DSS software such as HEC-DSSVue. The WRAP programs are linked at compilation with a HECDSS library of routines allowing them to read input data and store simulation results as HEC-DSS files. HEC-DSS references data records by their pathnames, which consist of six parts in the format /A/B/C/D/E/F/. The pathnames for input and output are assigned automatically by the WRAP programs. The DSS pathnames for WRAP output files are in the following standard format.

A – filename root of output file
B – identifier of control point, water right, reservoir, or water right group
C – identifier of variable such as NAT, REG, STO
D – date of the beginning of the time series such as 01JAN1940
E – time interval = MON or YEAR for *SIM* results (*SIMD* includes sub-monthly.)
F – CP, WR, Res, or WRG (control point, water right, reservoir, water right group)

*ESRI ArcGIS*

As discussed in the *Reference Manual*, geographic information system (GIS) software such as ArcGIS is useful in dealing with spatial aspects of a river basin in compiling WRAP input data and displaying simulation results. The ArcGIS software system is marketed by the Environmental Systems Research Institute (http://www.esri.com). ArcGIS is described by online documentation as well as by manuals published by ESRI Press and other publishers.

Chapters 1 and 3 of the *Reference Manual* include a discussion of use of ArcGIS in developing WRAP input datasets including watershed parameters for distributing flows from gaged to ungaged locations and the identification of the control point located immediately downstream of each control point. As noted in *Reference Manual* Chapters 1 and 6, the *WRAP Display Tool* available from the TCEQ displays WRAP simulation results in ArcGIS. The tool is applied as a toolbar installed in ArcMap to display water supply reliabilities, flow and storage frequencies, and other percentage-based indices derived from *WRAP-SIM* simulation results by ranges as color coded symbols on a map. *SIM* time series output data can also be plotted. The *WRAP Display Tool* provides flexibility for customization as well as standardized display features.

**Input and Output Files**

The WRAP programs are generalized for application to any river/reservoir system, with input files being developed for the particular river basin of concern. The TCEQ WAM System includes datasets for all of the river basins of Texas. Application of WRAP in Texas typically involves modifying existing data files for a river basin of concern. Proposed water development projects and management strategies and changes in water use are added to the existing WAM System datasets to support particular studies and analyses. For applications outside of Texas where datasets have not been compiled, collecting data and creating input datasets for the river basin or region of concern represents the majority of the effort of a WRAP simulation study.

The model-user provides input data files.  Certain WRAP programs also create files that are read by other WRAP programs.  File management is handled automatically within the software.  Simulation results are written to files for analysis, incorporation into reports, or export to auxiliary programs for plotting or further manipulation, analysis, and display.  With the exception of the binary DSS files and optional binary *SIM* output file, all of the input files read or output files created by WRAP programs are ordinary text files that may be read by any editor and easily viewed.  The *SIM* output OUT file can optionally be either binary or text.

A simulation is performed with *SIM* using input files of water rights and hydrology data provided by the model user.  *HYD* outputs hydrology input files for *SIM*.  *TABLES* reads *SIM* output files and organizes the simulation results in optional formats specified in a *TABLES* input file.  The organized simulation results are written to a *TABLES* output file.  Likewise, application of *SIMD*, *DAY*, and *SALT* involve file creation and management.  The executable WRAP programs and data files are interfaced through *WinWRAP* within the Microsoft Windows operating system in combination with use of Microsoft programs to access and edit WRAP input and output files.

Table 1.2 is a complete listing of the different types of data files used by the WRAP programs.  Table 1.3 is a matrix of computer programs and input/output files.  Input and output files associated with *SIM* are discussed in Chapter 2 of this *Users Manual*.  *TABLES* and *HYD* files are covered in Chapters 4 and 5, respectively.  Files associated with the programs *SIMD*, *DAY*, and *SALT* and the conditional reliability modeling features of *SIM* are covered in the *Supplemental Manual*.  The corresponding *TABLES* input and output files associated with the expanded modeling capabilities are also discussed in detail in the *Supplemental Manual*.

Names of files are in the format *root.extension*.  The root is an arbitrary name assigned by the user.  The 3-character extension is a designation of the type of data contained in the files.  Extensions are set by naming conventions incorporated in the programs.  Programs and files are connected by *WinWRAP* with user-supplied filename roots when the programs are executed.  The filename root is specified by the model-user through the beginning-of-execution log-in procedures managed by *WinWRAP*.  Certain files used in a single execution must have the same filename root, and all of the files may have the same root.  Common or different filename roots may be assigned to files as follows:

- The same root (root1 = root2 = root3 = root4 in Table 1.2) may be used for the filename of all files associated with a particular simulation.  The filename extension differentiates the different types of data contained in the files.

- Assigning a different root (root2 in Table 1.2) for the hydrology files (FLO, EVA, HYD, DIS, FAD) may be convenient though not required in the common situation in which the hydrology files remain unchanged while the DAT file is varied in multiple simulations to reflect alternative plans or scenarios.

- Assigning different roots (root3 and root4) for *TABLES* input and output files may be convenient though not required.  Also, unlike all the other file types, *TABLES* output filenames optionally allow user-specified extensions other than the set standard.

- Program *HYD* is typically applied with the input and output files differentiated with different roots (root5 and root6 in Table 1.2)

Table 1.2  Input and Output Files
_____

### *SIM* and *SIMD* Input Files

root1.DAT    required main input file containing all input *dat*a, except the voluminous hydrology
             related data contained in the following files
root2.FLO    inflow *IN* records with naturalized stream *flo*ws (optional filename root.INF)
root2.EVA    *eva*poration *EV* records with net evaporation-precipitation rates
root2HYD.DSS   *hyd*rology DSS file with naturalized flows and evaporation-precipitation rates
root2.DIS    flow *dis*tribution *FD* and *FC* and watershed parameter *WP* records for transferring
             flows from the *IN* records to other control points
root2.HYD    *IN* and *EV* records provided in a single *hyd*rology file in modified format in lieu of the
             root.FLO and root.EVA files
root2.FAD    *f*low *ad*justment *FA* records for adjusting naturalized stream flows
root1.BES    *b*eginning and/or *e*nding *s*torage listing activated by *JO* record field 5
root2.DCF    *d*aily or other sub-monthly *c*ontrol point and *f*low data read by *SIMD*

### *SIM* and *SIMD* Output Files

root1.MSS    *m*ess*a*ges reporting simulation progress and input data errors
root1.OUT    main simulation results *out*put file read by *TABLES* and *SALT*
root1.SOU    main *s*imulation results *ou*tput file in columnar format
root1.DSS    simulation results output file in HEC-DSS (*d*ata *s*torage *s*ystem) binary format
root1.HRR    *h*ydropower and *r*eservoir *r*elease file read by *TABLES*
root1.YRO    *y*ield-*r*eliability *o*utput table presenting the results of a *FY*-record analysis
root1.CRM    *c*onditional *r*eliability *m*odeling simulation results read by *TABLES*
root1.ZZZ    changes in stream flow availability in water rights sequence activated by *ZZ* record
root1.BES    *b*eginning and/or *e*nding *s*torage listing activated by *JO* record field 5
root1.BRS    *b*eginning *r*eservoir *s*torage listing activated by *FO* record field 9 to provide beginning
             reservoir storage for program *SALT* and *TABLES 5CR2* record routines
root1.SUB    *SIMD s*u*b*-monthly time step simulation results
root1.AFF    *SIMD a*nnual *f*lood *f*requency file with annual series of peak flow and storage

### *SALT* Input Files

root2.SIN    required *s*alinity *in*put file with concentrations or loads of entering flows
root2.DAT    required main *SIM/SIMD* input file from which *CP* records are read
root2.OUT    required main *SIM/SIMD out*put file with simulation results
root2.BRS    *b*eginning *r*eservoir *s*torage file created by *SIM/SIMD* and read by *SALT* to provide
             beginning reservoir storage if specified by *JC* record field 8
root2.BRC    *b*eginning *r*eservoir *c*oncentration file created by *SALT* and also read by *SALT* as
             specified by *JC* record field 9

### *SALT* Output Files

root1.SAL    *sal*inity simulation results read by *TABLES*
root1.SMS    *s*alinity *me*s*s*age file with simulation trace, error and warning messages, and
             intermediate and summary simulation results tables
root1.BRC    *b*eginning *r*eservoir *c*oncentration file created and read by *SALT*
_____

Table 1.2  Input and Output Files (continued)
_____

### *TABLES* Input Files

| | |
|---|---|
| root3.TIN | required *TABLES in*put file with specifications regarding tables to be developed |
| root1.DAT | *SIM/SIMD* input DAT file |
| root1.OUT | *SIM/SIMD* output OUT file |
| root1.ZZZ | *SIM/SIMD* output ZZZ file |
| root1.HRR | *SIM/SIMD* output HRR file |
| root1.DIS | *SIM/SIMD* input DIS file |
| root1.AFF | *SIMD a*nnual *f*lood *f*requency output file with annual series of peak flow and storage |
| root1.CRM | *SIM/SIMD c*onditional *r*eliability *m*odeling output file |
| root1.SFF | *s*torage-*f*low-*f*requency file created by *5CR1* record and read by *5CR2* record |

### *TABLES* Output Files

| | |
|---|---|
| root4.TOU | *TABLES ou*tput file with the tables developed by the various routines (User-selected filename extensions may replace the default TOU.) |
| root4.TMS | *TABLES m*essage file with tracking the computations and reporting input data errors |
| root4.DSS | Hydrologic Engineering Center *D*ata *S*torage *S*ystem file read by *HEC-DSSVue* |
| root4.SFF | *s*torage-*f*low-*f*requency file created by *5CR1* record and read by *5CR2* |

### *HYD* Input Files

| | |
|---|---|
| root5.HIN | *H*YD file with all *in*put data not included in the following hydrology files |
| root5.FLO | inflow *IN* records with stream *flo*ws |
| root5.EVA | *eva*poration *EV* records with net evaporation-precipitation rates |
| root5.DIS | flow *dis*tribution *FD & FC* and watershed parameter *WP* records |
| root5.HYD | *IN* and *EV* records in single *hyd*rology file in modified format |
| root5.DSS | *D*ata *S*torage *S*ystem file of stream flows and evaporation-precipitation depths |

### *HYD* Output Files

| | |
|---|---|
| root6.HOT | file with all output not included in the following files |
| root6.HMS | *H*YD *m*essage file tracking the computations and reporting input data errors |
| root6.FLO | inflow *IN* records with naturalized stream *flo*ws |
| root6.EVA | *eva*poration *EV* records with net evaporation-precipitation rates |
| root6.DSS | *D*ata *S*torage *S*ystem file of stream flows and evaporation-precipitation depths |

### *DAY* Input Files

| | |
|---|---|
| root1.DIN | main *DAY in*put file |
| root1.FLO | input file of monthly *flo*ws in either *IN* record or columnar format |
| root1.DCF | input file of *d*aily *f*lows in either *DF* record or columnar format |

### *DAY* Output Files

| | |
|---|---|
| root2.DAY | *DAY* output file |
| root2.DMS | *DAY m*essage file |

_____

Table 1.3  Matrix of Input/Output Files and Programs

| File Name | File Function | WRAP Programs | | | | | |
|---|---|---|---|---|---|---|---|
| | | SIM | SIMD | SALT | TABLES | HYD | DAY |
| *Main Required Input File for Each Program* | | | | | | | |
| DAT | *SIM* and *SIMD* input data file | input | input | | | | |
| SIN | *SALT* input file | | | input | | | |
| TIN | *TABLES* input file | | | | input | | |
| HIN | *HYD* input file | | | | | input | |
| DIN | *DAY* input file | | | | | | input |
| *Hydrology Input Data* | | | | | | | |
| FLO | *IN* record naturalized flows | input | input | | | in & out | input |
| EVA | *EV* record net evaporation | input | input | | | in & out | |
| DSS | DSS file with flow and evap data | in & out | in & out | | | in & out | |
| DIS | flow distribution parameters | input | input | | | input | |
| HYD | hydrology *IN* and *EV* records | input | input | | | input | |
| FAD | flow adjustments | input | input | | | | |
| DCF | daily or sub-monthly flow data | | input | | | | input |
| *Main Simulation Results Output File for Each Program* | | | | | | | |
| OUT | *SIM* and *SIMD* main output file | output | output | input | input | input | |
| CRM | conditional reliability model file | output | output | | input | | |
| SOU | results in columnar tables | output | output | | | | |
| SUB | *SIMD* sub-monthly time step file | | output | | input | | |
| SAL | *SALT* main output file | | | output | input | | |
| TOU | *TABLES* main output file | | | | output | | |
| DSS | DSS file with simulation results | output | output | output | output | | |
| DAY | *DAY* main output file | | | | | | output |
| *Message File for Each Program* | | | | | | | |
| MSS | *SIM* and *SIMD* message file | output | output | | | | |
| SMS | *SALT* message file | | | output | | | |
| TMS | *TABLES* message file | | | | output | | |
| HMS | *HYD* message file | | | | | output | |
| DMS | *DAY* message file | | | | | | output |
| *Special Purpose Files* | | | | | | | |
| HRR | hydropower and reservoir release | output | output | | input | | |
| YRO | yield reliability output | output | output | | | | |
| ZZZ | priority sequence flows | output | | | input | | |
| BES | beginning/ending storage | in & out | | | | | |
| BRS | beginning reservoir storage | output | output | input | input | | |
| BRC | beginning reservoir concentration | | | in & out | | | |
| SFF | storage-flow-frequency array | | | | | in & out | |
| AFF | annual flood frequency | | output | | | input | |

## Format of Input Records

The system of file and record types is designed to create well-organized datasets that can be conveniently read and modified by human model-users as well as efficiently read/written and manipulated by computers. The WRAP structure for organizing files and records is designed for effectively managing datasets that cover the full spectrum from small and simple to extremely large and complex.

Files are composed of records or lines of data. The records contained in the input data files for the WRAP programs are organized by record type. A record identifier entered at the beginning of the input data record defines the type of record. The various input data record types for *SIM*, *TABLES*, and *HYD* are defined in Chapters 3, 4, and 5, respectively, of this manual. *SIM* and *HYD* input records begin with one of the two-character record identifiers listed in Tables 3.1 and 5.5. *TABLES* records begin with the four-character identifiers listed in Table 4.2.

Records are divided into fields. Tables found in Chapters 3, 4, and 5 define the data that is entered in each field. The tables in Chapters 3, 4, and 5 defining record fields describe the record format in terms of fixed-width fields. However, as indicated below, fields with integer (I) and real (F) numerical data formats may optionally be delimited with commas. The examples in the *Reference Manual* include comma-delineated as well as fixed-width records. However, essentially all actual applications of WRAP to date have used only the fixed-width format option. Either format is fine for the computer to read, but the fixed-width format is much easier for human model-users to read.

*Fixed Field Width Format*

Most fields on *SIM* and *HYD* input records with numeric data have a width of eight characters. Most *TABLES* TIN file record fields for numeric entries are four characters wide. Some of the alphanumeric entries such as control point and reservoir identifiers have six-character fields; others have 8-character fields. Water right identifies may contain up to 16 characters. Various fields also have other widths.

The Fortran format specifications found in the fourth column of the record description tables in Chapters 3, 4, and 5 are defined by the following examples of possible formats.

A6 − Alphanumeric label in a field that is 6 characters wide. A character variable with the format Aw is limited to a maximum of w characters (6 in this example).

2x − Skip two spaces. Fields with the spacing descriptor x are not read.

F8.0 − Real number in field of 8 characters with any number of digits to the right of the decimal. Either include decimal or right justify the number. Numbers ranging from −9999999 to 99999999 may include 72648.5, 0.00019, and −4172.85.

12F8.0 − Twelve real numbers, each having a F8.0 specification.

I8 − Integer number right justified in field of 8 characters. Decimal is not allowed.

3I8 − Three integer numbers with each right justified in field of 8 characters.

Variables with integer (I) format specifications should be right-justified in the appropriate field with no decimal.  Trailing blanks are read as zeros.  Real variables (F format) should either be right justified or include the decimal.  Input values for Fortran character variables (alphanumeric (A) specification) are normally right-justified in the appropriate field to preclude the problem of reading unwanted trailing blanks to the right of the identifiers.  However, the WRAP code automatically removes trailing blanks for most of the alphanumeric character input variables.  Thus, as long as the values are in the correct field, right-justification is not required.

As an example, the first *IN* record from Example 2 in *Reference Manual* Chapter 2 is reproduced below in the standard fixed-field width format (A2,A6,I4,I4,12F8.0).

```
IN  CP1    1954   10200    6540    3710    7350   15100     904     112     328     972    2650   17300    1290
```

*Optional Comma-Delimited Format*

Alternatively, this record could be written in comma-delineated format as follows.

```
IN   CP1,1954,10200,6540,3710,7350,15100,904,112,328,972,2650,17300,1290,
```

Note that the second field (CP1 in A6 format) can not be truncated with a comma since it has an alphanumeric A6 format.  A comma delimits the third field, which is blank in integer I4 format.  Both fixed-width and comma-delineated data may be combined in the same record as illustrated below.

```
IN   CP1    1954   10200  6540,3710,7350,15100, 904, 112,    328     972    2650   17300,1290,
```

Commas may be used only to truncate numeric (integer I and real F format) data, not character variables and spacing (A and X formats).  A comma may be used to shorten the width of a field, but the number of characters in a field may not exceed that specified in this manual.

**Units of Measure**

As discussed in the *Reference Manual*, the units adopted must be computationally consistent, but any units can be used.  Often in typical WRAP applications, all input is entered in consistent units without needing conversions within the model.  However, several input variables including multipliers entered on the *XL* record for *SIM* and *HYD* may be used as unit conversions.

Most of the input data are volumes, areas, or depths, including annual and monthly diversion volumes, volume per month stream flow rates, reservoir storage volume and surface area, and net evaporation-precipitation depths.  The various flows must have volume per month or per year units that are consistent with the reservoir storage volume units.  Net evaporation volumes are depths multiplied by reservoir water surface areas.  Typical English units requiring no conversion factors are acre-feet for storage volume and volume/month or volume/year quantities; acres for reservoir surface area; and feet for monthly net evaporation depths.  Typical consistent metric units are million cubic meters for reservoir storage and volume per month or year quantities; square kilometers for reservoir area; and meters for monthly evaporation rates.  Multipliers entered on the *XL* or *CP* records or elsewhere are used as needed to convert the input data to a consistent set of units.

**Period-of-Analysis and Time Step**

The hydrologic period-of-analysis (simulation period) may encompass any integer number of years. The minimum length is one year. There is no limit on the maximum length in years of the hydrologic period-of-analysis. The programs *SIM*, *HYD*, and *SALT* are limited to a monthly computational time step. The program *SIMD* (D for daily) allows each of the 12 months of the year to be divided into any number of intervals (computational time steps) with the default being the number of days in each month (28 or 29 days in February and 30 or 31 days in the other months).

*SIM* has no capabilities for forecasting future flows or routing flow adjustments across time steps, with the exception of the next-month return flow and hydropower release options. Forecasting and routing are not pertinent with a monthly time step but are significant with smaller time steps such as a day. *SIMD* looks forward over a user-defined forecast period, typically ranging from one day to perhaps as long as 30 days, in determining stream flows upon which to base diversion and reservoir operating decisions. *SIMD* uses routing methods to lag and attenuate flow adjustments moving spatially downstream and forward in time.

*SIM* and *SIMD* include the same routines for performing conditional reliability modeling (CRM) simulations, with the results being used by *TABLES* to perform frequency and reliability analyses. The default is a single long-term (non-CRM) simulation. The conditional reliability *CR* record activates the CRM mode of dividing the hydrologic period-of-analysis into multiple short-term hydrologic simulation sequences with each simulation beginning with the same storage condition. Conditional reliability modeling is described in the *Supplemental Manual.* This *Users Manual* and accompanying *Reference Manual* cover only the simulation mode in which the simulation is performed for the complete single hydrologic period-of-analysis.

**Dimension Limits, Memory Requirements, and Execution Times**

A *WRAP-SIM* or *SIMD* dataset may include any number of control points, water rights, reservoirs, and other system components. No limits are imposed on the number of *CP*, *WR*, and *IF* records and other types of records included in a dataset, except for those types for which there is never more than one record. Arrays in the Fortran code are dimensioned to reserve memory space. Dynamic dimensioning allows array sizes to be set automatically by the program based on information obtained from the input files. Thus, computer memory requirements are dependent on the size of the input dataset. Program *SIM* performs an initial reading of the DAT and DIS files during which certain records are counted and certain parameters read solely for purposes of setting dimension limits and determining which other input files to activate. *SIM* sets dimension limits for most arrays based on the information obtained from the initial reading of data files, but several minor dimension limits are fixed at specified sizes which are noted at appropriate places in this manual. *SIMD* allocates memory for variable arrays similarly to *SIM*.

*TABLES* and the other *WRAP* programs are structured somewhat differently than *SIM* and *SIMD*. However, all of the programs incorporate dynamic dimensioning to efficiently manage computer memory resources while imposing essentially no limits on the number of input records or system components incorporated into the datasets for particular river basins being modeled.

Computer memory requirements for the WRAP programs are generally modest but do vary greatly depending upon the size of the input dataset and selection of optional input and output file management features. Likewise, execution times are relatively minimal but can vary significantly depending largely on the same factors that influence memory requirements. Memory requirements and run times depend on the size of the input dataset, user choices regarding selection of simulation results to write to output files, and optional organization and formats of input and output files. Memory requirements and run times depend upon the number of control points, water rights, reservoirs, and other system components in the input dataset, organization of hydrology input files, simulation options, and the size and format of the simulation results output file.

Memory requirements are also highly dependent upon the organizational format of input and output files. The grouping of *IN* records (naturalized flows) and *EV* records (net evaporation depths) are specified in *JO* record field 2. With options based on grouping the hydrology input by year, *SIM* has only one year of naturalized flows and evaporation rates in memory at one time. With options based on grouping the hydrology input by control point, *SIM* stores in memory concurrently naturalized flows and evaporation rates for all years. Likewise, with the program *SIM* standard OUT output file, simulation results are written to the OUT file as computed, with minimal memory requirements. With DSS or SOU output files activated, the program *SIM* stores all simulation results in memory for writing to the DSS and/or SOU file at the completion of the simulation. Activation of the optional DSS and/or SOU output files results in a dramatic many-fold increase in memory requirements.

Run times for *SIM* and *TABLES* are typically small enough to be of no concern to model-users unless the input datasets are extremely large. Computer execution times can be more than doubled or reduced by greater than 50 percent depending on user specification of the number of control points, water rights, and reservoirs to include in the output file. Writing simulation results to the output file requires considerable computer time relative to performing the simulation computations. The larger Texas WAM System datasets have many hundreds of control points, water rights, and reservoirs. Although the actual simulation computations are not affected, execution times can be greatly reduced by limiting the output written to the output file. Run times for the Texas WAM System datasets on a typical desktop computer range from several seconds to several minutes. For the larger datasets, *SIM* run times of two to three minutes incurred with all of the many hundreds of control points, water rights, and reservoirs included in the output data written to the OUT, SOU, or DSS files may be reduced to a minute or less simply by limiting output to a smaller number of selected control points, water rights, and/or reservoirs of particular interest.

The *SIM* simulation results OUT and CRM output files can optionally be created as either a formatted text file or unformatted binary file as specified by *JD* record field 7. The unformatted binary file is read only with *TABLES*, not directly with editors such as WordPad. The size of the output file is significantly reduced and, for simulations with large amounts of output data, the execution time is significantly reduced by selecting the unformatted binary output file option.

The preceding discussion focuses on monthly time step *SIM* simulations. Daily time step *SIMD* simulations have significantly greater memory and execution time requirements. The strategies for reducing memory requirements and run times for *SIM* are also applicable to a daily time step *SIMD* simulation.

# CHAPTER 2
# WRAP-SIM FILES

Applying WRAP involves working with computer programs, data files, and data records. Input and output files for the program *SIM* are described in this chapter. The content and format of *SIM* input records are explained in Chapter 3. Chapters 2 and 3 cover all of the features of *SIM* except for the conditional reliability modeling capabilities covered in the *Supplemental Manual*.

## Types of Input and Output Files

The types of *SIM* input and output files are listed in Table 2.1. Filenames are in the format *root.ext* with a user-specified *root* and a standard extension *ext* denoting the type of file. The extensions shown in Table 2.1 are used by both the software and model-users to refer to the different file types. For example, an input file with a filename of root.DAT is called a DAT file.

Table 2.1
Types of Input and Output Files

---

*Standard Default Input Files Read by SIM*

| | | |
|---|---|---|
| DAT | all input data except the hydrology data | Required |
| FLO | inflow *IN* records with naturalized stream flows | *JO* record field 2 |
| EVA | evaporation *EV* records with net evaporation depths | *JO* record field 2 |

*Standard Default Output Files Created by SIM*

| | | |
|---|---|---|
| OUT | simulation results | default |
| MSS | messages | automatic |

*Additional Optional Input Files Read by SIM*

| | | |
|---|---|---|
| DIS | flow distribution watershed parameters | *CP* record fields 6&9 |
| FAD | *FA* record adjustments to naturalized flows | *JO* Record field 3 |
| BES | input/output file for beginning-ending storage options | *JO* Record field 5 |
| HYD | alternative to FLO and EVA hydrology files | *JO* Record field 2 |
| DSS | DSS file as alternative to FLO and EVA hydrology files | *JO* Record field 2 |

*Additional Optional Output Files Created by SIM*

| | | |
|---|---|---|
| SOU | simulation results in columnar format | *OF* Record |
| DSS | simulation results in DSS (data storage system) file | *OF* Record |
| YRO | yield-reliability table with firm yield | *FY* Record |
| ZZZ | stream flow availability in rights priority sequence | *ZZ* Record |
| HRR | hydropower production and reservoir releases | *JO* Record field 4 |
| BES | input/output file for beginning-ending storage options | *JO* Record field 5 |
| CRM | conditional reliability modeling simulation results | *CR* record |
| BRS | beginning reservoir storage used by *TABLES* conditional reliability modeling routine and program *SALT* | *JO* Record field 6 |

---

*Chapter 2 SIM Files*

*SIM* OUT and CRM output files may be created as either text files or binary files read only by *TABLES*.  HEC-DSS (Hydrologic Engineering Center Data Storage System) files are in a direct-access binary format accessed only by HEC-DSSVue, WRAP programs, or other programs specifically designed to interact with DSS files.  Otherwise, *SIM* input and output files are text files that can be read with any editor.  Files are automatically opened or activated by *SIM* in response to options specified on the *JD*, *JO*, and/or *OF* records or other input records in the DAT file.

The DAT input file (filename root.DAT) is the only absolutely required input file.  FLO and EVA files are standards that are typically used but are not mandatory.  The main simulation results are written to either an OUT, SOU, DSS, and/or CRM file.  A conditional reliability *CR* record in the DAT file activates a CRM output file.  Otherwise, the OUT file is created by default.  An output file *OF* input record allows creation of SOU and/or DSS files in addition to or in lieu of the default OUT file.  The other optional input and output files each serve a specific purpose.

## SIM Input Files

The files provided by the model-user as input for *SIM* are comprised of the records described in the next chapter.  All input other than the *IN*, *EV*, *FD*, *FC*, *WP,* and *FA* records are stored in the main *SIM* input file with filename extension DAT.  Optionally, the *IN* and *EV* records may also be included in the DAT file.  Since all data associated with the other input files are optional, the DAT file may contain all of the input records and is the only absolutely required *SIM* input file.  However, typically the voluminous naturalized streamflow inflow *IN* records and net evaporation *EV* records are stored in separate FLO and EVA files.  The parameters on *FD*, *FC*, and *WP* records for distributing naturalized flows from gaged to ungaged sites must be provided in a DIS file if flow distribution computations are performed.

FLO and EVA files (filename extensions FLO and EVA) are the defaults for storing the stream flow inflow *IN* and net evaporation-precipitation *EV* records.  Optionally, if specified in *JO* record field 2, the *IN* and *EV* records may be included in the DAT file.  *SIM* also includes an option for combining the *IN/EV* records in a HYD file (filename root.HYD) in a format developed for the original version of the model but now seldom used.  The extensions FLO and INF may be used interchangeably.  The earlier extension INF was later replaced with FLO.

The naturalized stream flow volumes and net evaporation-precipitation depths optionally may be input as a DSS file, with the filename rootHYD.DSS, instead of the default FLO and EVA files.  DSS files are in a binary format that can be read by *SIM* or *HEC-DSSVue* but not by most other editors.  The DSS hydrology input file option is activated by *JO* record field 2.

The flow distribution file with filename root.DIS contains the set of all *FD/FC* records followed by the set of all *WP* records.  These data are used in distributing naturalized stream flows from gaged (known flow) to ungaged (unknown flow) control points.  A DIS file is opened automatically if flow distribution options are specified on one or more *CP* records (fields 6 or 9) or if the net evaporation-precipitation adjustment option is activated by the *JD* record field 10 that require the input data supplied by a DIS file.

An optional naturalized stream flow adjustment file (extension FAD) contains flow adjustment *FA* records.  The flow adjustment feature is activated by field 3 of the *JO* record.

Beginning of simulation storage contents may be read from a BES file, and ending storages may be written to the BES file. The beginning-ending-storage file is the only file that is both written (output) and read (input) by *SIM*. A BES file is opened automatically if pertinent beginning-ending-storage options are activated by *JO* record field 5. The beginning reservoir storage (BRS) file activated by *JO* record field 6 provides the storage contents of each reservoir at the beginning of the simulation in a format used by program *SALT* and a *TABLES* CRM routine.

## SIM Output Files

The standard *SIM* simulation results are written by default to the OUT file. The same simulation results can be written to the DSS, SOU, and/or OUT files, with the only difference being format. Information to help locate errors and potential problems in the input data is written to the MSS file. Supplemental output related to multiple-reservoir system releases and hydroelectric energy generation is written to the optional HRR file. A ZZZ file activated by a ZZ record tabulates intermediate stream flows during the water rights priority loop. A yield-reliability and firm yield analysis option writes a table to an YRO output file. The beginning-ending-storage (BES) file is designed for starting a simulation with the storage contents from the end of a preceding simulation. The output files mentioned above store results from modeling capabilities covered in this manual. The conditional reliability modeling (CRM) and beginning reservoir storage (BRS) files are associated primarily with modeling features covered in the *Supplemental Manual*.

Program *TABLES* reads the *SIM* OUT, CRM, DAT, HRR, ZZZ, and BRS files, performs additional data manipulations and computations, and organizes the simulation results in user-specified tables. Additional computations, such as computing reliability and frequency statistics, are performed by *TABLES* in conjunction with organizing and analyzing the *SIM* simulation results. Program *TABLES* is described in Chapter 4. The main *SIM* simulation results OUT file and HRR file may be viewed by the model-user but normally are not. Rather the simulation results are organized and summarized by *TABLES*, and the model-user works with a *TABLES* output file. *TABLES* can also read an OUT file and convert the *SIM* simulation results to a DSS file either directly without change or after performing various arithmetic manipulations of the data.

HEC-DSSVue reads DSS files created by either *SIM* or *TABLES* in order to develop plots or perform various data manipulations. The MSS, SOU, and YRO files are viewed directly by the model-user with an editor such as Microsoft WordPad without using *TABLES* or HEC-DSSVue.

## Basic Simulation Results Output (OUT) File

The *SIM* OUT file (filename extension OUT) is created as a formatted text file by default, but can optionally be created as an unformatted binary file as specified by *JD* record field 7. The OUT and CRM files are the only files that can be written as unformatted binary files read only by *TABLES* rather than text files or DSS files. Unlike a text file, a binary OUT file can be read only by *TABLES* but is smaller and requires less computer time to write and read. The primary reason for an unformatted binary OUT file is to reduce memory requirements and execution time. Precision may also be optimized since numbers are stored in the same form as they are computed. The formatted text OUT file is created in a direct access format with line returns inserted differently than the other text files. Microsoft WordPad reads the OUT file line breaks fine, but NotePad does not.

The contents and organization of the OUT file are outlined in detail in *Reference Manual* Chapter 5. *TABLES* provides capabilities to organize, analyze, tabulate, summarize, and display *SIM* simulation results in a variety of formats. Although *TABLES* is usually used to organize the simulation results in the OUT file, the model-user may sometimes want to examine the OUT file directly to track simulation results, explore problems, or better understand the computations. Of course, in this case, the OUT file must be created as a text file.

The OUT file is designed to compactly store the voluminous output data in the order in which it is computed. Within each month of simulation results, output records for user-specified water rights are written first in priority order, followed by selected control point output records, followed by the records for selected reservoir/hydropower projects. The simulation results variables recorded on water right, control point, and reservoir/hydropower output records are listed in Table 2.2 below and precisely defined in Chapter 5 of the *Reference Manual*. Output records are all optional. As discussed later in this chapter, the model-user specifies in the DAT file which types of output records and which water rights, control points, and/or reservoir/hydropower projects to include in the OUT file.

Table 2.2
Variables in the *SIM* Simulation Results Output (OUT, SOU, DSS) Files

| *WR* Record Right | Instream Flow Right | Control Point | Reservoir/Hydropower |
|---|---|---|---|
| diversion or energy target | instream flow target | diversion target | energy generated |
| diversion/energy shortage | flow shortage | diversion shortage | energy shortage |
| reservoir storage volume | reservoir storage volume | reservoir storage volume | secondary energy |
| evap-precip volume | evap-precip volume | evap-precip volume | storage volume |
| available stream flow | available stream flow | unappropriated flow | evap-precip volume |
| stream flow depletion | stream flow depletion | stream flow depletion | evap-precip depth |
| reservoir releases | required reservoir release | naturalized flow | adjusted evap-prec depth |
| return flow | reservoir release | regulated flow | reservoir inflow |
| available flow increase | reservoir release shortage | reservoir releases | reservoir release |
| water right identifier | water right identifier | return flow | turbine flow |
| first group identifier | | channel loss | water surface elevation |
| second group identifier | | channel loss credit | reservoir identifier |
| | | control point identifier | |

Some variables are unique to either water right, control point, or reservoir/hydropower records. For example, naturalized, regulated, and unappropriated flows are associated only with control points. Other data are repeated on two or three of the record types. For example, reservoir storage and net evaporation are written to all three records. If one water right with one reservoir is located at a control point, reservoir storage will be identical on all three records. However, the control point records contain the summation of storage at all reservoirs assigned to the control point. Likewise, multiple water rights may be assigned to the same reservoir. Diversions and shortages on a control point record are the totals for all the diversion rights assigned to the control point. The diversions and shortages on a water right output record are associated with a single *WR* input record.

## Simulation Results Output (SOU and DSS) Files

The DSS and SOU files record identically the same simulation results as the OUT file but in different formats. The time series variables are listed in Table 2.2. The selection of control points, water rights, and reservoir/hydropower projects to include in the simulation results output is the same for either the OUT, DSS, or SOU files and is described later in this chapter. DSS and SOU files are activated by selections on the output files *OF* input record. All, none, or any combination of OUT, DSS, and SOU output files may be created with the *OF* record. The DSS file is in a direct access binary format designed to be read by HEC-DSSVue. The SOU file option tabulates the simulation results in columns designed for either direct viewing or export into Microsoft Excel.

## Message (MSS) File

The message files created by *SIM* and each of the other WRAP programs should be viewed routinely to ascertain that the input datasets are executing correctly and to be alerted to any irregularities. The *SIM* message file (filename extension MSS) provides trace messages tracking the progress of the simulation, error and warning messages, and various other miscellaneous information. The extent of trace information to be provided is specified by input variable *ICHECK* entered on the *JD* record. The message file contains the following information designed to facilitate locating errors or problems in the input data:

- trace messages that track the progress of model execution and reading of input data
- error messages noting missing or erroneous input records with run termination
- warning messages noting potential problems without stopping execution
- features to reproduce input records to track which records were successfully read
- miscellaneous information created by special options such as negative incremental flow adjustments or dual simulation stream flow depletions

Trace messages are written as the input records are read and thus may be used to locate problems if program execution is terminated prior to completion of the simulation. *SIM* includes a number of data check routines that write error messages and stop program execution. Other routines in the model write warning messages without terminating program execution. The use of messages written to the MSS file for locating errors is discussed further in Chapter 7 of the *Reference Manual*.

Various other types of information may also be recorded in the message file. Negative incremental stream flow options activated by the *JD* record result in negative incremental flows being written to the MSS file. Dual simulation options specified by the *SO* or *PX* record allow stream flow depletions to be written to the message file.

## Hydropower and Reservoir Release (HRR) File

The hydropower production and multiple-reservoir system release file (filename extension HRR) lists releases from primary and secondary reservoirs for each month of the simulation for each water right selected for output. The file also contains the energy target and amount of energy generated by each hydroelectric power right. The release from a primary reservoir is simply the

diversion met by the right. This amount may include water from stream flow depletions and water released from secondary reservoirs as well as water taken from storage in the primary reservoir.

For each month, the data for each water right in the HRR file is written as two records. The second record is simply a list of identifiers for each reservoir associated with the right. Each reservoir identifier is found immediately below the corresponding release amount. The first record for each right contains the following data in the order listed:

- water right or water right group identifier
- number of reservoirs associated with the right
- year and month
- energy target and energy generated
- reservoir releases listed in the same order as the *WS* records in the input file

The parameter *SYSOUT* from the *JO* record activates the HRR file and specifies the type of water right identifier to be included in the file. The water right identifier in the first field of a HRR file output record optionally is either the water right identifier from of *WR* record field 11 or *IF* record field 10 or a water right group identifier from *WR* record field 12 or 13. The HRR file consists of rows of data for each month of the simulation. The 4SWR and 4SGP records activate the only program *TABLES* routine that reads a HRR file. A *TABLES* 4SWR record lists the monthly releases for each reservoir as a column in a table for a particular water right. The 4SGP record develops a table with the same format as the 4SWR record with a column for each reservoir but aggregates the releases from a reservoir for multiple rights.

### Priority Sequence Stream Flow Availability (ZZZ) File

The *ZZ* record activates a *SIM* feature that builds a special table described in Chapter 6 of the *Reference Manual* that is stored in a ZZZ file (filename extension ZZZ). The regulated flow, available flow, and upstream reservoir release at one or more specified control points are tabulated as each water right is simulated in the water rights priority sequence. The feature is designed to facilitate assessments of the impacts of individual water rights on stream flow availability at specified locations. The ZZZ file tabulation can be viewed directly with any editor or read by *TABLES* and organized as either time series or frequency tables.

### Yield versus Reliability Output (YRO) File

The firm yield *FY* record activates a routine described in Chapter 6 of the *Reference Manual* to develop a table of annual yield versus reliability, which is written to the YRO file. In a conventional *SIM* simulation, an annual water supply diversion target or hydropower target is entered in the water right *WR* record as the input variable *AMT*. Model applications may require computing volume and period reliabilities for a range of different values for *AMT*. This may be accomplished simply by running *SIM* multiple times, manually changing the *AMT* entry in *WR* record field 3 for each run. The *FY* record option automates this procedure, with the model internally repeating the simulation multiple times with the annual target amount *AMT* being systematically changed for each simulation. The results also include the firm yield, defined as the maximum value of *AMT* that has a computed reliability of 100 percent. The firm yield is the last entry in the yield-reliability table written to the YRO file.

## Beginning-Ending Storage (BES) File

The beginning-ending storage (BES) options described in Chapter 6 of the *Reference Manual* and controlled by the BES parameter in *JO* record field 5 involve writing end-of-simulation storages to the BES file and/or reading initial storages from the same file. This is the only file that may serve as both a *SIM* input and *SIM* output file.

The BES file consists of three columns: integer reservoir identifier, alphanumeric reservoir identifier, and storage volume. A BES file written by *SIM* includes all reservoirs listed in the conventional order established when the DAT file was read. A BES file read by *SIM* may include any number of the reservoirs but they must be listed in the order of the numeric identifiers. The BES file may be manually edited to change storage amounts or delete/add reservoirs. A reservoir may be removed either by entering a −1 for its storage amount or by deleting its entry from the file. If a BES file is read, for any reservoirs not included in the BES file, beginning storages are set in *SIM* by *WS* record fields 3 and 8 in the conventional manner.

## Beginning Reservoir Storage (BRS) File

The beginning reservoir storage (BRS) file consists of a table listing all reservoirs with the following four columns: reservoir identifier, control point, storage capacity, and beginning-of-simulation storage content. The BRS file is activated by *JO* record field 6. Program *SALT* and a *TABLES* conditional reliability modeling routine, both described in the *Supplemental Manual*, have options to read beginning-of-simulation storage from a BRS file. The reservoir listing in the BRS file may also be useful for general information.

## Conditional Reliability Modeling (CRM) File

The conditional reliability modeling (CRM) file activated by a *CR* record is described in the *Supplemental Manual*. *SIM* creates either an OUT file or CRM file, but not both. The same simulation result variables are contained in either the OUT or CRM file. However, the CRM file reflects the subdivision of the hydrologic period-of-analysis into multiple sequences associated with conditional reliability modeling.

## Specification of Information to Include in the Simulation Results

*WRAP-SIM* simulation results are written to the OUT, SOU, and DSS output files in the form of the following three sets of output records, which are repeated for each month.

1. *WR* record water right and *IF* record instream flow right output records
2. control point output records
3. reservoir/hydropower project output records

Simulation result tables developed with *TABLES* are based on data in the *SIM* OUT output file. In organizing simulation results with *TABLES*, the term *all* control points, *all* water rights, or *all* reservoirs in *TABLES* refers to *all* those included in the *SIM* output OUT file. Most tables in *TABLES* also include options for selecting sets of individual rights, control points, or

reservoirs from those in the *SIM* output file. Thus, in organizing *SIM* simulation results with *TABLES*, selection of water rights, control points, and/or reservoir/hydropower projects to be included is controlled by *SIM* input parameters discussed below governing creation of the OUT file and by *TABLES* input parameters discussed in Chapter 4 governing reading the OUT file.

*SIM* output records may be provided for every water right, control point, and reservoir/hydropower project. However, simulation results may be extremely voluminous. The size of the output file and computer execution time may be reduced by including only selected data. The *SIM* input file includes information specifying which water rights, control points, and reservoir/hydropower projects are to be included in the main output OUT, DSS, and SOU files. The same water rights are included in the optional HRR output file.

*JD* record fields 5, 6, and 12 in combination with *WO*, *GO*, *CO*, and *RO* records are used to specify which water rights, control points, and reservoirs to include in the output file. The *JD* record may specify that all or none of the control points and/or water rights be included in the output file. Output records may be specified for any number of water rights, water right groups, control points, and/or reservoirs listed on *WO*, *GO*, *CO*, and *RO* records, respectively. To reduce file size and run times, only simulation results of actual interest should be recorded.

### *Reservoir/Hydropower Output Records*

The *RO* record provides the only means to specify reservoir/hydropower output records. The options are all, none, or those reservoir/hydropower projects listed on *RO* records. Variables included on reservoir/hydropower records are listed in Table 2.2. Storage and net evaporation-precipitation are recorded on control point and water rights records as well as on the reservoir/hydropower records. Energy production and shortage are included on both water rights and reservoir/hydropower records. In many typical applications, in order to reduce computer run time and file size, reservoir/hydropower records will not be included in the output file if all the information of interest is available on water right and/or control point output records.

### *Control Point Output Records*

The following alternative methods are provided for specifying which control point records to include in the simulation results.

- The *JD* record field 5 allows selection of either the *none* or *all* options. If a −1 is entered in field 5, all control points will be output. If field 5 is blank or zero and there is no *CO* record, no control point is output.

- The *JD* record field 5 also allows output of just those control points for which *INMETHOD* in field 6 of the *CP* record is 0, 1, or 2 to be output. These are primary control points for which naturalized stream flows are entered on *IN* records rather than being synthesized. A −2 in field 5 activates this option.

- The *JD* record field 5 also allows the first any number of control points in the input file to be selected. For example, entering the integer 125 in field 5 of the

*JD* record results in output records for the first 125 control points in the order that the *CP* records are found in the *SIM* input file.

- Control points listed on the *CO* record are included in the output along with those that may be specified by the *JD* record. *CO* records may be used alone (blank field 5 on *JD* record) or in combination with two of the *JD* field 5 options.

*Water Right Output Records*

As indicated by Table 2.2, the water right and control point output records include the following variables in common: diversion shortage, diversion target, evaporation-precipitation volume, storage, and stream flow depletion. The values for these variables on the control point output record reflect the summation for all rights at that control point. If only one water right is assigned to a particular control point, the values for these variables will be the same on the water right versus control point output records. Other variables pertain to either a water right or a control point but not both. Water right, control point, and reservoir/hydropower output records all contain reservoir storage and net evaporation-precipitation volumes. Storage is refilled in priority order by any number of water rights associated with the same reservoir. The reservoir storage and net evaporation-precipitation volumes on the water right record are those amounts associated with that particular water right.

The following methods are provided for selecting the water rights to include in the simulation results.

- *JD* record field 6 allows selection of either no rights, all rights, all *WR* record rights excluding hydropower rights, all hydropower rights, or all instream flow rights.

- *JD* record field 6 also allows the first any number of water rights in the input file to be selected. For example, entering the integer 125 in *JD* record field 6 results in output records for the first 125 water rights in the order that the *WR* records are entered in the *SIM* input file.

- *WO* records are used to list the 16-character water right identifiers found in field 11 or alternate field 14 of the *WR* records or field 10 of the *IF* records. All rights with the identifiers listed on the *WO* records are output in addition to any that may be specified by the *JD* record as noted above.

- Group output *GO* records are used to list the 8-character water right group identifier found in fields 12 and 13 or alternate fields 15 and 16 of the *WR* record. All rights with the identifiers listed on *GO* records are output as well as those listed on *WO* records or specified by the *JD* record.

*Water Right Identifiers*

A *WR*-record water right may have a water right identifier with a length of up to 16 characters and two group identifiers not exceeding 8 characters each. *IF* records allow only the 16-character water right identifiers, not the group identifiers. The 16-character water right

identifier is unique to each water right.  If the same 16-character identifier is entered on more than one *WR* or *IF* record, this identifier is ignored on the second and subsequent records.  Any number of rights may have the same 8-character group identifier.  The purpose of the group identifiers is to associate multiple rights together as a group.  Unless specifically referenced by other records, water rights are not required to have identifiers.  Identifier fields on *WR* and *IF* records may be left blank.  Any, all, or none of the identifier fields may be used for any right.

Two alternative sets of three water rights identifiers may be included in the last six fields of the *WR* records (fields 11, 12, 13 and alternate fields 14, 15, 16).  Only one of the two sets is read in a single execution of *SIM*.  Input variable *IDSET* in *JD* record field 12 specifies whether the first or second set of three identifiers on the *WR* records is adopted in a particular model run.

Water right identifiers are used within the *SIM* simulation in selecting output and to reference rights for the firm yield *FY*, target options *TO*, and backup right *BU* record features.  Control point identifiers are used much more extensively in the model computations to assign locations to various system features and otherwise define the spatial connectivity of the system.

The water right identifier fields on the *WR*, *IF* and other records do not have to be right or left justified as long as the identifier stays within the specified field.  The program automatically removes trailing blanks, thus internally treating the identifiers like they were right justified.

Water right identifiers serve to identify rights in input and output files and tables created by *TABLES*.  *TABLES* also includes options to aggregate the data associated with all rights with the same group identifier.  The diversion targets, shortages, diversions, stream flow depletions, reservoir storage contents, and evaporation-precipitation volumes included in the output records for all water rights with the same group identifier in fields 12 and 13 or alternate fields 15 and 16 of the *WR* records may be summed within *TABLES* to obtain a set of aggregated total values.

For grouping purposes, all water rights with the same identifier in either of the two group identifier fields (second or third identifiers with up to 8 characters) compose a group.  The group identifiers serve three different purposes as follows.

1.  All rights with an identifier listed on the *WO* record or *GO* record will be included in the *SIM* simulation results output file.  Thus, multiple rights may be selected for inclusion in the output by including the same group identifier on each pertinent *WR* record and once on a *GO* record.

2.  Program *TABLES* can read a *SIM* output file and create tables for either individual rights or for the summation of values for all rights with the same group identifier.  For example, a table of diversion shortages (or stream flow depletions, etc) would show the total diversion shortage in each month for all rights with the same group identifier.

3.  The identifiers also allow the model-user to simply label the rights for general information.  Various naming schemes may be devised to use the set of identifiers to label and organize the rights by various categories.

**Locating Errors in the Input Data Files**

All of the WRAP programs contain similar features for detecting missing and erroneous records in the input files, which are described in Chapter 7 of the *Reference Manual*. Routines in *SIM* and the other programs facilitate finding many types of errors that violate format rules or result in detectable inconsistencies. These features include:

- trace messages tracking model progress in reading input and performing the simulation
- error messages accompanied by termination of model execution
- warning messages alerting users to possible peculiarities without stopping execution

Trace messages are written to the monitor tracking the progress of the *SIM* simulation. Other trace messages focused more on progress in reading input data are recorded in the message file (filename extension MSS). Warning and error messages are also written to the MSS file.

Routines incorporated in *SIM* for detecting input data inconsistencies and irregularities and associated warning and error messages are described in Chapter 7 of the *Reference Manual*. Error messages are written to the monitor and MSS file and program execution is terminated if definite problems are encountered in reading input data or performing the simulation computations. Warning messages are recorded in the MSS file without terminating program execution to alert the model-user to possible irregularities in the input data. Warning messages signal potential concerns that may or may not actually be problems. Message files generated by *SIM* and the other WRAP programs should be routinely reviewed to trace the simulation and view warning messages even if the program executes normally without premature termination.

Numerous different error and warning messages are possible. Most of the messages are generated by problems detected by the program while reading input data files, though various checks incorporated in the simulation computation routines also may generate error and warning messages. The messages are usually self-explanatory, but the *Reference Manual* Chapter 7 may be consulted as needed to better understand and respond to the messages.

Optional levels of information recorded in the *SIM* message MSS file for checking input data are specified by variable *ICHECK* in field 4 of the *JD* record and listed in Table 2.3. An *ICHECK* of 0 or 1 is usually adopted. An *ICHECK* of 1 activates all error and warning checks. Most warning message checks and several of the error checking routines requiring the most computer time are in effect only if *ICHECK* is 1. Deactivating the checking routines will reduce execution times slightly and may greatly reduce the size of the message file. After a number of runs of *SIM* with a particular dataset repeatedly generating a long list of warning messages, the model-user may prefer to deactivate the warning messages by switching *ICHECK* to 0.

If program execution is terminated prior to normal completion, the error message will usually provide sufficient information to identify the problem without needing to resort to the *ICHECK* options 2 through 7 activated by *JD* record field 4. However, options 2−7 discussed in *Reference Manual* Chapter 7 are sometimes useful in locating an erroneous input record. *ICHECK* option 8 writes information to the MSS file that is developed by routines activated by the *PX* record. *ICHECK* option 10 outlines the hydrologic sequences generated by a conditional reliability record, which are explained in Chapter 2 of the *Supplemental Manual*.

Table 2.3
Information Recorded in Message File for Various Values of ICHECK

---

ICHECK = 0    Trace messages are written to the MSS file.  Some error detection
              routines and most of the warning messages are deactivated.
ICHECK = 1    Trace messages and all error and warning routines are in effect.
ICHECK = 2    Trace messages plus all *UC* and *RF* records are written as read.
ICHECK = 3    Trace messages plus all *CP* records are written as read.
ICHECK = 4    Trace messages plus all *WR* and *IF* records are written as read.
ICHECK = 5    Trace messages plus all *SV* and *SA* records are written as read.
ICHECK = 6    Trace messages plus all *IN* and *EV* records are written as read.
ICHECK = 7    Trace messages plus all *FD*, *FC*, and *WP* records written as read.
ICHECK = 8    Trace messages plus all dual simulation information.
ICHECK = 9    Trace messages and most error checks are in effect but most of
              the warning messages are deactivated.
ICHECK = 10   Trace written to MSS file for conditional reliability modeling showing the
              sub-division of the hydrologic period-of-analysis into multiple sequences.

---

## Locating Errors in the SIM Output File

The content and format of the output records are defined in Tables 5.1 through 5.5 and accompanying narrative in Chapter 5 the *Reference Manual*.  Essentially all of the monthly time series variables computed by *SIM* can be written to the OUT file and examined to track the computations.  Water right output records are written to the OUT file as each water right is considered in priority order.  Control point and reservoir/hydropower output records are written to the OUT file for each month at the end of the water right priority loop.  The OUT file in text format may be read with Microsoft WordPad to track simulation results, including locating the last numbers computed prior to termination of the simulation.  If program execution is completed without an early termination, the SOU file provides an alternative easier-to-read organization of simulation results but does not directly trace the sequence of the computations.

After a *SIM* input dataset has been successfully debugged, irregularities in the *SIM* output OUT file should be rare.  However, program *TABLES* includes a routine activated by the TEST record that performs a series of checks on a *SIM* output OUT file.  The TEST option in *TABLES* is designed for use in the extremely unusual situation in which *TABLES* can not read an OUT file from an apparently successful *SIM* simulation.  The TEST record is included in Chapter 4 of this *Users Manual* along with the other *TABLES* input records.  The tests activated by the TEST record are described in Chapter 7 of the *Reference Manual*.  The tests are applicable only for an OUT file written in the default text file format, not the optional binary machine language form of OUT file activated by *JD* record field 7.

## CHAPTER 3
## WRAP-SIM INPUT RECORDS

The system for organizing *SIM* input datasets is based on file types, record types, and fields in each record. Input files are comprised of a set of required and optional records controlling various simulation options and representing the river/reservoir/rights system being modeled. The input record types are labeled by a two-character identifier that is placed at the beginning of each record. File types, record types, and associated record identifiers provide a system for organizing input datasets. The content and format of each type of *SIM* input record are described by this chapter. Example datasets are presented in the *Reference* and *Fundamentals Manuals*.

### Types of Input Records

The record types are listed in Table 3.1. One each of five types of records (*JD, ED, CP, WR* or *IF*, and *IN*) are required. The other records are optional. Various fields on most records are either optional or have default values and thus may be left blank in many applications. Many typical applications will require only fundamental *SIM* capabilities using less than a third of the 54 available record types. Other records are adopted to activate modeling options for various more complex or unusual water management situations. Ingenuity is applied in combining options activated by the different records to model unique situations. The system of record types is designed to create comprehensible, documented datasets that can be conveniently reviewed and modified by model-users as well as efficiently executed by the computer.

The *T1, T2, T3, JD, JO, OF, XL, CR, ZZ*, and *FY* records, if used, are included only once at the beginning of the DAT file. The other record types may be repeatedly used numerous times in a dataset. For example, a *CP* record is required for every control point, a *WR* or *IF* record is required for every water right, and at least one *WS* record is required for every reservoir. The total number of records contained in input files for typical river basin modeling applications range from less than a hundred to many thousands.

The record types are briefly described as follows. The sequential order of records and data contained in each field of each record are explained later in this chapter.

### *Records in the DAT File*

*Title **T1**, **T2**, and **T3** Records*.- The DAT input file begins with a required *T1* record followed by optional *T2* and *T3* records. The titles or headings provided on the title records are reproduced at the beginning of the main output file created by *SIM* and on the cover page created by *TABLES*. The title records may contain any descriptive information.

*Comment ** Record*.- Comment records beginning with a double asterisk may be entered almost anywhere within the input data. The comments are notes written by the model-user for information only and are not read (other than the ** identifier) or used in any way by the program. Notes are very useful in documenting a dataset. The ** is also routinely used to deactivate records without actually deleting them. Various records may be activated or deactivated in alternative simulation runs by adding or deleting the **.

Table 3.1
Types of SIM Input Records

_____

Basic Input File  (filename extension DAT)

*Records for organizing the simulation*

T1, T2, T3 *T*itles or headings at the beginning of the file that are reproduced in the output
**            comments or notes not read by the computer that may be inserted throughout
JD, JO    *J*ob control *D*ata for simulation and *J*ob *O*ptions switches for various features
CR        activation switch and specifications for *C*onditional *R*eliability modeling
OF        optional *O*utput *F*iles
XL        multiplication factors and parameter *L*imits
ZZ        special feature for tracking stream flow availability in water rights priority sequence
FY        *F*irm *Y*ield and yield-reliability table
WO, GO, CO, RO   *W*ater right, *G*roup, *C*ontrol point and *R*eservoir/hydropower *O*utput
ED        *E*nd of *D*ata

*Records for defining control point connectivity and providing information for each control point*

CP    *C*ontrol *P*oint connectivity and naturalized flow, evaporation, and channel loss data
CI    *C*onstant *In*flows or outflows entering or leaving system at a control point

*Records for entering water rights information*

UC    monthly water *U*se distribution *C*oefficients
UP    water *U*se type *P*riority adjustment factors
RF    monthly *R*eturn *F*low factors
WR    *W*ater *R*ight requirements
IF    *I*nstream *F*low requirements
SO    *S*upplemental water right *O*ptions
ML    *M*onthly *L*imits on stream flow depletions
BU    *B*ack*u*p water right
TO    *T*arget *O*ptions
FS    *F*low *S*witch for adjusting targets based on stream flow
TS/TSR   *T*arget *S*eries and *T*arget *S*eries *R*epeat
PX/AX   *P*riority sequence circumvention options
WS    *W*ater right reservoir *S*torage
HP    *H*ydroelectric *P*ower parameters
OR    *O*perating *R*ules for secondary reservoirs in a multiple-reservoir system
DI    *D*rought *I*ndex reservoirs
IS/IP drought *I*ndex *S*torage volumes (*IS* record) versus *P*ercentages (*IP* record) table
EA/EF/AF  *E*vaporation and flow *A*llocation options for reservoirs shared by multiple entities

*Records for describing additional characteristics of reservoirs*

SV/SA    *S*torage *V*olume (*SV* record) versus *S*urface *A*rea (*SA* record) table
PV/PE    *S*torage *V*olume (*PV* record) versus *E*levation (*PE* record) table for hydropower
TQ/TE    *T*ailwater discharge (*TQ* record) versus Elevation (*TE* record) table for hydropower
MS    *M*onthly varying *S*torage capacity defining seasonal rule curve operations

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Table 3.1 (Continued)
Types of SIM Input Records

_____

Hydrology Files  (filename extensions FLO, EVA, DIS, FAD)

IN    *IN*flows to the system (naturalized stream flows)
EV    *EV*vaporation (reservoir net evaporation-precipitation depths)

Flow Distribution File  (filename extension DIS)

FD    *F*low *D*istribution specifications for transferring flows from gaged to ungaged sites
FC    *F*low distribution *C*oefficients for certain flow distribution options
WP    *W*atershed *P*arameters used in the flow distribution computations
ED    *E*nd of *D*ata

Flow Adjustment File  (filename extension FAD)

FA    *F*low *A*djustments to be added to the stream flows

_____


*Job Control Data **JD** and Job Options **JO** Records*.-  General information controlling the simulation include the hydrologic period-of-analysis and parameters for several *SIM* computational features including negative incremental inflow options, system reservoir release decision options, beginning-ending storage options, and the natural priority option.  Switches are provided for input and output options and input error checking.

*Conditional Reliability **CR** Record*.-  The *CR* record activates the conditional reliability modeling simulation mode that is described in the *Supplemental Manual*.

*Optional Output Files **OF** Record*.-  The *OF* record activates the DSS and SOU output files.  The same simulation results are recorded in either a DSS, SOU, or OUT file but in different formats.

*Multiplication Factors and Parameter Limits **XL** Record*.-  The *XL* record includes multiplier factors used primarily for unit conversions, a set of limits on watershed parameters used in the NRCS CN method for transferring naturalized flows, and a limit for a warning message associated with a net evaporation-precipitation adjustment option.

*Flows in Water Rights Priority Sequence **ZZ** Record*.-  A table of regulated and available stream flows at specified control points after each water right in the simulation is created in a *ZZZ* file.

*Firm Yield and Yield-Reliability Table **FY** Record*.-  The *FY* record activates an iterative simulation routine for creating a yield-reliability table that includes the firm yield.

*Output Specification **CO, WO, GO, RO** Records*.-  *SIM* OUT file output records are of three types: control point, water right, and reservoir/hydropower.  The *JD* record and *CO*, *WO*, *GO*, and *RO* records control the selection of control points, water rights, groups of water rights, and reservoir/hydropower projects to include in the output.  Simulation results may be extremely voluminous.  The output selection options allow the size of the output file to be controlled.

Table 3.2
Input Records Associated with Component Features of SIM

_____

### *Organization of the Simulation*

| | |
|---|---|
| file activation | JO fields 2, 3, 4, 5, 6, OF |
| output control | WO, GO, CO, RO, JD, OF |
| simulation period | JD fields 2, 3 |
| error checks | JD field 4 |
| unit conversion factors | XL, CP fields 4, 5, WP field 6 |
| firm yield and yield-reliability analyses | FY |
| conditional reliability modeling | CR |
| comments and record deactivation | ** |
| end of dataset | ED |

### *Hydrology Features (Chapter 3 of Reference Manual)*

| | |
|---|---|
| naturalized stream flows | IN, JO field2, CP fields 4, 6, 7 |
| net reservoir evaporation-precipitation | EV, JO field2, CP fields 5, 8 |
| net evaporation-precipitation adjustment | FD, WP, CP 9, JD 10 |
| stream flow distribution to ungaged sites | FD, FC, WP, CP fields 6, 7, 11 |
| stream flow adjustments | FA, JO field 3 |
| channel losses | CP field 10 |
| watershed flow option | SO field 2 |
| negative incremental stream flow options | JD fields 8, 9 |

### *Water Management Features (Chapter 4 of Reference Manual)*

| | |
|---|---|
| water supply diversions and return flows | WR, UC, SO, PX, TO, RF, ML, TS |
| instream flow requirements | IF, UC, WS, TO, FS, SO, TS |
| hydroelectric power | WR, HP, UC, PV, PE, TQ, TE, XL |
| setting water use targets | WR, UC, DI, TO, FS, SO, TS |
| drought index | DI, IS, IP |
| water right priorities | WR, IF, UP, JO field 8 |
| flow allocation for rights with same priority | PX, AX, AF |
| circumvention of priority sequence | PX |
| reservoir storage | WS, SV, SA, PV, PE |
| reservoir system operating rules | WS, OR, MS, SO |
| monthly varying limits on storage capacity | MS |
| multiple owners of reservoir storage | WR, WS, EA, EF, AF |
| limits on stream flow depletions | ML, SO fields 3, 4 |
| limits on withdrawals from reservoir storage | SO fields 7, 8 |
| stream flow depletions from multiple locations | SO field 5 |
| constant inflows and outflows | CI, FA |
| backup right | BU |

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*Use Coefficient **UC** Record*.-  Sets of 12 factors associated with water use types are used to distribute annual diversion, energy generation, or instream flow requirements over the 12 months of the year.  The types of water use may be associated with particular uses, such as irrigation, municipal, and industrial water supply, or hydroelectric energy, or otherwise represent different distributions of annual requirements over the year.  *SIM* sums the 12 factors and divides each by the total to transform them to decimal fractions summing to unity.

*Use Priority **UP** Record*.-  Water right priorities entered on *WR* and *IF* records for a particular water use type can be replaced or adjusted by factors entered on a *UP* record.  Diversion, instream flow, or hydropower targets on *WR* or *IF* records may also be adjusted by a multiplier from a *UP* record.

*Monthly Return Flow **RF** Record*.-  One of the options for specifying return flows allows sets of 12 monthly return flow multipliers to be specified on *RF* records.  With this option, the portion of a diversion returned to the stream is computed within *SIM* by multiplying the diversion amount by the monthly return flow factor from the appropriate *RF* record.

*Control Point **CP** Record*.-  A *CP* record is required for each control point.  This record contains the six-character alpha-numeric identifier of the control point, the identifier of the next control point located immediately downstream, information related to sources of naturalized stream flow and net evaporation-precipitation rate data for the control point, and the channel loss factor for the river reach below the control point.  The location of all system components is based on entering control point identifiers on various records that reference back to the spatial configuration defined by the control points and next downstream control points listed on the *CP* records.

*Constant Inflows **CI** Record*.-  A set of 12 monthly inflows or outflows may be entered on a *CI* record.  For each year of the simulation, the constant flows are added to the naturalized flows at the control point designated on the *CI* record and at all downstream control points.  Any number of CI records may be assigned to a control point.  The *CI* record flows could represent return flows from water users supplied from groundwater, diversions from or to the control point not otherwise reflected in the water rights, or losses not otherwise reflected in channel loss factors.

*Water Right **WR** Record*.-  In *SIM*, a water right is defined as a *WR* or *IF* record with associated attached records with supplemental information.  Although an actual water right permit may be represented by a set of several *WR* records, in *WRAP* nomenclature, each *WR* or *IF* record is a water right and each right has one *WR* record or *IF* record.  The *WR* record contains the water right identification, control point location, annual permitted diversion or energy generation amount, use type (connection to *UC* records) for distributing the annual target over 12 months, priority number, type of right (connection to rules for meeting targets), drought index identifier (connection to *DI* record), and return flow specifications.  *WS*, *HP*, *OR*, *SO*, *TO*, *FS*, *TS*, and *PX* records attached to a *WR* or *IF* record provide optional additional information regarding the right.

*Instream Flow **IF** Record*.-  The *IF* record is similar to the *WR* record, except a instream flow target is entered rather than a diversion target, and several of the *WR* record fields are not applicable. *WS*, *UC*, *UP*, *DI*, *TO*, *FS*, and *TS* records are used the same with either *IF* or *WR* records.  The minimum instream flow target restricts the amount of water available to junior rights.  Any number of *IF* records may be assigned to a control point, changing the minimum flow target and priority.

*Supplemental Options SO Record*.-  *WR* and *IF* record water right requirements may be supplemented by additional information provided on a *SO* record.  Monthly, seasonal, and annual limits may be placed on stream flow depletions, diversions, and the amount of water that may be withdrawn from reservoir storage.  An alternate control point location for making stream flow depletions may be specified.  Intermediate targets to include in the output file may be selected. Certain options may be excluded from particular water rights.

*Monthly-Varying Limits on Stream flow Depletions ML Record*.-  Stream flow depletions for diversions and refilling storage, associated with a water right *WR* record, are constrained by these maximum allowable limits in each month.  A constant limit may be entered on the *SO* record.

*Backup BU Right*.-  The shortages incurred by one or more other water rights may be added to the diversion, minimum instream flow, or hydropower target of a right designated as a backup right by a *BU* record in the set of supporting records following its *WR* or *IF* record.  Shortages may be split between backup rights.  Backup rights may backup other backup rights.

*Target Options TO Record*.-  Diversion and instream flow targets may be defined as a function of reservoir drawdown and/or naturalized, regulated, and/or unappropriated stream flows at multiple locations using *TO* records.  Maximum and minimum limits may also be imposed.

*Flow Switch FS Record*.-  Instream flow, diversion, and hydropower targets may be switched on and off or otherwise adjusted as a function of whether or not the total regulated, naturalized, or available flow, stream flow depletion, or diversion volume during the current time period and/or accumulated during any specified number of preceding periods fall within a defined range.

*Target Series TS and Repeat Series TSR Records*.-  Diversion, instream flow, or hydropower targets or stream flow depletion limits may be entered on *TS* records for each month of the period-of-analysis.  The monthly amounts may vary between years as well as within the year.

*Priority Circumvention Options PX and AX Records*.-  Dual simulation options involve a repeat of the simulation with changes to water rights.  Stream flow depletions from an initial simulation may serve as limits in a subsequent simulation.  Stream flow availability limits and transient rights are designed to circumvent the normal priority sequence.  The priority-based determination of water availability may be adjusted.  A right may be activated and deactivated at different points in the simulation based on priorities.  A return flow may be governed by a different priority.

*Water Right Reservoir Storage WS Record*.-  Reservoir data on a *WS* record include active and inactive storage capacity and storage-area information.  *WS* records are associated with specific water right *WR* records.  One primary and multiple secondary reservoirs can be associated with a water right, with a *WS* record for each reservoir following the *WR* record.  The water right refills storage in the one primary reservoir as well as using it to supply water.  The secondary reservoirs associated with a right meet water use requirements but are not refilled by that particular water right.

*Hydroelectric Power HP Record*.-  Hydroelectric power parameters include tailwater elevation information, efficiency factor, turbine capacity, and limits constraining energy generation.  *HP* record hydropower parameters are associated with the reservoir described by a particular *WS* record.

*Reservoir System Operating Rules **OR** Record*.-  One primary and any number of secondary reservoirs may be associated with a water right.  *WS* records are provided for each reservoir.  An *OR* record follows the *WR* record for each secondary reservoir to specify multiple-reservoir operating rules.  An *OR* record can also be provided for a single secondary reservoir associated with a water right, if needed to either specify the control point location or to activate the pump/pipeline conveyance option.  The *OR* record includes the reservoir control point, storage zones used to define release rules, and the gravity-flow versus pipeline switch.

*Storage **SV** versus Area **SA** Records*.-  A pair of *SV* and *SA* records provides a table of storage volume versus surface area for a reservoir.  Each storage volume on the *SV* record corresponds to the surface area in the corresponding field of the *SA* record.  The *SV/SA* records represent one of two optional methods for providing a reservoir storage versus area relationship.  The alternative option involves use of a regression equation with coefficients entered on a *WS* record.  Reservoir storage-area relationships are used within *SIM* for computing net evaporation-precipitation amounts.  For a simulated storage volume, the reservoir water surface area is determined by linear interpolation of the *SV/SA* table.

*Storage **PV** versus Elevation **PE** Records*.-  Each reservoir associated with a hydroelectric power right requires a pair of *PV* and *PE* records defining the volume-elevation relationship.  Storage volumes are entered on the *PV* record, and the corresponding water surface elevations are entered on the *PE* record.  The storage-elevation relationship is used for computing the head term in the power equation.  For a simulated storage volume, the reservoir water surface elevation is determined by linear interpolation of the *PV/PE* table.

*Tailwater Discharge **TQ** versus Elevation **TE** Records*.-  Hydropower head is reservoir water surface elevation minus the water surface elevation of the tailwater downstream.  Head computations require a tailwater elevation.  A constant tailwater elevation may be specified on the *WS* record.  Alternatively, a tailwater rating table may be entered as a pair of *TQ* and *TE* records.  The tailwater elevation is determined by linear interpolation of this table.

*Monthly Storage Limit **MS** Record*.-  A set of 12 monthly reservoir storage capacities may be entered on a *MS* record to define a seasonal rule curve operating plan.  Any storage contents above capacity are spilled at the beginning of the month.  Seasonally varying storage capacities are normally associated with seasonal reallocations of storage capacity between flood control and conservation pools.

*Drought Index Reservoirs **DI** Record and Storage **IS** versus Percentage **IP** Records*.-  A drought index mechanism allows diversion, instream flow, and hydroelectric energy generation targets to be expressed as a function of storage in either selected reservoirs or all of the reservoirs.  Reservoirs to be included in a drought index are specified on a *DI* record.  A drought index is defined as a table of total storage (*IS* record) versus percentage (*IP* record).  The storage-percentage relationship is for the total contents of reservoirs specified by a *DI* record.  In each month of the simulation, given the computed storage in the specified reservoirs, the index as a percentage is determined from this relationship by linear interpolation.  The percentage is converted to a fraction and multiplied by the diversion, instream flow, or hydroelectric power target determined from a *WR* or *IF* record and *UC* record and other target setting records to compute an adjusted target.

*Evaporation Allocation **EA**, Evaporation Factors **EF**, and Available Flow **AF** Records*.- The storage capacity of a reservoir may be shared by multiple entities. A set of *WR* and associated records may be used to model the allocation of storage capacity between the multiple owners. An *EA* record defines the manner in which the reservoir evaporation-precipitation is incorporated in the water allocation. An *EF* record provides supplemental information for one of the *EA* record options. An *AF* record is used to allocate available stream flow for rights sharing the same priority.

*End-of-Data **ED** Record*.- The *ED* record is placed at the end of the series of records discussed above in the DAT input file. The *ED* record has no input fields and simply indicates the end of the data file. An *ED* record also ends the flow distribution DIS input file.

### Records in the Hydrology Files (Filename Extensions FLO and EVA)

*Inflow **IN** and Evaporation **EV** Records*.- Naturalized stream flow sequences covering the hydrologic period-of-analysis for each control point are either entered on series of inflow *IN* records or computed from naturalized flows entered on *IN* records at one or more other control points. Reservoir net evaporation-precipitation depths for each control point with a reservoir are entered on *EV* records in the same format as *IN* records. *IN* and *EV* records are stored in various optional alternative record and file formats. *IN* and *EV* records are normally stored in FLO and EVA files, respectively, but optionally may be stored in a DAT or HYD file. Unit conversions and other information affecting *IN* and *EV* records are entered on *CP* and *XL* records.

### Records in the Flow Distribution File (Filename Extension DIS)

*Flow Distribution **FD** Record*.- *FD*, *FC*, and *WP* records provide information for transferring naturalized stream flows from gaged (known flow) to ungaged (unknown flow) sites. An *FD* record is required for each ungaged control point for which flows are to be synthesized. The identifiers for all pertinent control points are entered on the *FD* record.

*Flow Coefficient **FC** Record*.- Coefficients for the optional coefficient equation flow distribution method are entered on a *FC* record.

*Watershed Parameter **WP** Record*.- The watershed drainage area, curve number, and mean precipitation are provided on a *WP* record for each gaged and ungaged control point for which this information is needed.

*End-of-Data **ED** Record*.- The *ED* record is placed at the end of the DIS input file as well as at the end of the DAT file. The *ED* record has no input fields and simply indicates the end of the data file.

### Records in the Flow Adjustment File (Filename Extension FAD)

*Stream Flow Adjustment **FA** Record*.- Time sequences of adjustments on *FA* records are added to the naturalized flows at a control point and all downstream control points. *FA* record flow adjustments are similar to *CI* record adjustments. Whereas *CI* records contain a set of 12 monthly adjustments that are repeated each year, *FA* records provide multiple-year time series of flow adjustments that vary between years as well as between the 12 months of the year.

## Sequential Order of Input Records

The *JD* and *ED* records and at least one *CP*, one *WR* or *IF*, and one *IN* record are required. All other records are optional. The records are organized in the DAT, FLO, EVA, DIS, and FAD input files in the sequential order outlined in Table 3.3. The records for each input file are listed in Table 3.3 in the sequential order in which they occur in the file.

## Format and Content of Each Type of Input Record

The sets of required and optional records in the *SIM* input files contain information organizing the simulation and representing the river/reservoir/use system being modeled. Input files are prepared using any editor, spreadsheet, and/or other software. Only those records and those fields of a particular record are used as needed for the particular modeling application. Fields not needed are simply left blank. For fields with numeric entries, leaving the field blank is equivalent to entering a zero. The 2-character record identifiers are required. Records with the first two characters blank are not allowed in a data set; this includes totally blank records.

Both comma-delimited and fixed field-width formats are outlined in Chapter 1. Either format option may be used. However, the records are described in the remainder of this chapter in terms of the fixed field-width format. Several representative Fortran format specifications found in the fourth column of the record description tables are defined as follows.

F8.0 − Real number in field of 8 characters with any number of digits to the right of the decimal. Either include the decimal or right justify the number.

5F8.0 − Five real numbers, each having a F8.0 specification.

I8 − Integer number with maximum of 8 digits. Right justified, no decimal.

3I8 − Three integers with each right justified in field of 8 characters.

A2 − Alphanumeric label (character variable) in a field that is 2 characters wide.

2x − Two spaces are skipped. Fields with the spacing descriptor x are not read.

2x,A6 − Two blank spaces followed by an alphanumeric variable with maximum of six characters.

Variables with integer specifications (I format) should be right-justified in the appropriate field with no decimal. Trailing blanks are read as zeros. Real variables (F format) should either be right justified or include the decimal with any number of digits to its right. Input values for Fortran character variables (alphanumeric (A) specification) are normally right-justified in the appropriate field to preclude the problem of reading unwanted trailing blanks to the right of the identifiers. However, the WRAP code automatically removes trailing blanks for most of the alphanumeric character input variables such as control point, water right, and reservoir identifiers. Thus, as long as the alphanumeric identifiers are in the correct field, right-justification is not required.

The remainder of this chapter consists of a series of tables and accompanying explanations providing instructions regarding the format and content of each type of input record. Table 3.4 is a quick reference chart for the most commonly used records.

Table 3.3
Sequential Order of Input Records

_____

### *Basic Input File  (filename root.DAT)*

T1,T2,T3  Titles or Headings    T1 is first record.  Optional T2 and T3 records follow.
**          Comments           Comments may be inserted throughout.
JD          Job Control Data    Required JD record follows T1/T2/T3 records.
JO          Job Options         Optional JO and CR records are grouped with required JD record.
CR          Conditional Reliability  Optional JO and CR records are grouped with required JD record.
-----------------------------------------------------------------------------------------------------------------------
OF          Optional Output Files  Optional OF record is located any place between JD and UC records.
XL          Multiplication Factors  Optional XL record is located any place between JD and UC records.
FY          Firm Yield          Optional FY record is located any place between JD and UC records.
ZZ          Flow Availability   Optional ZZ record is located any place between JD and UC records.
-----------------------------------------------------------------------------------------------------------------------
CO          Control Point Output      CO, RO, WO, GO records are optional and are inserted in any
RO          Reservoir Output          order following the JD record and preceding the UC records.
WO          Water Rights Output
GO          Groups of Water Rights to Output
-----------------------------------------------------------------------------------------------------------------------
UC          Use Distribution    Set of all UC records follow JD and precede CP and RF records.
UP          Use Priority        Set of all UP records follows set of all UC records.
RF          Return Flow Factors  Set of all RF records follows UC and precedes CP records.
-----------------------------------------------------------------------------------------------------------------------
CP          Control Point       All CP records grouped together in any order; at least one.
CI          Constant Inflows    Set of all CI records in any order follows set of all CP records.
-----------------------------------------------------------------------------------------------------------------------
IF          Instream Flow       IF and WR records are grouped together in any order, with the set of
WR          Water Right         WS/HP/OR, SO, ML, BU, TO, FS, TS, and PX records following the
SO          Supplemental Options  corresponding WR or IF record.  HP and OR records must follow a
ML          Monthly Limits      WS record.  WS, SO, ML, BU, TO, FS, TS, and PX/AX records may
BU          Back-up Right       be in any order, but the complete set must immediately follow the
TO          Target Options      corresponding WR or IF record.
FS          Flow Switch
TS          Target Series
PX          Priority circumvention
AX          Stream flow Allocation Factors
-------------------------------------
WS          Reservoir Storage   HP and OR records follow a WS record.
HP          Hydroelectric Power
OR          Operating Rules for a Multiple-Reservoir System
-----------------------------------------------------------------------------------------------------------------------
SV          Storage Volume      Set of all SV-SA tables grouped together in any order, with
SA          Surface Area        each SA immediately following corresponding SV.
-----------------------------------------------------------------------------------------------------------------------
PV          Storage Volume      Set of all PV-PE tables grouped together in any order, with
PE          Surface Elevation   each PE immediately following corresponding PV.
_____

Table 3.3 (Continued)
Sequential Order of Input Records

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*__Basic Input File  (filename root.DAT)__* (continued)

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| | | |
|---|---|---|
| TQ | Tailwater Discharge | Set of all TQ-TE tables grouped together in any order, with |
| TE | Tailwater Elevation | each TE immediately following corresponding TQ. |

---

MS, DI/IS/IP, and EA/EF records are connected to reservoirs. The sets of MS, DI/IS/IP, and EA/EF records are placed in the DAT file after the complete grouping of all SV/SA, PV/PE, and TQ/TE records and before the ED record. All MS records are grouped together. All sets of DI/IS/IP records are grouped together. All pairs of EA/EF records are grouped together. However, the relative placement of the MS, DI/IS/IP, and EA/EF groups are arbitrary. For example, the EA/EF records may be either before or after the MS and/or DI/IS/IP records.

---

| | | |
|---|---|---|
| MS | Monthly Varying Storage Capacity | Set of all MS records grouped together. |

---

| | | |
|---|---|---|
| DI | Drought Index Reservoirs | Set of all DI/IS/IP records grouped together. Each DI record |
| IS/IP | Index Storage/Percentage | must be followed by an IS record followed by an IP record. |

---

| | | |
|---|---|---|
| EA | Evaporation Allocation/Factors | Set of all EA/EF/AF records grouped together. |
| EF | Evaporation Allocation Factors | EF record follows EA record.  AF follows EA/EF. |
| AF | Available Stream flow Allocation Factors | |

---

| | | |
|---|---|---|
| ED | End of Data | Last record in DAT file except optionally for IN/EV records. |

---

*__Stream Flow (root.FLO) and Evaporation-Precipitation (root.EVA) Files__*
Standard default format is subject to change by INEV in JO record field 2.
Optionally, IN and EV records may follow ED record in DAT file.

| | | |
|---|---|---|
| IN | Inflows | IN records are grouped together by year.  The set of IN records for all control points for a particular year is followed by the set for the next year. |
| EV | Evaporation | EV records are organized the same as IN records. |

*__Flow Distribution File  (filename root.DIS)__*

| | | |
|---|---|---|
| FD | Flow Distribution | |
| FC | Flow Distribution Coefficients | Each FC record follows the corresponding FD record. |
| WP | Watershed Parameters | The set of all WP records follows the set of all FD/FC records. |
| ED | End of Data | The DIS file ends with a ED record. |

*__Flow Adjustment File  (filename root.FAD)__*

| | | |
|---|---|---|
| FA | Flow Adjustment | Set of all FA records. |

---

*Chapter 3 SIM Input*

Table 3.4
Quick Reference Chart for SIM

| Fields | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | |
| | | | | | | Columns | | | | | |
| 2 | 8 | 16 | 24 | 32 | 40 | 48 | 56 | 64 | 72 | 80 | page |
| Basic Input Data File (filename root.DAT) | | | | | | | | | | | |
| T1 | | | | | | | | | | | 39 |
| T2 | | | | | | | | | | | 39 |
| T3 | | | | | | | | | | | 39 |
| ** | | | | | | | | | | | 39 |
| JD | NYRS | YRST | ICHECK | CPOUT | OUTWR | IDSET | ADJINC | NEGINC | | | 40 |
| JO | INEV | FAD | SYSOUT | BES | BRS | STOFLG | NPOPT | PASS2 | | | 42 |
| CR | CR1 | CR2 | CR3 | CR4 | | | | | | | 44 |
| FY | FYIN1 | FYIN2 | FYIN3 | FYIN4 | FYIN5 | FYWRID | FYGROUP | | | | 45 |
| XL | STX | INX | EVX | CIX | SAX | POWFCT | DEPTHX | CNLN | CNUB | MPLB | 46 |
| CO | NCPOUT | CPOUID | CPOUID | CPOUID | CPOUID | CPOUID | | | | | 52 |
| RO | NREOUT | REOUID | REOUID | REOUID | REOUID | REOUID | | | | | 52 |
| WO | NWOUT | | WROUT | | WROUT | | WROUT | | WROUT | | 53 |
| GO | NGOUT | GROUP | GROUP | GROUP | GROUP | GROUP | | | | | 53 |
| UC | USEID | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | 54 |
| UP | USEID | USEP | USEM | USEFAC | | | | | | | 55 |
| RF | RFID | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | 56 |
| CI | CIID | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | 57 |
| CP | CPID1 | CPID2 | CPDT1 | CPDT2 | INMETHOD | CPIN | CPEV | EWA | CL | INWS | 58 |
| WR | CP | AMT | USE | priority | Type RFM | RFAC | RCP | DINDEX | | WRID | 50 |
| IF | CP | AMT | USE | priority | IFFLAG | DINDEX | | WRID | | | 62 |
| SO | WSHED | MONDEP | ANNDEP | ACPID | BACKUP | MRW | ARW | ISHT | | | 66 |
| ML | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | 69 |
| TO | TARGET | FACT | TOCOMB | TOLIM | TOLIM | TOFLOW | TORES | TOWR | TOCONT | | 70 |
| BU | BU | BUX | BUWRID | BUG | | | | | | | 73 |
| FS | FSCP | FSX | FSX | FSI | FSI | FSI | FSI | | | | 74 |
| TS | TSL | TSYR2 | QTS | QTS | QTS | QTS | QTS | QTS | QTS | QTS | 77 |
| WS | RES | capacity | A | B | C | INACT | BEGIN | IEAR | SA | LAKESD | 78 |
| HP | WRSYS | WRSYS | TELEV | TQCAP | TPCAP | | | | | | 80 |
| OR | CP | WRSYS(2) | WRSYS(5) | WRSYS(4) | SN2 | WRSYS(6) | WRSYS(7) | WRSYS(8) | | | 81 |
| PX | DUAL | XAX | XCP | XCPID | XP | XPR | XPRIOR | XPOUT | WRID1 | WRID2 | 84 |
| SV | RES | TARA | TARA | TARA | TARA | TARA | TARA | TARA | TARA | TARA | 89 |
| SA | | TARB | TARB | TARB | TARB | TARB | TARB | TARB | TARB | TARB | 89 |
| PV | RES | TARA | TARA | TARA | TARA | TARA | TARA | TARA | TARA | TARA | 90 |
| PE | | TARB | TARB | TARB | TARB | TARB | TARB | TARB | TARB | TARB | 90 |
| MS | RES | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | 91 |
| DI | DI | DINUM | DIRES | DIRES | DIRES | DIRES | DIRES | DIRES | DIRES | DIRES | 92 |
| IS | NS | DISTO | DISTO | DISTO | DISTO | DISTO | DISTO | DISTO | DISTO | DISTO | 92 |
| IP | | DIPER | DISPER | DISPER | DISPER | DISPER | DISPER | DISPER | DISPER | DISPER | 92 |
| ED | | | | | | | | | | | 39 |
| Flow File (filename root.FLO) | | | | | | | | | | | |
| IN | ID | NYR PYR | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | 96 |
| Net Evaporation-Precipitation File (filename root.EVA) | | | | | | | | | | | |
| EV | ID | NYR PYR | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | 96 |
| Flow Distribution File (filename root.DIS) | | | | | | | | | | | |
| FD | ID | IDDS | NGAGE | UGID(1) | UGID(2) | UGID(3) | UGID(4) | UGID(5) | UGID(6) | UGID(7) | 100 |
| FC | COEF1 | COEF2 | COEF3 | | | | | | | | 100 |
| WP | ID | DA | CN | MP | DAF | | | | | | 100 |
| ED | | | | | | | | | | | 39 |
| Flow Adjustment File (filename root.FAD) | | | | | | | | | | | |
| FA | ID | PYR | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | 101 |

**T1, T2,** and **T3** Records – Titles or Headings

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | T1,T2,T3 | Record identifier |
| 2 | 3-78 | TITLE | A78 | AN | Title or heading |

The *SIM* DAT file begins with an optional *T1* record that optionally may be followed by *T2* and *T3* records. Headings provided by these title records are printed at the beginning of the OUT file and on the *TABLES* cover page. Without the title records, the three title lines default to blanks.

**\*\*** Record – Comments

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | \*\* | Record identifier |
| 2 | 3-no limit | | | AN | Comments which are not read by the program |

A record beginning with two asterisks \*\* is not read by the program, except for the \*\* identifier. Comment \*\* records are used to insert notes in the input dataset or to temporarily deactivate selected records. Any number of comment records may be placed at the following locations.

- Almost any logical place in the DAT file. For several record types, \*\* records may be inserted between groups of records but not within the group.
- Before the first *IN* and *EV* records for each year in the FLO and EVA files.
- Before the *FD* records and between the *FD* and *WP* records in the DIS file.

**ED** Record – End of Data

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | ED | Record identifier |

The *ED* record ends both the DAT and DIS files. The *ED* record is the last record in the DAT file if the *IN* and *EV* records are stored in FLO and EVA files or a HYD file. If *IN* and *EV* records are included in the DAT file, they follow after the *ED* record. The *ED* record is the last record in a DIS file signaling the end of the *FD/FC/WP* records.

*Record Sequencing*. A DAT file begins with the optional *T1*, *T2* and *T3* records, if used, followed by *JD*, *JO*, and *CR* records. The required *JD* and optional *JO* and *CR* records must be grouped together, but the three records may be placed in any order. Fields 1, 2, and 3 (*CD*, *NYRS*, *YRST*) are the only required entries on the *JD* record, with the other fields left blank unless actually needed. The optional *JO* record normally follows behind the *JD* record.

**JD** Record – Simulation Job Control Data

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | JD | Record identifier |
| 2 | 3-8 | NYRS | I6 | + | Number of years in the simulation period-of-analysis. |
| 3 | 9-16 | YRST | I8 | + | First year of simulation.   All *IN* and *EV* records before year YRST will be skipped. |
| | | | | | *Level of Error Checks and Traces* |
| 4 | 24 | ICHECK | I8 | blank,0 | Normal trace, reduced error, and no warning checks. |
| | | | | 1 | Normal trace and complete error and warning checks. |
| | | | | 2 | *UC* and *RF* records are copied to MSS file. |
| | | | | 3 | *CP* records are copied to MSS file. |
| | | | | 4 | *WR/IF* records are copied to MSS file. |
| | | | | 5 | *SV/SA* records are copied to MSS file. |
| | | | | 6 | *IN/EV* records are copied to MSS file. |
| | | | | 7 | *FD/FC/WP* records are copied to MSS file. |
| | | | | 8 | Dual simulation information is recorded in MSS file. |
| | | | | 9 | Full error checks but warning messages deactivated. |
| | | | | 10 | Conditional reliability modeling trace is written. |
| | | | | | *Simulation Results Output* |
| 5 | 31-32 | CPOUT | I8 | −1 | Control point data is output for all control points. |
| | | | | −2 | Control point data is output only for cp's with *IN* records plus those cp's listed on *CO* records. |
| | | | | + | Control point output is limited to first CPOUT control points plus those cp's listed on *CO* records. |
| | | | | blank,0 | Control point output is specified only by CO records, with no CP output without a *CO* record. |
| 6 | 39-40 | OUTWR | I8 | −1 | Water rights data is output for all *WR* and *IF* record rights except hydropower rights. |
| | | | | −2 | All *WR* and *IF* record rights including hydropower. |
| | | | | −3 | Non-hydropower *WR* record rights. |
| | | | | −4 | Instream flow (*IF* record) rights. |
| | | | | + | Water right output is limited to first OUTWR rights in input file plus those listed on *WO* and *GO* records. |
| | | | | blank,0 | Water rights output is specified by *WO* and/or *GO* records, with no wr output without these records. |
| 7 | 48 | OUTFILE | I8 | blank,0,1 | OUT file is created as a formatted text file. |
| | | | | 2 | OUT file is created as an unformatted binary file. |
| | | | | | *Negative Incremental Naturalized Flow Options* |
| 8 | 56 | ADJINC | I8 | blank,0,1 | Option 1: No adjustments are performed. |
| | | | | 2 | Option 2: Downstream flow adjustments at all cp's. |
| | | | | 3 | Option 3: Upstream adjustments applied at all cp's. |
| | | | | −3 | Option 3: Upstream adjustments at all primary cp's. |
| | | | | 4 | Option 4: Adjustment only at downstream cps. |
| | | | | −4 | Option 4: Adjustment at primary downstream cps. |
| | | | | 5 | Option 5: Alternative simulation approach. |

**JD** Record – Simulation Job Control Data  (Continued)

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| | | | | | *Negative Incremental Flow Adjustments to MSS File* |
| 9 | 64 | NEGINC | I8 | blank,0,1 | No adjustments written. |
| | | | | 2 | Downstream adjustments written to MSS file. |
| | | | | 3 | Upstream adjustments written to MSS file. |
| | | | | | *Default for Evaporation-Precipitation Adjustment* |
| 10 | 72 | EPADJ | I8 | blank,0 | No adjustment unless specified on *CP* record |
| | | | | –1 | Adjustments based on ungaged CP (*FD* field 2) |
| | | | | –2 | Adjustments based on gaged CP (*FD* record field 3) |
| | | | | | *Dimension Limit for IS/IP, SV/SA, PV/PE, and TQ/TE Records* |
| 11 | 80 | TL | I8 | Blank, ≤12 | Default maximum limit = 12 pairs of values in tables. |
| | | | | ≥13 | Maximum limit on number of entries in tables. |
| | | | | | *Alternate Water Right Identifiers in WR Record Fields 11-13 and 14-16* |
| 12 | 88 | IDSET | I8 | blank,0,1 | First set of identifiers on *WR* input records are used. |
| | | | | 2 | Second set of identifiers on *WR* records are used. |

## Explanation of JD Record Fields

*Field 4*:  The various levels of checks and messages are defined in Table 2.3 of Chapter 2. *ICHECK* options 1 or 0 should normally be selected unless specific needs arise for other options.

*Fields 5 and 6*:  Fields 5, 6, and 12 in combination with *CO*, *RO*, *WO*, and *GO* records control which simulation results are written to the output file as explained in the preceding Chapter 2.

*Field 7*:  With the default option 1, the OUT file is in text format readable with Microsoft WordPad.  Creating the OUT file in binary machine language format (option 2) readable only with *TABLES* reduces run-time, reduces the file size, and increases precision for small numbers.

*Fields 8 and 9*:  The negative incremental flow options are explained in Chapter 3 of the *Reference Manual*.  Field 8 controls the choice of optional computation method.  Field 9 allows the negative incremental adjustments used in the computations to be printed to the message file for information.  *ADJINC* option 4 is recommended for most applications.

*Field 10*:  Methodology for correcting the evaporation-precipitation depths from the *EV* records for runoff from the land area covered by a reservoir is explained in the *Reference Manual* Chapter 3.  *EPADJ* in field 10 sets a default.  The option specified in the *JD* record field 10 is used for all control points for which the *CP* record field 9 is blank [*EWA(cp)*=0].  *EWA(cp)* entered in field 9 of a *CP* record supercedes the default set in field 10 of the *JD* record.

*Field 11*:  The table defining a drought index (*IS/IP* records) and tables of reservoir storage volume versus surface area (*SV/SA* records), storage volume versus elevation (*PV/PE* records), and tailwater discharge versus elevation (*TQ/TE* records) are entered as pairs of numbers, which by default can not exceed 12 entries on each record.  The maximum limit on the number of entries on *IS*, *IP*, *SV*, *SA*, *PV*, *PE*, *TQ*, and *TE* records can be increased above the default of 12 by entering a higher dimension limit TL in *JD* record field 11.

**JO** Record – Simulation Job Options

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | JO | Record identifier |
| | | | | | *Organization of IN and EV Records* |
| 2 | 8 | INEV | I6 | blank,0,1 | Grouped by years in FLO and EVA files. |
| | | | | –1 | Grouped by years in FLO file. No EVA file. |
| | | | | 2 | Grouped by control points in FLO and EVA files. |
| | | | | –2 | Grouped by control points in FLO file. No EVA file. |
| | | | | 3 | Grouped by years in DAT file. |
| | | | | 4 | Grouped by control points in DAT file. |
| | | | | 5 | Grouped by years in HYD file in HYD file format. |
| | | | | 6 | HEC-DSS hydrology input file. |
| | | | | | *Flow Adjustment (FAD) Input File* |
| 3 | 16 | FAD | I8 | 1 | FAD file is read and flow adjustments performed. |
| | | | | | *Hydropower and Reservoir Release (HRR) File* |
| 4 | 24 | SYSOUT | I8 | blank,0 | HRR output file is not created. |
| | | | | 1 | Water right identifier written to HRR file. |
| | | | | 2 | First group identifier written to HRR file. |
| | | | | 3 | Second group identifier written to *HRR* file. |
| | | | | | *Beginning-Ending Storage (BES) Options* |
| 5 | 32 | BES | I8 | blank, 0 | Feature is not used and BES file is not created. |
| | | | | 1 | Ending storages written to BES file. |
| | | | | 2 | Beginning storages read from BES file. |
| | | | | 3 | Both beginning read and ending written to BES file. |
| | | | | 4 | Cycling with BES file automatically created/read. |
| | | | | 5 | Cycling without use of a BES file. |
| | | | | 6 | Information-only table with water rights data added. |
| | | | | | *Beginning Reservoir Storage (BRS) File* |
| 6 | 40 | BRS | I8 | 1 | BRS file is created. |
| | | | | | *Multiple-Reservoir System Release Options* |
| 7 | 48 | STOFLG | I8 | blank,0 | End-of-period storage used for system release rules. |
| | | | | 1 | Beginning-of-period storage is used for system rules. |
| | | | | | *Drought Index Reservoir Storage Timing* |
| 8 | 56 | STODI | I8 | blank,0 | Beginning-of-period storage used for drought index. |
| | | | | 1 | End-of-period storage is used for drought index. |
| | | | | 2 | Average of beginning and ending storage is used. |
| | | | | | *Alternative Water Right Priority Schemes* |
| 9 | 64 | NPOPT | I8 | 1 | Automated natural upstream-to-downstream priority. |
| | | | | 2 | Priorities are set by sequencing of *WR & IF* records. |
| | | | | 3 | Priorities are set by sequencing of *CP* records. |
| | | | | | *Option to Require Second Pass in All Months* |
| 10 | 72 | PASS2 | I8 | blank,0,1 | *IFFLAG* in *IF* field 7 controls 2nd pass option. |
| | | | | 2 | Second pass is activated for all months regardless. |
| | | | | | *Dual Simulation Option Default* |
| 11 | 80 | DUALD | I8 | + | Default for options defined by *PX* record field 2. |

## Explanation of JO Record Fields

**Field 2**:  The options for organizing the inflows *IN* and evaporation *EV* records are outlined later in this chapter following the description of the *IN* and *EV* records.

**Field 3**:  This field activates the flow adjustment input file (filename root.FAD) which consists of *FA* records with flow volume amounts to be added to naturalized stream flows.

**Field 4**:  *SYSOUT* activates the hydropower and multiple reservoir system release output file (filename root.HRR) and specifies the type of water right identifiers to be written to the file.

**Field 5**:  The beginning-ending storage *BES* switch in *JO* record field 5 activates the options outlined in Chapter 6 of the *Reference Manual*.  All options except option 5 require activation of a BES file, which is opened automatically.

**Field 6**:  The beginning reservoir storage file (filename root.BRS) provides beginning-of-simulation storage contents for use by Program *SALT* and by a conditional reliability modeling routine in Program *TABLES*.  The BRS table may also be created for general information.

**Field 7**:  The *STOFLG* switch is relevant only for reservoirs operated as a multiple-reservoir system that also have multiple water rights associated with one or more of the system reservoirs. Multiple-reservoir system release decisions are based on parameters from the operating rules *OR* record (*Reference Manual* Chapter 4).  *STOFLG* allows the multiple-reservoir operating rules to be applied alternatively based on either beginning-of-period storage or latest computed end-of-period storage.  The latest computed end-of-period storage reflects end-of-period storage computed for the current period for other more senior rights at the same reservoir.

**Field 8**:  A drought index is defined by *DI*, *IS*, and *IP* records.  *STODI* in *JO* record field 8 allows the drought index to be alternatively based on either beginning-of-period storage, latest computed end-of-period storage, or the average of the beginning and latest ending storage.  The latest end-of-period storage for all of the *DI* record reservoirs is recomputed when each right connected to the drought index is considered in the water right priority sequence.  More senior rights at each reservoir are reflected in the end-of-period storage, but junior rights are not.

**Field 9**:  These alternative priority options replace the normal priorities entered in field 5 of the *WR* and *IF* records.  With NPOPT option 1, priorities are automatically set in upstream-to-downstream order making each right senior to all other rights located at downstream control points.  With option 1, for multiple rights at the same control point, priorities from *WR/IF* field 5 govern.  With NPOPT option 2, priorities are set in the order that *WR* and *IF* records are entered in the DAT file, with the first right entered being most senior.  With NPOPT option 3, priorities are set by the order in which control points are placed in the DAT file.  With option 3, for multiple rights at the same control point, priorities are set by the order of the *WR* and *IF* records.

**Field 10**:  *PASS2* over-rides the *IFMETH* option entered in *IF* record field 6 and forces a second pass through the water rights computation loop in every month regardless of conditions.

**Field 11**:  The dual simulation options selected by the parameter DUAL(wr) entered in *PX* record field 2 or *SO* record field 14 are defined later in the description of the *PX* record.  A default option for all water rights can be set in *JO* record field 11 subject to being replaced for individual water rights by *PX* record field 2 or *SO* record field 14.

**CR** Record  –  Conditional Reliability Modeling

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | CR | Record identifier |
| 2 | 3-8 | CR1 | I6 | + | Length of simulation period in months |
|   |     |     |    | blank,0 | Default = 12 |
| 3 | 9-16 | CR2 | I8 | + | Starting month for annual cycle option |
|   |      |     |    | blank,0,– | Monthly cycle option is activated |
| 4 | 17-24 | CR3 | I8 | + | Months excluded from output file are still simulated |
|   |       |     |    | blank,0 | Only the months written to output file are simulated |
| 5 | 25-32 | CR4 | F8.0 | + | Factor by which all starting storages are multiplied |
|   |       |     |      | blank,0 | Default = 1.0 |
|   |       |     |      | $\leq -1$ | CR4 = 0.0 |

The required *JD* and optional *JO* and *CR* records must be grouped together, but the three records may be placed in any order.  No other records may be placed between the *JD*, *JO*, and *CR* records, except comment (**) records.

The *CR* record activates the conditional reliability modeling (CRM) simulation mode.  The *CR* record is the only *SIM* input record associated specifically with CRM.  Conditional reliability modeling is described in Chapter 2 of the *Supplemental Manual*.  Without the *CR* record, a conventional long-term simulation is performed by default and an OUT file is created.  With the *CR* record, the period-of-analysis hydrology is divided into multiple hydrologic simulation sequences.  The simulation is performed for each hydrologic sequence starting with the same initial storage conditions.  The results are stored in a CRM output file (filename root.CRM) which replaces the OUT file.  Program *TABLES* reads the CRM file and performs CRM reliability and frequency analyses based on either weighting all the sequences equally or assigning varying probabilities.  The *Supplemental Manual* documents *TABLES* methodologies and input records for conditional reliability analyses.

**FY** Record – Firm Yield and Yield-Reliability Table

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | FY | Record identifier |
| 2 | 3-8 | FYIN(1) | F6.0 | + | Fraction (0.0-1.0) of monthly target that must be met in order to not count the month a failure in meeting the target in the period reliability computations. |
| | | | | blank,0 | Default = 1.0 |
| 3 | 9-16 | FYIN(2) | F8.0 | + | Initial value for the annual target amount. (Must be greater than zero.) |
| 4 | 10-24 | FYIN(3) | F8.0 | + | Incremental decrease for first level of decreases for iterative simulations. (Must be greater than zero.) |
| 5 | 25-32 | FYIN(4) | F8.0 | + | Incremental decrease for second level of decreases. |
| | | | | blank,0 | Optional second level is not used. |
| 6 | 33-40 | FYIN(5) | F8.0 | + | Incremental decrease for third level of decreases. |
| | | | | blank,0 | Optional third and fourth levels are not used. |
| 7 | 41-56 | FYWRID | A16 | AN | Water right identifier for *FY* record rights. |
| 8 | 57-64 | FYGROUP | A8 | AN | Water right group identifier for *FY* record rights. |
| 9 | 65-72 | MFY | I8 | blank,0,1 | Proportional to amounts in *WR* record field 3. |
| | | | | 2 | Based on priorities in *WR* record field 5. |
| 10 | 73-80 | SIM3 | I8 | blank,0 | Simulation results are not written to root.OUT file. |
| | | | | +,– | Results for final iteration are written to OUT file. |

The *FY* record activates the yield-reliability analysis described in Chapter 6 of the *Reference Manual*. The *FY* record is inserted any place between the *CR/JD/JO* records and *UC* records.

***Fields 7, 8, 9***: The *FY* record yield analysis may be applied to a water right identified in *FY* record field 7 (*WR* record field 11) or to a set of any number of up to 100 rights identified by field 8 of the *FY* record which connects to the group identifiers in fields 12 and 13 of the *WR* records. *MFY* entered in *FY* record field 9 switches between two alternative options for allocating the total annual yield between the specified water rights.

1. The default of leaving *FY* record field 9 blank or entering a zero or 1 activates the option in which the yield is allocated between rights in proportion to the annual diversion amounts in *WR* record field 3. Thus, the allocation is based on fixed fractions.

2. The second option (MFY=2) is based on the priorities from field 5 of the *WR* records. The yield is assigned to the most senior priority right up to the *WR* record field 3 diversion amount. Any yield remaining is assigned to the right with the next most senior priority up to its *WR* record field 3 diversion amount, and so forth. Upon reaching the most junior right, all of the remaining yield, if any remains, is assigned to the most junior right regardless of its *WR* record field 3 diversion amount.

**XL** Record – Multiplication Factors and Parameter Limits

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | XL | Record identifier |
| | | | | | *Multiplication Factors Applied to Input Data* |
| 2 | 3-8 | STX | F6.0 | + | Multiplier of reservoir storage volumes on *WS*, *OR*, *SV*, *PV*, *MS*, and *IS* records. |
| | | | | Blank, 0 | Default = 1.0 |
| 3 | 9-16 | INX | F8.0 | + | Multiplier of flows on *IN* records, subject to being superceded by non-blank *CP* record field 4. |
| | | | | Blank, 0 | Default = 1.0 |
| 4 | 17-24 | EVX | F8.0 | + | Multiplier of E-P rates on *EV* records, subject to being superceded by non-blank *CP* record field 5. |
| | | | | Blank, 0 | Default = 1.0 |
| 5 | 25-32 | CIX | F8.0 | + | Multiplier of flows on *CI* records. |
| | | | | Blank, 0 | Default = 1.0 |
| 6 | 33-40 | SAX | F8.0 | + | Multiplier of reservoir surface areas on *SA* records. |
| | | | | Blank, 0 | Default = 1.0 |
| | | | | | *Multiplication Factors Used in Computations* |
| 7 | 41-48 | POWFCT | F8.0 | + | Multiplier factor for hydropower computations. |
| | | | | Blank, 0 | Default = 0.0010237  (Reference Manual Chapter 4) |
| 8 | 49-56 | DEPTHX | F8.0 | + | Multiplier factor for runoff depth in NRCS CN method flow distribution computations. |
| | | | | Blank, 0 | Default = 0.01875  (Reference Manual Chapter 3) |
| | | | | | *Limits on CN and Mean Precipitation* |
| 9 | 57-64 | CNLB | F8.0 | + | Lower limit on CN  (Reference Manual Chapter 3) |
| | | | | Blank, 0 | Default = 0.0 |
| 10 | 65-72 | CNUB | F8.0 | + | Upper limit on CN |
| | | | | Blank, 0 | Default = 100.0 |
| 11 | 73-80 | MPLB | F8.0 | + | Lower limit on MP |
| | | | | Blank, 0 | Default = 0.0 |
| 12 | 81-88 | MPUB | F8.0 | + | Upper limit on MP |
| | | | | Blank, 0 | Default = 100 inches or other rainfall unit in effect |
| | | | | | *Warning Limit on Runoff EP-Adjustment* |
| 13 | 89-96 | EPWL | F8.0 | + | Limit for warning message (Reference Manual Ch 3) |
| | | | | Blank, 0 | Default = 2.0 feet or other depth unit in effect |

The optional *FY*, *XL*, *OF*, *ZZ*, *CO*, *RO*, *WO*, and *GO* records must all be placed between the *CR*/*JD/JO* records and *UC* records but can otherwise be in any order.

## Explanation of XL Record Fields

***Fields 2-8***:  The multiplication factors in fields 2 through 8 of the *XL* record are intended primarily for unit conversions as discussed below.

***Fields 9-12***:  The curve number (CN) and mean-precipitation (MP) are watershed parameters entered on *WP* records for use in distributing flows from gaged to ungaged control points.  The CN and MP for incremental sub-watersheds are computed from the input values for total watersheds. The CN and MP input and computations may result in unreasonable values.  Upper and lower limits may be specified in *XL* record fields 9-12 as discussed in Chapter 3 of the *Reference Manual*.

***Field 13***:  An option activated by *EPADJ* in *JD* record field 10 and *EWA* in *CP* record field 9 adjusts net evaporation-precipitation depths from *EV* records for the precipitation runoff from a reservoir site that is already reflected in the naturalized stream flows.  An optional warning message is printed if the adjustment in the runoff depth exceeds a limit specified in *XL* record field 13.  The default is 2.0 units, which would be 2.0 feet if the net evaporation computations are in feet.

## Unit Conversions

The multiplication factors in fields 2 through 8 of the *XL* record are intended primarily for unit conversions.  The factor *STX* (field 2) with default of 1.0 is multiplied by the storage volume data entered on several other records.  The model user must adopt a consistent unit (acre-feet, million cubic meters, etc.) for all the variables representing reservoir storage volumes.  However, *STX* allows input data entered in any other units to be converted to the adopted unit.

The variables *INX*, *EVX*, *CIX*, and *SAX* in fields 2, 3, 4, 5 are factors, with defaults of 1.0, by which the data entered on *IN*, *EV*, *CI*, and *SA* records are multiplied.   The multipliers *CPDT(cp,1)* and *CPDT(cp,2)* entered on *CP* records replace *INX* and *EVX* for individual control points.   *INX* and *EVX* from the *XL* record are applied to *IN* record flows and *EV* record evaporation depths for all control points for which the *CPDT(cp,1)* and *CPDT(cp,2)* fields in the *CP* record are blank.  The constant inflows entered on *CI* records are multiplied by *CIX* from the *XL* record.  The reservoir water surface areas entered on *SA* records are multiplied by the *SAX* from the *XL* record.

The input variable *DAF* on the *WP* record may be used as a conversion factor to convert *WP* record drainage areas from any units to any other units.  The *WP* record mean precipitation may be in any units since this data is used in the form of precipitation ratios.  However, the mean precipitation values for all watersheds should be in the same units.

The optional watershed area *EWA(cp)* entered in *CP* record field 9 must be in the same units as the reservoir surface areas.

The variable *POWFCT* entered in *XL* record field 7 is a multiplier factor used in the hydroelectric power computations, which reflects unit conversions and the specific weight of water.  This factor is discussed in the hydropower section of Chapter 4 of the *Reference Manual*.

The factor *DEPTHX* entered in *XL* record field 8 is used in the NRCS curve number (CN) method for distributing flows from gaged to ungaged sites as discussed in Chapter 3 of the *Reference Manual*.

**OF** Record  –  Optional Output Files Record

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | OF | Record identifier |
| 2 | 3-8 | DSS(1) | I6 | 1 | OUT output file is activated. |
|   |     |        |    | blank,0 | OUT output file is not activated. |
| 3 | 9-16 | DSS(2) | I8 | 1 | SOU output file is activated. |
|   |     |        |    | blank,0 | SOU output file is not activated. |
| 4 | 10-24 | DSS(3) | I8 | 1 | DSS output file is activated. |
|   |     |        |    | blank,0 | DSS output file is not activated. |
| 5 | 25-32 | DSS(4) | I8 | blank,0 | Default set of variables in SOU and DSS files. |
|   |     |        |    | 1 | All variables are included in SOU and DSS files. |
|   |     |        |    | 2, 3, ... ,13 | DSS file is limited to include only the first DSS(4) variables listed on the following page. |
| 6 | 33-40 | DSS(5) | I8 | + | Hydrology DSS input file is created. |
|   |     |        |    | blank,0 | DSS input file creation option is not activated. |
|   |     |        |    | | *DSS Message MSS File Options* |
| 7 | 41-48 | DSS(6) | I8 | 1 | Messages that DSS files are opened or closed. |
|   |     |        |    | blank,0,2 | Error and warning messages (default). |
|   |     |        |    | 3 | Pathnames to MSS file as DSS records are written. |
|   |     |        |    | 4 | Pathnames to MSS file as DSS records are read. |
|   |     |        |    | 7 | Beginning level of DSS debugging messages. |
|   |     |        |    | 8 | Intermediate level of DSS debugging messages. |
|   |     |        |    | 9 | Maximum level of DSS debugging messages. |
| 8 | 49-56 | DSSMONTH | 5x,A3 | AN | First month in DSS file (JAN, FEB, MAR, ... , DEC) |
|   |     |        |    | blank | The default first month label is JAN |

Without an *OF* record, *SIM* simulation results are written to an OUT file to be read by *TABLES*. The *OF* record creates output files with filename extensions SOU and DSS which are not read by *TABLES*. A DSS (Data Storage System) file is read by *HEC-DSSVue*. A *SOU* file is in text format read by any editor. The OUT, SOU, and DSS files contain the same simulation results output data, but in different formats. Variables included in the simulation results are defined in *Reference Manual* Table 5.1 and *Users Manual* Table 4.10 and are also listed here on page 50.

*OF* record field 5 activates another optional feature which converts the naturalized flows and net evaporation-precipitation depths read from *IN* and *EV* records to a DSS hydrology input file. The file conversion is performed by an execution of *SIM* without performing the simulation. INEV option 6 in *JO* record field 2 specifies reading of hydrology data from a previously created DSS file for an actual *SIM* simulation.

#### **Explanation of OF Record Fields**

***Field 2***:  Without the *OF* record, *SIM* always creates either an OUT or CRM output file. With an optional *OF* record, the conventional OUT file is created only if activated in *OF* record field 2.

**Field 3**: The SOU file created by DSS(2) contains the same time series of simulation results as the OUT file but in a different format. The first and second columns of each table in a SOU file are the year and month and the subsequent columns are the corresponding values for each output variable. The SOU file is a text file which can be read with any editor but not by *TABLES*. The columns of output data can also be easily transported to a Microsoft Excel spreadsheet.

**Field 4**: The DSS output file contains the same simulation results as the OUT and SOU files but in a format that can be read only by *HEC-DSSVue* or other Hydrologic Engineering Center (HEC) Data Storage System (DSS) software. The time series of simulation results can be plotted, tabulated, or manipulated within HEC-DSSVue. The parts of a DSS pathname are always referenced as /A/B/C/D/E/F/ which are automatically defined within *SIM* as follows.

> A − filename root
> B − control point, water right, or reservoir identifier
> C − type of data such as NAT, REG, UNA, shown in parenthesis on preceding page
> D − starting date (day=1/month/year)
> E − 1MON specifying monthly time step
> F − CP, WR, or RES specifying control point, water right, or reservoir output record

**Field 5**: Output variables are listed on the preceding page as well as in Table 5.1 of the *Reference Manual* and Table 4.10 of this *Users Manual*. If *OF* record field 5 is blank, the default set of variables listed on the preceding page is included in the SOU and DSS files. With a 1 entered for DSS(4) in field 5, the DSS and SOU files contain all of the variables. With a DSS(4) of 2 or greater, the DSS file is limited to the first DSS(4) variables in the lists. The labels shown in parenthesis on the preceding page are used as identifiers in the DSS pathnames and SOU table headings and correspond to the time series record identifiers in Table 4.10.

**Field 6**: The special feature activated by field 6 converts FLO and EVA input files to a hydrology input DSS file with the filename rootHYD.DSS. With a 1 entered in field 6, *SIM* does nothing but create the hydrology input file; the simulation is not performed. Naturalized flows and net evaporation-precipitation rates are read from *IN* and *EV* records in FLO and EVA files or a DAT file and written to the DSS file. This DSS file is then read by *SIM* in subsequent simulations. The parts of a DSS pathname are always referenced as /A/B/C/D/E/F/ which are automatically defined for hydrology input files within *SIM* as follows.

> A − filename root with HYD appended
> B − control point identifier
> C − IN or EV indicating flows (IN records) or net evaporation rates (EV records)
> D − starting date (day=1/month/year)
> E − 1MON specifying monthly time step
> F − FLOW or EVAP specifying naturalized flow or net evaporation-precipitation

**Field 7**: DSS(6) sets the level of DSS messages to be written to the MSS message file. A higher level incorporates all lower level messages. The default is level 2. Levels 3 or 4 will provide a listing of the DSS records as they are read or written. Levels 7, 8, and 9 provide debugging messages for DSS subroutines which WRAP users should hopefully never see or need.

**Field 8**: DSS data includes a label of the first month of the time series. If field 8 is blank, the default label is JAN. Either of the labels FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, DEC may optionally be entered to define the first month of the time series data.

## Simulation Results Monthly Variables
### Recorded in OUT, SOU, and DSS Files

Control Point Output Records (DSS file) or Table Columns (SOU file)

*Default List for DSS(4) = 0*
naturalized stream flow (NAT)
regulated stream flow (REG)
unappropriated stream flow (UNA)
end-of-month reservoir storage (STO)
diversion target (TAR)
diversion shortage (SHT)

*Complete List for DSS(4) = 1*
naturalized stream flow (NAT)
regulated stream flow (REG)
unappropriated stream flow (UNA)
channel loss credits (CLC)
channel losses (CLO)
return flows returned here (RFR)
upstream reservoir releases (URR)
control point inflows (CPI)
end-of-month reservoir storage (STO)
reservoir net evaporation volume (EVA)
stream flow depletions (DEP)
diversion target (TAR)
diversion shortage (SHT)
diversion amount (DIV)

Reservoir Output Records (DSS file) or Table Columns (SOU file)

*Default List for DSS(4) = 0*
end-of-month reservoir storage (STO)
net evaporation-precipitation volume (EVA)
net evaporation-precipitation depth (EPD)
reservoir water surface elevation (WSE)

*Complete List for DSS(4) = 1*
end-of-month reservoir storage (STO)
net evaporation-precipitation volume (EVA)
power shortage or secondary energy (HPS)
hydroelectric energy generated (HPE)
inflows from stream flow depletions (RID)
inflows from reservoir releases (RIR)
releases accessible to hydropower (RAH)
releases not accessible to hydro (RNA)
adjusted evaporation-precipitation depth (EPD)
net evaporation depths (EVR)
reservoir water surface elevation (WSE)

Water Right Output Records (DSS file) or Table Columns (SOU file)

*Default for WR Record Water Rights*
diversion target (TAR)
diversion shortage (SHT)
diversion or energy amount (DIV)
end-of-month reservoir storage (STO)
stream flow depletion (DEP)

*Default for IF Record Water Rights*
instream flow target (IFT)
instream flow shortage (IFS)

*Complete List for DSS(4) = 1*
reservoir storage volume (STO)
reservoir net evaporation volume (EVA)
stream flow depletion (DEP)
diversion or hydropower target (TAR)
diversion or energy shortage (SHT)
diversion or energy amount (DIV)
available stream flow (ASF)
releases from secondary reservoirs (ROR)
return flow (RFL) or instream flow target (IFT)
available increase (XAV) or IF shortage (IFS)

**ZZ** Record – Regulated and Available Flows in Water Right Priority Sequence

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | ZZ | Record identifier |
| 2 | 3-8 | ZZ | I6 | +<br>blank,0,1 | Number of control points.<br>Default is one control point. |
| 3 | 9-16 | ZZX | F8.0 | +<br>blank,0 | Change required to include right in output table.<br>All water rights are included in ZZZ file output table. |
| 4 | 17-32 | ZZWR | A16 | AN<br>blank,0 | Most junior water right included in the output table.<br>All water rights are included in ZZZ file output table. |
| 5<br>6-no limit | 35-40<br>41-no limit | ZZCP(Z)<br>Z=1,ZZ | 2x,A6 | AN | Identifiers of control points for which flows are<br>determined and tabulated in ZZZ file output table. |

A *SIM* feature described in Chapter 6 of the *Reference Manual* and controlled by the *ZZ* record is designed to facilitate assessments of the effects of each individual water right on regulated and available stream flows at specified control points. Regulated flows, available flows, and upstream reservoir releases are tabulated in a ZZZ file after each individual water right is simulated in the priority loop. Intermediate available flows in the water rights priority sequence become unappropriated flows after the most junior water right is simulated. The reservoir releases included in the table are a component of regulated flows and include only releases from reservoirs located at or upstream of a control point that are made to meet water right diversion, storage, or instream flow requirements at a control point located further downstream.

The ZZZ file table may be read directly with any editor. The *TABLES* 2ZZZ and 2ZZF records activate *TABLES* options for reading a ZZZ file and organizing the simulation results in optional time series formats or developing frequency tables.

### Explanation of ZZ Record Fields

***Fields 2 and 5***: Tables are created for one or more control points with identifiers listed in field 5 and subsequent fields. The number of control points is entered in field 2 with a default of one. A control point identifier must be entered in field 5 and additional identifiers may be entered in field 6 and subsequent fields. A stream flow tabulation is created for each control point listed.

***Fields 3 and 4***: With the default option, flows are tabulated each month at the beginning of the water rights priority loop and after each water right is simulated in the priority sequence. By default, all water rights from the most senior to the most junior are included in the tabulation. Options activated by *ZZ* record fields 3 and 4 are designed to limit the water rights included in the *ZZZ* file table to only pertinent rights. The parameter ZZX in *ZZ* record field 3 sets a minimum flow change required for a water right to be included in the table. Monthly flow volumes are tabulated after a water right is simulated only if the change in either the regulated flow, available flow, or upstream release equals or exceeds ZZX. If a water right identifier is entered in *ZZ* field 4, the tabulation stops after reaching that water right in the priority sequence.

**CO** Record − Control Point Output Records to be Included in Output File

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | CO | Record identifier |
| 2 | 7-8 | NCPOUT | I6 | + | Number of control point identifiers listed on *CO* records. NCPOUT is entered only on first *CO* record. Field 2 should always be blank on the second and subsequent *CO* records. |
| | | | | blank,0 | *CO* records are ignored if NCPOUT is zero. |
| 3-7 | 9-48 | CPOUID(J) J=1,5 | 5(2x,A6) | AN | Control point identifiers. Output records for cp's with these identifiers will be included in output file. |

**RO** Record − Reservoir/Hydropower Output Records to be Included in Output File

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | RO | record identifier |
| 2 | 7-8 | NREOUT | I6 | + | Number of reservoir identifiers listed on *RO* records. NREOUT is entered only on first *RO* record. Field 2 should always be blank on the second and subsequent *RO* records. |
| | | | | −1 | All reservoirs are included in output. |
| | | | | blank,0 | *RO* records are ignored if NREOUT is zero. |
| 3-7 | 9-48 | REOUID(J) J=1,5 | 5(2x,A6) | AN | Reservoir identifiers. Output records for reservoirs with these identifiers will be included in output file. |

The optional *CO*, *RO*, *WO*, and *GO* records are placed as a group between the *JD/JO* records and *UC* records. All *CO* records are grouped together. All *RO* records are grouped as a set. Likewise, all *WO* are grouped together, and all *GO* records are grouped together. It does not matter which of the four sets of records precede or follow the others. All are optional. The *CO*, *RO*, *WO*, and *GO* records are all organized in the same way.

Any number of *CO*, *RO*, *WO*, and *GO* records are used along with *JD* record fields 5-7 to select data to include in the simulation results written to the OUT, SOU, and/or DSS files. Any number of identifiers may be provided on any number of *CO*, *RO*, *WO*, and *GO* records, with five identifiers per record. However, no more than one *CO*, one *RO*, one *WO*, and one *GO* record can be used to specify in field 2 the number of control points, reservoirs, water rights or water right groups, respectively, to include. For example, 53 control point identifiers would be listed on 11 *CO* records with five identifiers on each of ten records and three on the 11th record. The integer 53 would be entered in field 2 of the first *CO* record.

**WO** Record  –  Water Right Output Records to be Included in Output File

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | WO | Record identifier |
| 2 | 7-8 | NWOUT | I6 | + | Number of water rights identifiers listed on *WO* records.  NWOUT is entered only on first WO record.  Field 2 should always be blank on the second and subsequent *WO* records. |
|   |   |   |   | blank,0 | *WO* records are ignored if NWOUT is zero. |
| 3-7 | 9-88 | WROUT(J) J=1,5 | 5A16 | AN | Water right identifiers.  Water right output records for rights with these identifiers will be included in output. |

**GO** Record  –  Groups of Water Rights Output Records to be Included in Output File

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | GO | Record identifier |
| 2 | 7-8 | NGOUT | I6 | + | Number of water rights identifiers listed on *GO* records.  NGOUT is entered only on first *GO* record.  Field 2 should always be blank on the second and subsequent *GO* records. |
|   |   |   |   | blank,0 | *GO* records are ignored if NGOUT is zero. |
| 3-7 | 9-48 | GROUP(J) J=1,5 | 5A8 | AN | Water right identifiers. Water right output records for rights with these identifiers will be included in output. |

Two sets of three optional water right identifiers are provided in fields 11-16 of the *WR* record. Only one of the two sets of three identifiers is read by *SIM*.  The selection of which of the two sets to use is specified by *IDSET* in *JD* record field 12.  Water right output records are selected by matching identifiers on *WO* records with the first identifier on the *WR* records and matching the *GO* record group identifiers with the second and third identifiers on the *WR* records.

#### Sequencing of *FY, XL, OF, ZZ, CO, RO, WO,* and *GO* Records in DAT File

*SIM* reads the *FY, XL, OF, ZZ, CO, RO, WO,* and *GO* records as the section of the DAT file that follows the *CR*/*JD/JO* records and precedes the *UC* records.  The *FY, XL, OF, ZZ, CO, RO, WO,* and *GO* records must all be inserted between the *CR*/*JD/JO* records and *UC* records but can otherwise be in any order, except multiple *CO, RO, WO,* and *GO* records should be grouped together.  For example, all *CO* records must be grouped together, and all *RO* records must be grouped together.  *FY, XL, OF,* and *ZZ* records are each a single record.

**UC** Record  –  Water Use Coefficients (12 monthly use distribution coefficients per record)

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | UC | Record identifier |
| 2 | 3-8 | USEID | A6 | AN | Identifier relates sets of use factors to the use type in field 4 of *WR* and *IF* records. |
| 3-14 | 9-104 | PDUSCF | 12F8.0 | + | Monthly water use coefficients for the 12 months. |

**UC** Records  –  Water Use Coefficients (two records with six monthly coefficients each)

*First **UC** Record*  –  Water Use Identifier and Monthly Distribution Coefficients for Months 1-6

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | UC | Record identifier |
| 2 | 3-8 | USEID | A6 | AN | Identifier relates sets of use factors to the use type in field 4 of *WR* and *IF* records. |
| 3-8 | 9-56 | PDUSCF (months 1-6) | 6F8.0 | + | Monthly water use coefficients for months 1-6. Six coefficients are entered on each of 2 UC records. |

*Second **UC** Record*  –  Monthly Distribution Coefficients for Months 7 through 12

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | UC | Record identifier |
| 2 | 3-8 |  | 6x |  | Field 2 of second record is not used. |
| 3-8 | 9-56 | PDUSCF (months 7-12) | 6F8.0 | + | Monthly water use coefficients for months 7-12. Six coefficients are entered on each of 2 UC records. |

A *UC* record with 12 coefficients or a pair of *UC* records with six coefficients each is provided for each water use type.  The two alternative forms of *UC* records are the same except for the number of coefficients included on each record.

The use identifier in field 2 of the single or first *UC* record corresponds to the use identifier in field 4 of the *WR* and *IF* records.  The set of 12 monthly factors is used to distribute an annual diversion, instream flow, or hydroelectric energy requirement over the 12 months of the year. *SIM* divides each monthly coefficient by the sum of the 12 coefficients to obtain a set of 12 monthly multipliers.

**UP** Record – Water Use Priority Adjustment Factors

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | UC | Record identifier |
| 2 | 3-8 | USEID | A6 | AN | Identifier connects sets of priority factors to the water use type in field 4 of *WR* and *IF* records. |
| 3 | 9-16 | USEP(I) | I8 | + | Priority number which overrides *WR/IF* field 5. |
| 4 | 17-24 | USEADD(I) | I8 | + | Integer number to be added to priority numbers. |
| 5 | 25-32 | USEMUL(I) | F8.0 | + | Factor by which to multiply priority numbers. |
| 6 | 33-40 | USEFAC(I) I=1,NUSES | F8.0 | + | Factor by which to multiply target amounts. |

*UP* records allow modifications to priorities set in field 5 of *WR* and *IF* records to be applied to selected types of water rights identified by the use type identifier in field 4 of the *WR* and *IF* records and field 2 of the *UP* record.

## Explanation of UP Record Fields

*Field 2*:  Priorities specified on *WR* and *IF* records can be overridden for groups of water rights with a particular water use identifier by the parameters entered on a *UP* record.  Water use type identifiers are specified in field 4 of *WR* and *IF* records and field 2 of the *UP* record.  The water use identifier in *UP* record field 2 must also either be also found in field 2 of a *UC* record or be the standard *NDAYS* or constant (blank) options associated with *WR* and *IF* record field 4.

*Field 3*:  For all water rights with the water use identifier entered in *UP* record field 2, the water use priority entered in *UP* record field 3 of replaces the priority number in field 5 of the *WR* or *IF* record.  *UP* record priorities supercede *WR* record priorities.

*Field 4*:  Priorities set by *WR* or *IF* records are revised by adding to them an integer number entered in *UP* record field 4.

*Field 5*:  Priorities set by *WR* or *IF* records are revised by multiplying by a factor entered in *UP* record field 5.

*Field 6*:  Diversion, instream flow, or hydropower targets from *WR* and *IF* records are multiplied by *USEFAC* from *UP* record field 6 if this field is not blank.  The default multiplier factor is 1.0.

## Sequencing of Sets of *UC*, *UP*, *RF*, *CP*, and *CI* Records in DAT File

The set of all *UP* records follows immediately behind the set of all *UC* records.
The set of all *RF* records follows next after the set of all *UP* records.
The set of all *CP* records follows next after the set of all *RF* records.
The set of all *CI* records follows next after the set of all *CP* records.

**RF** Record  –  Monthly Multipliers for Return Flows (12 factors per record)

| field | column | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | RF | Record identifier |
| 2 | 3-8 | RFID(wr) | A6 | AN | Identifier relates sets of return flow multipliers to field 8 of *WR* record.    [wr = 1,NWRTS] |
| 3-14 | 9-104 | RF (wr,M=1,12) | 12F8.0 | + | Monthly return flow factors for 12 months. |

**RF** Record  –  Monthly Multipliers for Return Flows (two records with six factors each)

*First RF Record*  –  Return Flow Coefficients for Months 1 through 6

| field | column | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | RF | Record identifier |
| 2 | 3-8 | RFID(wr) | A6 | AN | Identifier relates sets of return flow multipliers to field 8 of *WR* record.    [wr = 1,NWRTS] |
| 3-8 | 9-56 | RF (wr,M=1,6) | 6F8.0 | + | Monthly return flow factors for months 1-6 Six factors entered on first RF record, six on second. |

*Second RF Record*  –  Return Flow Coefficients for Month 7 through 12

| field | column | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | RF | Record identifier |
| 2 | 3-8 | | 6x | | Field 2 of second record is not used. |
| 3-8 | 9-56 | RF (wr,M=7,12) | 6F8.0 | + | Monthly return flow factors for months 7-12 Six factors entered on first RF record, six on second. |

*RF* records are required for each *RFIDWR* entered in field 8 of *WR* records for return flow options 3 and 4.  The diversion amount for a month is multiplied by the appropriate factor from the *RF* record to obtain the return flow.  The set of all *RF* records follows the of all *UP* records or the set of all *UC* records if there are no *UP* records.

**CI** Record – Constant Inflows and/or Outflows (12 monthly flows per record)

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | CI | Record identifier |
| 2 | 3-8 | CIID | A6 | AN | Control point identifier |
| 3-14 | 9-104 | CI(M=1,12) | 12F8.0 | +,– | Flow added to naturalized flow at control point CIID for month M. |

The set of all *CI* records follows the set of all *CP* records. Any number of optional *CI* records may be entered for any control point in any order. Two alternative *CI* record formats include 12 monthly flows on either one record or two records.

*SIM* adds flows on the *CI* records to the inflows to the naturalized stream flows at the specified control point and, with adjustments for channel losses, at all downstream control points.

**CI** Records – Constant Inflows and/or Outflows (two records with six monthly flows each)

*First **CI** Record* – Constant Inflows and/or Outflows for Months 1-6

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | UC | Record identifier |
| 2 | 3-8 | CIID | A6 | AN | Control point identifier |
| 3-8 | 9-56 | CI(M=1,6) | 6F8.0 | + | Monthly flows for months 1-6. Six flows are entered on each of two CI records. |

*Second **CI** Record* – Constant Inflows and/or Outflows for Months 7 through 12

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | UC | Record identifier |
| 2 | 3-8 | | 6x | | Field 2 of second record is not used. |
| 3-8 | 9-56 | CI(M=7,12) | 6F8.0 | + | Monthly flows for months 7-12. Six flows are entered on each of two CI records. |

**CP** Record  –  Control Point Information

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | CP | Record identifier |
| 2 | 3-8 | CPID(cp,1) | A6 | AN | Control point identifier   [cp = 1,NCPTS] |
| 3 | 11-16 | CPID(cp,2) | 2x,A6 | AN | Identifier of next downstream control point. |
|   |   |   |   | blank,OUT | Outlet. There is no control point downstream. |
|   |   |   |   | *Multiplier Factors* | |
| 4 | 17-24 | CPDT(cp,1) | F8.0 | + | Factor by which inflows on IN records are multiplied |
|   |   |   |   | blank,0 | Default factor = 1.0 |
| 5 | 25-32 | CPDT(cp,2) | F8.0 | + | Factor by which evaporation rates are multiplied |
|   |   |   |   | blank,0 | Default factor = 1.0 |
|   |   |   |   | *Method for Obtaining Naturalized Flows* | |
| 6 | 40 | INMETHOD (cp) | I8 | blank,0,1 | *IN* records are input for this control point. |
|   |   |   |   | 2 | Specifications are provided by *CPIN(cp)* in field 7. |
|   |   |   |   | 3 | Flow distribution equation is used. |
|   |   |   |   | 4 | NRCS CN method with synthesized flows limited to not exceed source control point flows |
|   |   |   |   | 5 | NRCS CN method without above noted flow limit |
|   |   |   |   | 6 | Channel loss coefficient with DAR method |
|   |   |   |   | 7 | Drainage area ratio method (areas from *WP* records) |
|   |   |   |   | 8 | NRCS CN method with channel losses |
|   |   |   |   | 9 | Control point flow does not limit available flow. |
| 7 | 43-48 | CPIN(cp) | 2x,A6 | AN | Control point from which *IN* records are repeated. |
|   |   |   |   | NONE | The words *none, zero, NONE, or ZERO* entered in this |
|   |   |   |   | ZERO | field indicate zero stream flows at this control point. |
|   |   |   |   | *Method for Obtaining Net Evaporation-Precipitation* | |
| 8 | 51-56 | CPEV(cp) | 2x,A6 | blank | *EV* records are read as input. |
|   |   |   |   | AN | Control point from which *EV* records are repeated. |
|   |   |   |   | NEXT | *EV* records for next downstream cp are repeated. |
|   |   |   |   | NONE | The words *none, zero, NONE, or ZERO* in this field |
|   |   |   |   | ZERO | indicate zero net evaporation at this control point. |
|   |   |   |   | *Evaporation-Precipitation Adjustment* | |
| 9 | 57-64 | EWA(cp) | F8.0 | blank,0 | Default set by *JD* record field 10 is used. |
|   |   |   |   | −1.0 | Ungaged CP from *FD* record field 2 is used. |
|   |   |   |   | −2.0 | Gaged CP from *FD* record field 3 is used. |
|   |   |   |   | −3.0, <−3.0 | No adjustment. (Overrides non-blank *JD* field 10) |
|   |   |   |   | + | Watershed area in acres for E-P adjustment. |
|   |   |   |   | *Channel Loss Factor* | |
| 10 | 65-72 | CL(cp) | F8.0 | + | Channel loss factor for stream reach below CP. |
|   |   |   |   | blank | The default channel loss factor value is 0.0. |
|   |   |   |   | *Watershed Areas on WP Records* | |
| 11 | 73-80 | INWS(cp) | I8 | blank,0 | Parameters on WP record are for the total watershed. |
|   |   |   |   | + | Parameters on WP record are for incremental watersheds.  (any positive integer) |

## Explanation of CP Record Fields

A *CP* record is required for each and every control point. The control points may be entered in any order, but all *CP* records must be grouped together separated by nothing except ** records.

*Field 2*: The six alphanumeric character identifier of the control point is entered on various other types of records to designate location.

*Field 3*: The control point located immediately downstream of each control point is designated in order for the model to delineate the spatial configuration of the river system.

*Field 4, 5*: The naturalized flows from the *IN* records and net evaporation depths from *EV* records are multiplied by factors in fields 4 and 5 that could be unit conversions, drainage area ratios, or other factors.

*Field 6*: Naturalized flows at a control point may be provided as input on *IN* records or synthesized within the model by optional methods selected by field 6. Option 9 allows a control point without stream flow data to be excluded from the available flow computations.

*Field 7*: The naturalized stream flows at a control point may be repeated from those provided at another control point or set at zero.

*Field 8*: The evaporation-precipitation depths at a control point may be repeated from another specified control point or from the nearest downstream control point with data or set at zero.

*Field 9*: A methodology described in Chapter 3 of the *Reference Manual* adjusts the evaporation-precipitation depths from the *EV* records for runoff from the land area covered by a reservoir that is reflected in the naturalized stream flows to prevent double-counting. *EWA(cp)* of −1 or −2 results in the runoff depth adjustment being computed by dividing the naturalized stream flow by watershed area as defined by *FD* records. For *EPADJ* = −1, the ungaged control point of *FD* record field 2 is used. For *EPADJ* = −2, the gaged control point in *FD* record field 3 record is used. For either option, the control point in field 2 of the *CP* record connects to the control point in field 2 of the *FD* record. However, for ungaged control points, the runoff depth computations may be based on flow/area at either the ungaged or gaged site.

*EPADJ* in *JD* record field 10 sets the default used to correct the evaporation-precipitation depths. The option specified in the *JD* record field 10 is used for all control points for which the *CP* record field 9 is blank [*EWA(cp)*=0]. *EWA(cp)* entered in field 9 of a *CP* record supersedes the default set in field 10 of the *JD* record.

*Field 10*: The channel loss in a river reach is defined as the flow at the upstream control point multiplied by the channel loss factor entered in *CP* record field 10 for the upstream control point.

*Field 11*: The drainage area, curve number, and mean precipitation provided on watershed parameter WP records in a DIS file are used to distribute flows from gaged to ungaged control points. *CP* record field 11 is used to indicate whether these watershed parameters are for the total watershed above the control point or incremental subwatersheds between control points. The default is total watersheds.

**WR** Record  −  Water Right

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | WR | Record identifier |
| 2 | 3-8 | CP | A6 | AN | Control point identifier |
| 3 | 9-16 | AMT | F8.0 | 0,+ | Diversion (types 1-3 in field 6), inflow (type 4), hydropower (types 5-6), or storage (type 7) target |
| 4 | 19-24 | USE | 2x,A6 | blank | Monthly target is 1/12 of annual AMT in field 3. |
|   |   |   |   | AN | Use type identifier to connect to *UC* and *UP* records |
|   |   |   |   | NDAYS | Distribution based on number of days in each month |
|   |   |   |   | XMONTH | Monthly rather than annual target in field 3 |
| 5 | 25-32 | WRNUM(wr,7) | I8 | −,0,+ | Priority number |
| | | | | | *Water Right Type* |
| 6 | 36 | WRNUM (wr,5) | I4 | blank,0,1 | Type 1 water right (refills reservoir storage) |
|   |   |   |   | 2 | Type 2 water right (no refilling storage) |
|   |   |   |   | 3 | Type 3 water right (no stream flow depletions) |
|   |   |   |   | 4 | Type 4 water right (inflow to river system) |
|   |   |   |   | 5, −1 | Type 5 water right (hydroelectric power) |
|   |   |   |   | 6, −3 | Type 6 water right (hydroelectric power) |
|   |   |   |   | 7 | Type 7 water right (target sets storage capacity) |
| | | | | | *Return Flow Specifications* |
| 7 | 40 | RFMETH (wr) | I4 | blank,0,1 | Constant factor, flows returned same month |
|   |   |   |   | 2 | Constant factor, flows returned next month |
|   |   |   |   | 3 | Monthly factors, flows returned same month |
|   |   |   |   | 4 | Monthly factors, flows returned next month |
| 8 | 41-48 | RFAC | F8.0 | + | Constant return flow factor |
|   |   | RFIDWR | 2x,A6 | AN | Identifier on RF record for monthly factors |
| 9 | 51-56 | RCP | 2x,A6 | blank | Flow returned to next downstream control point |
|   |   |   |   | AN | Identifier of control point to return flow |
| | | | | | *Drought Index* |
| 10 | 63-64 | DINDEX(wr) | 6x,I2 | blank,0 | Drought index is not used for this water right. |
|   |   |   |   | +,− | Integer identifier of drought index. *DI* record field 2. If positive, the drought index is applied as step 3 outlined on page 64.  A negative sign switches to applying the drought index as step 6 on page 64. |
| | | | | | *First Set of Identifiers* |
| 11 | 65-80 | WRID(wr) | A16 | AN | Water right identifier |
| 12 | 81-88 | WRIDS(,1) | A8 | AN | Optional water right group identifier |
| 13 | 89-96 | WRIDS(,2) | A8 | AN | Optional water right group identifier |
| | | | | | *Alternate Set of Identifiers (JD Record Field 12)* |
| 14 | 97-112 | WRID(wr) | A16 | AN | Alternate water right identifier |
| 15 | 113-120 | WRIDS(,1) | A8 | AN | Alternate second water right identifier  (group) |
| 16 | 121-128 | WRIDS(,2) | A8 | AN | Alternate third water right identifier  (group) |

### Explanation of WR Record Fields

**_Field 2_**:  The water right has access to available stream flow at this control point.  Stream flow depletions for diversions and maintaining storage for the right occur at this control point.

**_Field 3_**:  An annual diversion volume (type 1, 2 or 3), inflow volume (type 4), hydroelectric energy (type 5 or 6), or storage volume (type 7) target is converted within *SIM* to monthly targets by using *UC* record factors and may be further adjusted by options on other auxiliary records. With XMONTH entered in field 4, the target in field 3 is a monthly rather than annual amount. A −1 sets a very large AMT, which is greater than any possible stream flow.  Resulting targets and shortages are incorporated in the simulation but are not included in summations and output.

**_Field 4_**:  The water use identifier serves the sole purpose of connecting *WR* and *IF* records to *UC* and *UP* records.  Any alphanumeric identifier of 6 characters or less may be used along with the two following special cases.  If *WR* or *IF* record field 4 is blank, the 12 monthly water use factors default to a uniform 1/12.  If the term *NDAYS* is entered in *WR* or *IF* record field 4, the 12 factors otherwise read on the *UC* records are set at the number of days in each month starting with January (31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31).  *SIM* divides these factors by their sum of 365 to obtain the monthly multiplier factors.

XMONTH or xmonth in field 4 indicates that the target in field 3 is already a monthly amount.

**_Field 5_**:  The priority number is an integer reflecting relative priorities that governs the order in which water rights are considered in the simulation.  A blank field 5 assigns a priority of zero, which is treated like any other integer number.  The priority in field 5 may be over-ridden or adjusted by factors entered on the *UP* record.  Priorities may also be replaced by the upstream-to-downstream natural priority option activated by *JO* record field 9.

**_Field 6_**:  The water right types defined in *Reference Manual* Chapter 4 specify rules for meeting water right requirements.  The default type 1 right allows a diversion target to be supplied from stream flow depletions and/or storage in one or more reservoirs.  The diversion is met from stream flow to the extent that stream flow is available and then from storage.  One primary reservoir can be refilled from stream flow depletions and releases from other system reservoirs. The diversion and primary reservoir must be at the control point (field 2) with both having access to available stream flow at that control point.  Types 2 and 3 rights do not refill storage and thus do not have to be at the same control point as the reservoir.  A type 2 right is supplied by stream flow depletions at the *WR* record field 2 control point and releases from storage in one or more reservoirs.  A type 3 right is supplied only by releases from reservoir storage.

Types 5 and 6 rights are similar to types 1 and 3 rights except hydroelectric power generation replaces the diversion target.  A type 4 right discharges water into the stream.  Type 7 rights refill a reservoir to a monthly target storage capacity determined the same way as a diversion target.

**_Fields 7, 8, 9_**:  All or a portion of the diversion may be returned to the river system at the same control point as the diversion or at any other control point.  Hydropower releases are also treated as return flows.  The optional methods are outlined in Chapter 4 of the *Reference Manual*.

**_Field 10_**:  The drought index in field 10 assigns a set of *DI/IS/IP* records to the water right.  The drought index in *WR* field 10 or *IF* field 8 connects to the *NDI* entered in *DI* record field 2.

**_Fields 11-16_**:  Water right identifiers are described in Chapter 2 of this *Users Manual*.

**IF** Record – Instream Flow Requirement

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | IF | Record identifier |
| 2 | 3-8 | CP | A6 | AN | Control point identifier |
| 3 | 9-16 | AMT | F8.0 | + | Annual minimum instream flow target |
| 4 | 19-24 | USE | 2x,A6 | blank | Monthly target is 1/12 of annual AMT in field 3. |
| | | | | AN | Use type identifier to connect to *UC* and *UP* records |
| | | | | NDAYS | Distribution based on number of days in each month |
| | | | | XMONTH | Monthly rather than annual target in field 3 |
| 5 | 25-32 | WRNUM(7) | I8 | –,0,+ | Priority number |
| | | | | | *Parameters Defining Instream Flow Requirements* |
| 6 | 36 | WRNUM (wr,10) | I4 | Blank,0,1 | Junior *IF* target at cp replaces preceding senior target. |
| | | | | 2 | Largest *IF* record target at control point is adopted. |
| | | | | 3 | Smallest *IF* record target at control point is adopted. |
| 7 | 39-40 | IFMETH (wr) | I4 | blank,0,1 | Constraints on water availability during first pass |
| | | | | 2 | Constraints on water availability during second pass |
| | | | | –2 | Constraints during both first and second passes |
| | | | | 3 | Constraints during first pass, reservoir storage used |
| | | | | 4 | Constraints during second pass, reservoir storage |
| | | | | –4 | Constraints during both first and second passes |
| 8 | 44 | IFFLAG2 (wr) | I4 | blank,0 | Instream flow limit is based on total regulated flow. |
| | | | | 1,non-zero | Reservoir releases for downstream use are excluded. |
| 9 | 47-48 | DINDEX (wr) | I4 | blank,0 | Drought index is not used for this water right. |
| | | | | +,– | Integer identifier of drought index. *DI* record field 2. If positive, the drought index is applied as step 3 outlined on page 64. A negative sign switches to applying the drought index as step 6 on page 64. |
| | | | | | *Water Right Identifier* |
| 10 | 49-64 | WRID(wr) | A16 | AN | Water right identifier (optional) |

The data entered in fields 1, 2, 3, 4, 5, 9, and 10 of the *IF* record are similar for both *IF* and *WR* record water rights. These common variables are explained on the preceding page. *IF* record fields 6, 7, and 8 dealing specifically with instream flow right computations are discussed below.

Field 6 is pertinent only if more than one *IF* record with associated *FS*, *TO*, *TS*, *SO*, and *WS* records assigns a target for the same control point. As the multiple *IF* records (with auxiliary *FS*, *TO*, *TS*, *SO*, *WS* records) at the same control point are activated in the water rights priority sequence each month, the field 6 parameter controls the combination of *IF* record minimum instream flow targets. With the default option 1, the current *IF* record target replaces all other targets set at the control point by other more senior *IF* record rights. With option 2, the largest of the new versus preceding target is adopted. With option 3, the *IF* record instream flow target is adopted only if it is smaller than the target already set by the preceding more senior *IF* right.

*IF* record field 7 *IFMETH* options 1 and 2 constrain stream flow depletions by all junior rights to protect instream flow targets but do not require releases from storage.  Options 3 and 4 result in releases from storage in reservoirs identified by *WS* records associated with the *IF* record to mitigate instream flow shortages.

*IFMETH* options 2, –2, 4 and –4 exist for the sole purpose of partially mitigating the problems of (1) senior *WR*-record rights not having access to water made available by junior *WR*-record rights through either same-month option diversion return flows or same-month option hydropower releases and (2) the contribution of reservoir releases not being credited in meeting instream flow targets at intermediate control points between the dam and diversion site assuming *IFFLAG2* is zero (blank field 8).  *IFMETH* options 1 and 3 should be used if these problems are not a concern and perhaps even if these problems are a concern.

*IFMETH* options 2 and 4 involve a possible repeat of the simulation, which is called a second pass through the water rights loop.  Instream flow requirements are not activated during the first pass, and a second pass with instream flow requirements activated is performed if and only if at least one instream flow shortage occurs during the first pass.  Options –2 and –4 mean that the instream flow requirements are activated for the first pass as well as second pass.  *PASS2* in *JO* record field 10 forces a second pass in all months regardless of the *IF* record *IFMETH* option.

Warning:  With *IFMETH* options 2 and 4, instream flow requirements are not reflected in unappropriated flows for months without a second pass.

### Building Diversion, Instream Flow, and Hydropower Targets

Various options may be applied individually or in combination to define targets for water supply diversions (*WR* record type 1, 2, or 3), discharge into a stream (*WR* type 4), hydroelectric energy (*WR* type 5 or 6), refilling storage (*WR* type 7), or minimum instream flows (*IF* record).  Targets are normally associated with diversion, hydropower, and instream flow requirements.  However, type 4 discharge and type 7 storage targets are computed the same way as the others.  For *WR* record rights, a target is set by a single *WR* record along with auxiliary optional *SO*, *TO*, *TS*, *FS*, *DI*, and *BU* records.  For *IF* record water rights, a minimum instream flow target at a control point is likewise set by an *IF* record, along with its optional supporting *SO*, *TO*, *TS*, *FS*, or *DI* records, but the instream flow target can be defined within the water rights priority sequence by multiple *IF* records at the same control point.  A target may be set by combining *IF* records.

Targets for most rights are set simply by applying only the first step outlined below.  More complex requirements are modeled by exercising ingenuity in combining multiple options within the framework outlined below.  In comparing targets determined in different ways, either the smallest or largest may be adopted or targets may be combined through arithmetic operations.  A monthly target is set in *SIM* in a procedure consisting of the following sequential steps.

1.  The model combines the annual amount *AMT* entered in field 3 of the *WR* or *IF* record with a monthly multiplier determined from *UC* record distribution coefficients to obtain a target for a particular month.  *UC* records are not required if the target is constant over the year.

2.  The backup right *BU* record activates the backup option as this second step in the target building routine or alternatively as step 9.  The shortages incurred by one or more other specified rights are added to the target of the current right determined in step 1 above.

3.  The optional drought index defined by a set of *DI/IS/IP* records modifies the target determined in required step 1 and optional step 2 above as a function of reservoir storage. Alternatively, a negative *DINDEX* entered on the *WR/IF* record switches application of the drought index until step 6 below.

4.  One or multiple *TO* records may be used to continue to build a diversion or instream flow target. As specified by *TOTARGET* in field 2 of the *TO* record, the target is defined as a function of naturalized, regulated, or unappropriated stream flow, reservoir storage or drawdown, or water taken by another water right. The *TO* record based diversion or instream flow target is combined with the target determined in the preceding steps by either taking the maximum or minimum of the two targets or by adding them together as specified by *TOCOMB*. Lower and upper limits are placed on the stream flow/storage-based targets by fields 5 and 6, if these fields have positive (non-blank) entries. The first two of the three different applications of the fields 5 and 6 limits described on the next page are applied here. The third variation is activated by TOTARGET=10 with the limits applied later as step 7.

    The continuation option (*TOCONT*=CONT in *TO* field 10) allows the target building to continue using the next *TO* record. The target developed based on the next record is added to or subtracted from the previously computed target or alternatively the maximum or minimum value is adopted or the *TO* fields 5 and 6 limits applied. The *TO* record target building may be repeated any number of times. Each new intermediate target is combined with the preceding cumulative intermediate target.

5.  A time series of monthly targets for each month of the hydrologic period-of-analysis may be entered on *TS* records. The manner in which a *TS* record target is combined with the preceding intermediate (steps 1-4 above) target is specified by *TSL* entered in the field 2 of the *TS* record for the first year.

    *   The phrase *MAX* entered for variable *TSL* in *TS* record field 2 specifies adoption of the greater of the steps 1-4 intermediate target or the step 5 target from the *TS* record.

    *   Entering *MIN* for *TSL* specifies adoption of the lesser of the steps 1-4 versus step 5 values.

    *   Entering *ADD*, *MUL*, or *SUB* for *TSL* specifies adding or multiplying the steps 1-4 and step 5 targets or subtracting the step 5 values from the steps 1-4 values.

6.  A drought index defined by a set of *DI/IS/IP* records modifies the target determined above as a function of the storage content of specified reservoirs. The drought index may be applied at this sixth step of the sequence or as step 3 above.

7.  *TOTARGET*=10 in *TO* record field 2 results in *TO* record fields 5 and 6 limits being applied at this point in the computations as discussed on the next page.

8.  A flow switch *FS* record may modify the target based on the total volume of regulated, naturalized, or unappropriated flows, stream flow depletions, or diversions accumulated in the current month and/or during a specified preceding number of months.

9.  The *BU* record backup feature allows the shortage from one or more other rights to be added to the target determined as outlined above. Optionally, the backup may be applied as step 2.

### *TO Record Lower and Upper Limits on Targets*

The lower and upper limits on targets specified in *TO* record fields 5 and 6 are applied in step 7 for *TOTARGET* option 10 and otherwise in step 4.  With the first two options listed below applied in step 4 described on the preceding page, the limits are imposed upon completion of the other step 4 adjustments specified by a particular *TO* record.  Different limits may be specified for each individual *TO* record in a series of multiple *TO* records in step 4.

- With option *LIM* entered in *TO* record field 4, the target computed in step 4 is adopted if it falls between the lower and upper limits; otherwise the target is set at zero.

- Without *LIM* in *TO* field 4 and without 10 in field 2, *TO* record fields 5 and 6 limits are also applied in step 4.  If the target would otherwise fall below the lower limit, it is set at the lower limit.  If the target is otherwise greater than the upper limit, it is set at the upper limit.

- With *TOTARGET* option 10 in *TO* record field 2, *TO* record fields 5 and 6 lower and upper limits are imposed upon the computed target amount as step 7.  If the target computed in steps 1 through 6 would otherwise fall below the lower limit, it is set at the lower limit.  If the target would otherwise be greater than the upper limit, it is set at the upper limit.

### *FS Record Adjustments Based on Accumulative Flow Volume*

The *FS* record features are motivated primarily by instream flow requirements that switch on or off depending on current and/or preceding flow conditions.  However, either instream flow, diversion, or hydropower targets may be modified by multiplying the target set by *WR* or *IF* and supporting records by one of two factors selected based on whether or not the total accumulative volume of a user-selected variable at a specified control point falls within a defined range.  Options are provided for defining the time period over which the monthly switch variable flows are summed to obtain the total cumulative volume.  The flow accumulation period may include the current period in which the target is being set and/or any number of preceding periods.  Optionally, the flow accumulation period may be limited to a specified season of the year.

### *SO Record Limits on Diversions, Stream Flow Depletions, and Regulated Flows*

*MONDEP* and *ANNDEP* in *SO* record fields 7 and 8 place monthly and annual or seasonal limits on stream flow depletions taken by a particular water right. Constraints are placed on diversions by the annual/seasonal diversion limit *ADL(wr)* from *SO* record field 10 and the monthly and annual/seasonal reservoir withdrawal limits *MRW(wr)* and *ARW(wr)* from the *SO* record fields 7 and 8.  For an instream flow *IF* record right, *ADL(wr)* is a regulated flow limit.  Seasons are defined by *LM(wr,1)* and *LM(wr,2)* from *SO* fields 11 and 12.  For a *WR* record right, starting with the first month of each year or season, the total cumulative amount diverted by a right that year/season is recorded.  Further diversions are curtailed upon reaching the limit *ADL(wr)*.  Likewise, the cumulative annual amount diverted from reservoir storage each year or season is limited to *ARW(wr)*.  For an *IF* record right, the total regulated stream flow is accumulated, and the instream flow requirement is deactivated upon reaching the limit *ADL(wr)*.  The dual simulation options of *SO* field 14 or the *PX* record allow stream flow depletions determined during an initial simulation to serve as limits on depletions during a subsequent simulation.

**SO** Record  –  Supplemental Water Right Options

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | SO | Record identifier |
| | | | | | *Option for Limiting Water Availability* |
| 2 | 3-8 | WSHED (wr) | F6.0 | + | Drainage area ratio or other naturalized flow multiplier. |
| | | | | blank | Watershed flow limit option not used. |
| | | | | | *Stream Flow Depletion Limits* |
| 3 | 9-16 | MONDEP (wr) | F8.0 | + | Monthly maximum limit on stream flow depletions. |
| | | | | blank,0 | Either there is no monthly limit on stream flow depletions or limits are entered on a *ML* record. |
| 4 | 17-24 | ANNDEP (wr) | F8.0 | + | Annual or seasonal limit on stream flow depletions. |
| | | | | blank,0 | No annual/seasonal limit on stream flow depletions. |
| | | | | | *Alternate Control Point for Stream flow Depletions* |
| 5 | 27-32 | ACPID | 2x,A6 | AN | Identifier of alternative control point for stream flow. |
| | | | | blank,0 | Control point specified in field 2 of *WR/IF* record. |
| | | | | | *Backup Water Right* |
| 6 | 35-40 | BACKUP | 2x,A6 | BACKUP | Shortages for another specified right are added to the target at the end of target building process. |
| | | | | BFIRST | Shortages for another specified right are added to the target at the beginning of target building process. |
| | | | | RETURN | Diversion shortages for another right multiplied by RFAC (default=1.0) to be subtracted from target for type 4 right.  Used only for type 4 right. |
| | | | | blank | Feature is not used, or *BU* record version is used. |
| | | | | | *Reservoir Withdrawal Limits* |
| 7 | 41-48 | MRW(wr) | F8.0 | + | Monthly limit on withdrawals from reservoir storage. |
| 8 | 49-56 | ARW(wr) | F8.0 | + | Annual/seasonal limit on withdrawals from storage. |
| | | | | | *Targets and Shortages Written to Output File* |
| 9 | 64 | ISHT(wr) | I8 | blank, 0, 9 | Last target and shortage computed is in output file. |
| | | | | 1 | Target and shortage written to output file based on *AMT* from *WR* record field 3 after step 1 of the target building process described on pages 63-64. |
| | | | | 2 | After applying *BFIRST* backup option (after step 2). |
| | | | | 3 | After applying drought index (after step 3). |
| | | | | 4 | After applying options on *TO* record (after step 4). |
| | | | | 5 | After *TS* records (after step 5). |
| | | | | 6 | After applying drought index (after step 6). |
| | | | | 7 | After applying options on *TO* record (after step 7). |
| | | | | 8 | After applying options on *FS* record (after step 8). |
| | | | | | *Diversion or Instream Flow Limits* |
| 10 | 65-72 | ADL(wr) | F8.0 | + | Annual or seasonal diversion limit for *WR* record. |
| | | | | + | Annual or seasonal regulated flow limit for *IF* record. |

**SO** Record  –  Supplemental Water Right Options (Continued)

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| | | | | | *ANNDEP(wr), ARW(wr), ADL(wr) Seasons* |
| 11 | 79-80 | LM(wr,1) | I8 | blank,0,1 | Season begins in the first month of the year. |
| | | | | 1-12 | Month of year defining beginning of single season. |
| | | | | –1 to –9 | Cyclic season with length defined by *LM(wr,2)*. |
| 12 | 87-88 | LM(wr,2) | I8 | blank,0,12 | Season ends in the last (12th) month of the year. |
| | | | | 1-12 | Month of year defining ending of single season. |
| | | | | | Length of season if *LM(wr,1)* is negative. |
| | | | | | *Options to Not Apply Features for this Right* |
| 13 | 89-96 | NOTFLAG | A6 | NOCLWR | Channel losses are not applied to stream flow depletions and return flows for this water right. |
| | | | | NORFCL | Channel losses are not applied to just return flows. |
| | | | | IFNOTA | Instream flow *IF* rights do not restrict this *WR* right. |
| | | | | NONSFD | Negative stream flow depletions at set to zero. |
| | | | | NEGSFD | Negative stream flow depletions are not at set to zero. |
| | | | | | *Dual Simulation (Same as PX Record Field 2)* |
| 14 | 97-104 | DUAL(wr) | I8 | *PX* Record field 2 | The dual simulation feature is activated the same by either *PX* record field 2 or *SO* record field 14. |

### Explanation of SO Record Fields

*Field 2*:  A drainage area or other parameter ratio *WSHED* entered in field 2 activates the watershed flow option in which the stream flow available to the right is limited to the lesser of: (1) the naturalized stream flow at the control point of the right multiplied by the factor in field 2 and (2) available flow at this control point (*WR* or *IF* record field 2) and all downstream control points as normally computed.

*Fields 3 and 4*:  *MONDEP* and *ANNDEP* are used to specify monthly and annual or seasonal limits on the amount of stream flow that may be taken by the right.  Application of this option will typically involve filling storage in an off-channel reservoir, but may be applicable to other situations as well.

*Field 5*:  The alternate control point identifier (*ACPID*) allows stream flow depletions to be made at a control point other than the location indicated in field 2 of the *WR* record.  This option is applicable for a reservoir with stream inflows at the control point specified in field 2 of the *WR* record that also receives water through pipelines or canals from one or more other river/reservoir system locations.

*Field 6*:  An expanded version of the backup feature is activated by the recently added *BU* record.  The *RETURN* option has been replaced with the recently added *PX* record *XP* option 1. Though made basically obsolete by the *BU* and *PX* records, *SO* record field 6 can still be used.

*Fields 7 and 8*:  *MRW* and *ARW* are used to specify monthly and annual or seasonal limits on the maximum amount of water that may be withdrawn from reservoir storage by the right.

***Field 9***:  Targets are established in a series of optional steps activated by *SO*, *BU*, *DI*, *TO*, *FS*, and *TS* records.  Intermediate targets may be computed in the process of setting the actual target to be used in the simulation.  Only one of these targets and associated shortage are written to the *SIM* output file.  *ISHT(wr)* in *SO* record field 9 specifies which target and corresponding shortage to write to the output file.  The default (blank field 9) is to write the final target and shortage at the end of the computations to the output file.  A one in field 9 results in recording the monthly target initially derived from combining *AMT* from *WR* record field 3 with the distribution factors from *UC* records, which is described as step 1 on the preceding pages.  A 2 or 3 in *SO* record field 9 specifies use of the target after applying a backup right (step 2) or drought index (step 3) and so forth.  If the steps 2 through 9 options are not applied, the same step 1 target and shortage are written to the output file regardless of the *ISHT(wr)* entry in field 9.

*ISHT(wr)* in *SO* field 9 governs the choice of which monthly targets and shortages are written to the *SIM* output file.  The simulation computations are not affected in any way except for the back-up feature activated by a *BU* record or *SO* record field 6.  The shortage of the other rights added to the target of the back-up right is the shortage specified by *ISHT(wr)*.

***Field 10***:  When used with a *WR* record right, starting with the first month of each year or season, the total cumulative amount diverted by that right during that year or season is recorded.  Further diversions are curtailed upon reaching the limit specified by *ADL(wr)*.

When used with a *IF* record right, starting with the first month of each year or season, the total cumulative amount of regulated stream flow at that control point during that year or season is recorded.  The instream flow requirement is switched off upon reaching the limit specified by *ADL(wr)*.  The target specified by an *IF* and supporting records is valid as long as the *ADL(wr)* limit has not been reached.  The instream flow target is deactivated if the cumulative regulated flow at the *IF* record control point reaches *ADL(wr)* in the previous month.  Thus, for an *IF* record right, the *ADL(wr)* is a cumulative regulated flow limit with the *IF* requirements no longer being enforced after the month in which the accumulated flows reach or exceed the limit.

***Fields 11 and 12***:  Seasons defined by *LM(wr,1)* and *LM(wr,2)* are applicable to the limits on stream flow depletions *ANNDEP(wr)*, withdrawals from reservoir storage *ARW(wr)*, and diversions/regulated flows *ADL(wr)* in fields 4, 8, and 10.  Seasons range from 1 to 12 months.  If both *LM(wr,1)* and *LM(wr,2)* are blank or zero (default), the limits are annual based on amounts accumulated starting in month 1.  This is identical to *LM(wr,1)* and *LM(wr,2)* being set at 1 and 12, respectively.  Seasons of less than 12 months may be defined with *LM(wr,1)* and *LM(wr,2)* in two alternative ways as follows.

1.  Integers 1 to 12 define a single season extending from *LM(wr,1)* to *LM(wr,2)*.  For example, *LM(wr,1)*=6 and *LM(wr,2)*=8 define a season extending from June (month 6) through August (month 8).  *LM(wr,1)*=10 and *LM(wr,2)*=2 defines a season extending from November (month 10) through February (month 2).  The limits *ANNDEP(wr)*, *ARW(wr)*, and *ADL(wr)* are applied during the season extending from month *LM(wr,1)* to month *LM(wr,2)* by comparing to cumulative amounts that have been accumulated beginning in month *LM(wr,1)*.

2.  Another alternative method for defining seasons is activated by entering a negative integer for *LM(wr,1)* and a positive integer from 2 to 12 for *LM(wr,2)*.  The negative *LM(wr,1)* flags the choice of this alternative option.  The *LM(wr,2)* defines the length of a season in months.  Seasons begin in month 1 and repeat through the 12-month year.  For example, *LM(wr,1)* =

−1 (or any negative integer) and *LM(wr,2)*=3 divides the year into the following four seasons: months 1-3, months 4-6, months 7-9, and months 10-12. *LM(wr,1)*= −1 and *LM(wr,2)*=6 divides the year into the following two seasons: months 1-6 and months 7-12. If *LM(wr,2)* is greater than 6, only a single season is defined. For example, *LM(wr,1)*= −1 and *LM(wr,2)*=8 defines a season extending from month 1 through month 8. Thus, *LM(wr,1)*= −1 and *LM(wr,2)*=8 has the same effect as *LM(wr,1)*=8 and *LM(wr,2)*=12. The limits *ANNDEP(wr)*, *ARW(wr)*, and *ADL(wr)* are applied during each season by comparing to amounts that have been accumulated beginning in the first month of that season.

***Field 13***:  The parameter NOTFLAG switches off various modeling features for this particular water right.  Field 13 is designed to be used for experimentation or in special circumstances.

Entering *NOCLWR* results in channel losses not being applied to the stream flow depletions and return flows associated with this water right.  *NORFCL* results in channel losses being omitted for just the return flows.  These options affect only subroutine *AVALB* where downstream flows are adjusted for the effects of flows leaving or entering the stream at an upstream control point.

*IFNOTA* results in the right not being constrained by instream flow requirements.  This option facilitates assessment of impacts of instream flow requirements on particular *WR* record rights.

*NONSFD* and *NEGSFD* deal with negative stream flow depletions.  A negative net evaporation-precipitation depth from an *EV* record representing precipitation on a reservoir water surface exceeding evaporation combined with a reservoir filled to capacity may generate additional flow represented as a negative stream flow depletion.  *NONSFD* results in negative stream flow depletions being changed to zero.  With multiple refilling rights at the same reservoir, *SIM* normally limits negative stream flow depletions to the most junior right at the reservoir. *NEGSFD* allows multiple rights at the same reservoir to generate negative flow depletions.

**ML** Record  −  Monthly-Varying Limits on Stream Flow Depletions

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | ML | Record identifier |
| 2 | 3-8 | MSD(L,1) | F6.0 | + | Stream flow depletion limit for Month 1 |
| 3 | 9-16 | MSD(L,2) | F8.0 | + | Stream flow depletion limit for Month 2 |
| 4 | 17-24 | MSD(L,3) | F8.0 | + | Stream flow depletion limit for Month 3 |
| 5 | 25-32 | MSD(L,4) | F8.0 | + | Stream flow depletion limit for Month 4 |
| 6 | 33-40 | MSD(L,5) | F8.0 | + | Stream flow depletion limit for Month 5 |
| 7 | 41-48 | MSD(L,6) | F8.0 | + | Stream flow depletion limit for Month 6 |
| 8 | 49-56 | MSD(L,7) | F8.0 | + | Stream flow depletion limit for Month 7 |
| 9 | 57-64 | MSD(L,8) | F8.0 | + | Stream flow depletion limit for Month 8 |
| 10 | 65-72 | MSD(L,9) | F8.0 | + | Stream flow depletion limit for Month 9 |
| 11 | 73-80 | MSD(L,10) | F8.0 | + | Stream flow depletion limit for Month 10 |
| 12 | 81-88 | MSD(L,11) | F8.0 | + | Stream flow depletion limit for Month 11 |
| 13 | 89-96 | MSD(L,12) | F8.0 | + | Stream flow depletion limit for Month 12 |

Stream flow depletions for refilling reservoir storage and diversions, associated with a water right (*WR* record) are constrained by these maximum allowable limits in each month.  If the limit is the same in all months, it may entered as variable *MONDEP* in field 3 of the *SO* record.

**TO** Record  –  Target Options

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | TO | Record identifier |
| | | | | | *Stream Flow at Control Point from Field 7* |
| 2 | 7-8 | TOTARGET | I6 | 1 | Target based on same-month naturalized stream flow. |
| | | (n) | | −1 | Target based on prior-month naturalized stream flow. |
| | | | | 2 | Target based on same-month regulated stream flows. |
| | | | | −2 | Target based on prior-month regulated stream flows. |
| | | | | 3 | Unappropriated stream flows same month. |
| | | | | −3 | Unappropriated stream flows previous month. |
| | | | | | *Reservoir Specified in Field 8* |
| | | | | 4 | Target based on reservoir storage in same month. |
| | | | | −4 | Reservoir storage in previous month. |
| | | | | 5 | Target based on reservoir drawdown in same month. |
| | | | | −5 | Reservoir drawdown in previous month. |
| | | | | | *Water Right Specified in Field 9* |
| | | | | 6 | Target based on stream flow depletion for month. |
| | | | | 7 | Target based on seasonal/annual depletion to date. |
| | | | | −7 | Cumulative flow depletion excludes current month. |
| | | | | 8 | Based on withdrawal from storage for month. |
| | | | | 9 | Based on seasonal withdrawal from storage to date. |
| | | | | −9 | Cumulative withdrawal excludes current month. |
| | | | | 11 | Target based on diversion for month. |
| | | | | 12 | Target based on cumulative diversion to date. |
| | | | | −12 | Cumulative diversion excludes current month. |
| | | | | | *Minimum and Maximum Limits on Target* |
| | | | | 10 | Fields 5&6 limits applied as step 7 on page 64. |
| | | | | | *Multiplier Factor* |
| 3 | 9-16 | FACT(n) | F8.0 | + or − | Factor multiplied by field 2 amount (default=1.0) |
| | | | | | *Apply Limit or Combine with Intermediate Target* |
| 4 | 17-24 | TOCOMB (n) | 5x,A3 | Blank, SET | This is the target, no preceding intermediate target. |
| | | | | ADD, SUB | Target is added to or subtracted from previous target. |
| | | | | MUL, DIV | Previous target is multiplied or divided by this target. |
| | | | | MAX | Maximum of this versus preceding target is adopted. |
| | | | | MIN | Minimum of this versus preceding target is adopted. |
| | | | | LIM | *AMT* from *WR/IF* field 3 and *UC/DI* records applied if target falls within limits of *TO* fields 5 and 6 |
| | | | | | *Lower and Upper Limits* |
| 5 | 25-32 | TOLIM(n,1) | F8.0 | blank | No lower limit. |
| | | | | + | Lower limit on either target or quantity setting target. |
| | | | | −1 | Limit set at inflow to control point in field 7. |
| 6 | 33-40 | TOLIM(n,2) | F8.0 | blank | No upper limit. |
| | | | | + | Upper limit on either target or quantity setting target. |
| | | | | −1 | Limit set at inflow at control point in field 7. |

**TO** Record  –  Target Options (Continued)

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| | | | | | *Control Point, Reservoir, or Water Right Identifier* |
| 7 | 43-48 | TOFLOW | 2x,A6 | blank | Control point from *WR* record field 2 used for target. |
| | | | | AN | Control point of stream flow used to set target. |
| 8 | 51-56 | TORES(n) | 2x,A6 | AN | Identifier of reservoir used to set target (*TO* field 2). |
| 9 | 57-72 | TOWR(n) | A16 | AN | Identifier of water right used to set target (*TO* field 2) |
| | | | | | *Continue with Another TO Record* |
| 10 | 73-80 | TOCONT | A8 | blank | Continuation option is not used. |
| | | | | CONT | Following *TO* record continues building target. |

The *TO* record is included in the set of supporting records that follow a *WR* or *IF* record.  The sequencing of *SO*, *ML*, *BU*, *TO*, *FS*, *TS*, *PX*, *WS*, *HP*, and *OR* records are described on page 83. The target setting features controlled by the *TO* record are components of the step-by-step procedure for setting targets for diversions, instream flows, and hydropower production that is outlined on pages 63-64.

### Explanation of TO Record Fields

*__Field 2__*:  *TOTARGET* specifies whether the target is based on naturalized, regulated, or unappropriated flow at the control point specified in field 7, or storage or drawdown in the reservoir specified in field 8, or stream flow depletion, diversion, or withdrawal from storage incurred by the water right specified in field 9.  Any of these variables may be multiplied by *FACT(n)* from field 3.

A positive 1, 2, 3, 4, or 5 for *TOTARGET* flags use of stream flow or storage amounts in the current month at that stage in the water rights priority-based computation loop.  The regulated or unappropriated (available) flow or reservoir storage or drawdown values reflect the effects of only senior rights.  A negative integer flags the use of values from the preceding month.

With *TOTARGET* of 6, 7, 8, 9, 11, or 12, the target is based on another right's total stream flow depletion (6,7), withdrawal from reservoir storage (8,9), or from diversion (11,12), which may be either monthly amounts (6,8,11) or cumulative amounts since the beginning of the year (7,9,12). These are the latest amounts computed in the water right computation sequence for the right identified as *TOWR* in field 9.  The monthly amounts are volumes in the current month for rights that are senior to the *WR* or *IF* record right supplemented by the *TO* record and preceding-month amounts for junior rights, with the following exception.  Junior rights are affected by second pass options activated by *JO* record field 9 and *IF* record field 6.  For a junior *TOWR* right, the stream flow depletion, reservoir withdrawal, or diversion from the preceding month is used for the first pass.  The current-month amount from the first pass is used for the second pass.  For a senior *TOWR* right, amounts computed in the current-month are always used.

Options 7, −7, 9, −9, 12, −12 are based on an annual season defined by *SO* record fields 11 and 12, with the default being the entire year from month 1 through month 12.  A *TOTARGET* of −7, −9, or −12 in *TO* record field 2 is the same as entries of 7, 9, or 12, except the current month is

not included in the accumulative sum of depletions, withdrawals, or diversions since the beginning of the season or year. For *TOTARGET* options −7, −9, or −12, the current month is not included in the cumulative annual total. For options 7, 9, or 12, the current month is included in the cumulative annual total to date. The monthly amounts are volumes for either the current or preceding month as described in the preceding paragraph.

<u>*Field 3*</u>: The variable specified in field 2 is multiplied by the factor *FACT* in field 3 to set a diversion or instream flow target. The default (blank field 3) is a multiplier *FACT* of 1.0.

<u>*Field 4*</u>: *TOCOMB* specifies the manner in which the target resulting from this *TO* record is used. The default (blank field 4) is to simply set the target to the value computed (*TOCOMB* = SET). Alternatively, the target resulting from a *TO* record may be combined with a preceding cumulative intermediate target specified by the preceding *TO* record.

- The values may be added, the second subtracted from the first, or the first multiplied or divided by the second (*TOCOMB* = ADD, SUB, MUL, DIV). Negative results possible with subtraction are set equal to zero.

- Optionally, either the minimum or maximum adopted (*TOCOMB* = MAX, MIN).

- Optionally, (*TOCOM* = LIM), the *AMT* from the *WR* or *IF* record field 3 adjusted by use coefficient *UC* and drought index *DI* records is adopted if the *TOTARGET*-specified target falls between the limits entered in *TO* record fields 5 and 6, and otherwise the preceding *TO* record target (or zero if no prior *TO* record) is adopted.

<u>*Fields 5 and 6*</u>: The target limits may be applied in three different alternative ways described on page 65 either within step 4 (two alternatives) or as step 7 outlined on page 64.

The lower and upper limits on the target may be entered directly as numbers in fields 5 and 6. Alternatively, a –1 in either field 5 or 6 sets the target limit at the inflow to the control point in *TO* record field 7 in the current month exclusion of releases from secondary reservoirs located upstream of the control point for water rights located at or downstream of the control point. This inflow is the regulated flow less secondary reservoir releases plus the stream flow depletions at the control point at that point in the water right priority sequence computations.

<u>*Field 7*</u>: For *TOTARGET* (field 2) of 1, –1, 2, –2, 3, –3, the control point location of the stream flow is entered in field 7. If field 7 is blank, the control point of the water right target in field 2 of the *WR* or *IF* record is the stream flow location. The continuation option (field 10) allows multiple *TO* records to be used to combine flows at multiple locations.

<u>*Field 8*</u>: For *TOTARGET* (field 2) of 4, –4, 5, –5, the reservoir in which the storage content or drawdown is adopted for setting the diversion or instream flow target is entered in field 8. A primary application for this option is to allow a diversion and return flow to refill a reservoir.

<u>*Field 9*</u>: For *TOTARGET* (field 2) of 6, 7, 8, 9, 11, 12, −12, the other water right considered in setting the diversion or instream flow target is entered in field 9.

<u>*Field 10*</u>: The phrase *CONT* entered in field 10 indicates that the next record is another *TO* record that continues to build the diversion or instream flow target. Any number of *TO* records may be attached to an *IF* or *WR* record. For the second and subsequent *TO* records, *CONT* must be entered in field 10 of the preceding record.

**BU** Record – Backup Right

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | BU | Record identifier |
| 2 | 3-8 | BU | I6 | blank,0,1,2 | Back-up is applied as step 2 described on page 63. |
|   |     |    |    | 9 | Back-up is applied as step 9 described on page 64. |
| 3 | 9-16 | BUX(n) | F8.0 | + | Factor by which the shortage is multiplied. |
|   |      |        |      | blank,0 | Default = 1.0 |
| 4 | 17-32 | BUWRID | A16 | AN | Identifier of water right being backed up. |
|   |       |        |     | blank | Default is next preceding right record in the DAT file if both fields 4 and 5 are blank. |
| 5 | 33-40 | BUG(n) | A8 | AN | Group of water rights being backed up. |

The water right identified on the *WR* or *IF* record provides a supplemental backup for the diversion, instream flow, or hydropower requirement of one or more other *WR* or *IF* record rights identified in *BU* record fields 4 and 5. Shortages incurred by the other rights are added to the target of this back-up right in the water rights priority loop. If the other right is senior to the backup right, its shortage is added to the target of the backup right in the current month. If the other right is junior, its shortage is added to the target of the backup right in the next month. Back-up rights can back-up other back-up rights in sequences of any number of back-up rights.

If the *PX* record field 4 XCP control point limit option is activated for the right being backed up, the increase in stream flow depletion resulting from activating the XCP option, rather than shortage, is added to the target of the backup right.

<div align="center">

**Explanation of BU Record Fields**

</div>

*Field 2*: Shortages may be added to the target of the back-up right at either of two alternative steps in the target building process outlined on pages 63-64. The shortages may be added to the target as either the default step 2 or as step 9.

*Field 3*: The shortages are multiplied by the factor *BUX* entered in field 3 prior to adding the product to the target of the back-up right. Shortages may be divided between multiple back-up rights by applying fractional multiplier factors for the individual back-up rights that sum to 1.0.

*Fields 4 and 5*: The water right identifier *BUWRID* in *BU* record field 4 connects to *WRID* in *WR* record field 11 or *IF* record field 9 of a single other right being backed up. The water right group *BUG* in field 5 corresponds to *WRIDS* in WR record fields 12 and 13 and allows any number of rights to be backed up by this backup right. Unique water right identifiers are assigned on *WR* or *IF* records to each individual right, but any number of *WR* records can share the same group identifier. The shortages incurred by all rights with water right identifier *BUWRID* and/or water right group identifier *BUG* are added to the target of the backup right. If *BU* record fields 4 and 5 are both blank, the default is for the single other right being backed up to be the *WR* or *IF* record right found immediately preceding the *WR* or *IF* record of the backup right in the DAT input file.

**FS** Record  –  Flow Switch for Adjusting Targets Based on Accumulated Flow Volume

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | FS | Record identifier |
| | | | | | *Flow Variable Defining Switch* |
| 2 | 3-8 | FSV | I6 | blank,0,1 | Regulated flow |
| | | | | 2 | Naturalized flow |
| | | | | 3 | Unappropriated or available flow |
| | | | | 4 | Stream flow depletion |
| | | | | 5 | Diversion |
| | | | | 6 | Inflow to control point excluding upstream releases |
| 3 | 9-16 | FSCP | A6 | AN | Control point identifier of switch variable location. |
| | | | | blank | Control point from *IF/WR* record is the default. |
| | | | | | *Lower and Upper Regulated Flow Bounds* |
| 4 | 17-24 | FSX(FS,1) | F8.0 | + | Lower bound.  Default = 0.0 |
| 5 | 25-32 | FSX(FS,2) | F8.0 | + | Upper bound.  Default = 9,000,000,000.0 |
| | | | | | *Target Multiplier Factors* |
| 6 | 33-40 | FSX(FS,3) | F8.0 | + | Factor applied if flow variable is within bounds. |
| 7 | 41-48 | FSX(FS,4) | F8.0 | + | Factor if flow variable (field 2) is not within bounds. |
| | | | | | *Parameters Defining Flow Summation Period* |
| 8 | 55-56 | FSI(FS,1) | I8 | + | Number of time steps not counting the current period. |
| 9 | 63-64 | FSI(FS,2) | I8 | + | Beginning month (1, 2, ... , 12) for annual cycle. |
| | | | | blank,0 | Default is continuous without an annual cycle. |
| 10 | 72 | FSI(FS,3) | I8 | + | Ending month for annual cycle summation period. |
| | | | | blank,0 | Default is eleven months after the beginning month. |
| 11 | 80 | FSI(FS,4) | I8 | blank,0,1 | Second pass or latest regulated flow in current period. |
| | | | | 2 | Latest regulated flow in current period in summation. |
| | | | | 3 | Current period is not included in flow summation. |

The instream flow, diversion, or hydropower target specified by *IF* or *WR* and supporting records is multiplied by a *FSX* factor from either field 6 or 7 of the associated *FS* record depending on whether or not the total accumulated volume of the switch variable selected in field 2 falls within the lower and/or upper limits defined by *FS* fields 4 and 5.  The target is multiplied by *FSX(FS,3)* from field 6 if:

   field 3 *FSX(FS,1)* $\leq$ accumulative volume of field 2 *FSV* $\leq$ field 4 *FSX(FS,2)*

Otherwise, the target is multiplied by *FSX(FS,4)* from field 7.  The *FSI* parameters entered in fields 8, 9, 10, and 11 define the time period over which the field 2 *FSV* monthly volumes are summed to compute the total accumulated volume of flow at the specified control point.

### Explanation of FS Record Fields

*Fields 2 and 3*:  The flow switch variable *FSV* is selected in field 2.  The FSV is a flow volume occurring at the control point specified in field 3 which is accumulated.  Each of the field 2 variables is defined in *Reference Manual* Chapter 5 and the glossary of Appendix A.

***Fields 4 and 5***:  The cumulative volume summation for the field 2 *FSV* switch variable will fall either in or out of the range defined by the lower and upper bounds specified in fields 4 and 5.

***Fields 6 and 7***:  The instream flow, diversion, or hydropower target is initially computed in the conventional manner.  The target is then multiplied by the *FSX* factor from either field 6 or 7 depending on whether or not the volume accumulation of the *FSV* variable in field 2 at the control point in field 3 during the summation period is in the range defined by fields 4 and 5. Multiplier factors of 0.0 and 1.0 act as a switch that turns the target completely off or on. However, any values of the multiplier factors may be used to adjust the target.

***Fields 8, 9, 10, 11***:  A time period and scheme for computing the total accumulated volume are specified in fields 8, 9, 10, and 11.  The time period over which regulated flows are summed may include the current time step and/or any number *FSI(FS,1)* of preceding time steps.  *FSI(FS,4)* indicates whether or not and how the current time step is included in the volume summation.  If *FSI(FS,1)* is zero, only the current time step is considered.  The summation period *FSI(FS,1)* entered in field 8 may be any number of months in *SIM* or any number of days or other sub-monthly time intervals in *SIMD*.  Optionally, a season of the year may defined by specifying starting *FSI(FS,2)* and ending *FSI(FS,3)* months in *FS* record fields 9 and 10.  Only periods falling in the months *FSI(FS,2)* through *FSI(FS,3)* are included in the flow summation.

In setting an instream flow, diversion, or hydropower target in a particular time step of the simulation, the regulated flow volume activating the target adjustment switch is the sum of the volumes in the current period and/or preceding *FSI(FS,1)* periods subject to the optional limitation of including only flows that happen to occur in months *FSI(FS,2)* through *FSI(FS,3)*.

***Field 8***:  *FSI(FS,1)* is the number of time periods over which flows are added, not counting the current time step for which the instream flow, diversion, or hydropower target is being set. *FSI(FS,1)* may be any integer number.  In *SIM*, *FSI(FS,1)* is a number of months.  In *SIMD*, *FSI(FS,1)* is in units of days or other sub-monthly time steps.  The *FSI(FS,1)* time steps immediately precede the current time step.  For the first *FSI(FS,1)* plus one time steps of the simulation, the flow accumulation period extends back to the beginning of the simulation.

***Fields 9 and 10***:  Specification of beginning and ending months in fields 9 and 10 allows a season to be defined that repeats in an annual cycle.  Of the current and preceding *FSI(FS,1)* time periods, only those periods that fall in months between and including the beginning and ending months *FSI(FS,2)* and *FSI(FS,3)* are included in the flow volume summation.  *FSI(FS,1)* and *FSI(FS,4)* define the sequence of time periods reflected in the flow summation, with the exception that any periods falling outside the season from *FSI(FS,2)* through *FSI(FS,3)* are omitted.  Time steps after month *FSI(FS,3)* from field 9 and before *FSI(FS,2)* are omitted from the flow summation.  For example, with months 6 and 8 entered in fields 8 and 9, flow volumes during all months except June, July, and August (months 6, 7, 8) are omitted from the summation.  With months 10 and 2 entered in fields 8 and 9, respectively, regulated flows in months 10, 11, 12, 1, and 2 (October through February) are eligible for inclusion in the moving cumulative flow volume summation for the flow switch variable (FSV) defined in field 2.

***Field 11***:  *FSI(FS,4)* indicates whether or not and how the current time step is included in the volume summation.  With option 3, flow in the current period is not included in the summation. Options 1 and 2 both include the *FSV* flow in the current period in the summation.  With the default option 1, if *PASS2* in *JO* record field 10 or *IFMETH* in *IF* record field 6 results in a

second pass through the water rights loop, the FSV flow at the end of the first pass is included in the cumulative flow summation. Otherwise, the latest *FVS* flow computed in the priority loop reflecting only senior rights is adopted for the summation. With option 2, the latest *FVS* flow in the priority loop reflecting only senior rights is adopted. Without activation of *JO* record field 9 or *IF* record field 6 second pass options, *FSI(FS,4)* options 1 and 2 are the same.

## **TSR** Record – Repeat of Another Target Series

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-3 | CD,TSC | A2,A1 | TSR | Record identifier |
| | | | | | *Manner of Applying TS Amounts* |
| 2 | 6-8 | TSL | 2x,A3 | blank | *TS* record amounts are the only targets used. |
| | | | | MAX, max | Maximum of two alternative targets is adopted. |
| | | | | MIN, min | Minimum of two alternative targets is adopted. |
| | | | | ADD, add | *TS* record amount is added to preceding target. |
| | | | | SUB, sub | *TS* record amount is subtracted from preceding target. |
| | | | | MUL, mul | *TS* record amount is multiplied by preceding target. |
| | | | | SDL, sdl | Upper limit on allowable stream flow depletions. |
| | | | | | *Series to be Repeated* |
| 3 | 9-16 | K | I8 | blank,0 | Repeat the last time series read. |
| | | | | + | Number of the time series to be repeated. |
| | | | | | *Coefficients for Equation* |
| 4 | 17-24 | TSA | F8.0 | blank,0 | Default multiplier = 1.0 |
| | | | | + | Multiplier factor in the equation below. |
| 5 | 25-32 | TSB | F8.0 | blank,0 | Default number to be added = 0.0 |
| | | | | + | Addition factor in the equation below. |
| | | | | | $QTS(yr,\text{TSCOUNT},mt) = TSA [QTS(yr,K,mt)] + TSB$ |

A target series $QTS(yr,\text{TSCOUNT},mt)$ associated with a particular *WR* or *IF* record may be repeated or computed from the target series $QTS(yr,\text{TSL},mt)$ previously entered as *TS* records for another *WR* or *IF* record based on the following equation:

$$QTS(yr,\text{TSCOUNT},mt) = TSA [QTS(yr,K,mt)] + TSB$$

The factors TSA and TSB are entered in *TSR* record fields 4 and 5. $QTS(yr,\text{TSL},mt)$ are entered on a previous set of *TS* records or developed with a previous *TSR* record.

Target series are automatically numbered consecutively (1, 2, 3, ...) by *WRAP-SIM* in the order read from the DAT file. K in *TSR* record field 3 is the integer identifier of the series to be repeated. For example, a 3 entered for K in *TSR* record field 3 would repeat the third set of *TR* record quantities found in the dataset. The default is to repeat the last series read.

**TS** Record  –  Target Series

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | TS | Identifier required for first year, optional thereafter. |
| | | | | | *Manner of Applying TS Amounts* |
| 2 | 3-8 | TSL | 3X,A3 | blank | *TS* record amounts are the only targets used. |
| | | (first record) | | MAX, max | Maximum of two alternative targets is adopted. |
| | | | | MIN, min | Minimum of two alternative targets is adopted. |
| | | | | ADD, add | *TS* record amount is added to preceding target. |
| | | | | SUB, sub | *TS* record amount is subtracted from preceding target. (A negative result will be set equal to zero.) |
| | | | | MUL, mul | *TS* record amount is multiplied by preceding target. |
| | | | | SDL, sdl | Upper limit on allowable stream flow depletions. |
| | | | | | *TSL* is read with just the first year. This field is not read after first record. |
| | | | | | *Years Covered* |
| 3 | 9-12 | TSYR1 | I4 | – | Beginning year (optional) |
| 4 | 13-16 | TSYR2 | I4 | + | Ending year (required) |
| | | | | | *Amounts of Targets or Limits* |
| 5-16 | 17-112 | QTS (yr,wr,mt) | 12F8.0 | + | Amounts for each of the 12 months of the year |

Monthly targets entered on *TS* records are for either diversion, instream flow, or hydroelectric energy requirements depending upon the *WR* and *IF* record preceding the *TS* records. The *TS* records may be the only option selected to enter target amounts for a particular *IF* or *WR* record water right. Alternatively, *TS* records may be integrated with other options for setting targets. The mechanism incorporated in *WRAP-SIM* for combining *TS* record targets with other alternative targets are outlined as step 5 on page 64.

With SDL (stream flow depletion limit) entered in field 2 for variable *TSL*, the *QTS* values in fields 5-16 are defined as upper limits on stream flow depletions used to constrain water availability in the same manner as the other stream flow depletion limits activated by *SO* record fields 3 and 4 or *ML* records. The *TS* record SDL option may be used in conjunction with the DUAL option activated by *PX* record field 2.

*TS* records provide monthly targets or limits for each month of each year of the hydrologic period-of-analysis. The entire period-of-analysis must be covered, but the number of *TS* records range from one to the number of years in the period-of-analysis. The 12 amounts on each record may be applicable in each year of any sequence of years ranging in length from one year to the entire period-of-analysis. The beginning and ending year of the sub-period covered by an individual *TS* record are specified in fields 3 and 4. However, field 4 controls the program. Field 3 is not used by the program except in an error check and may be left blank. The 12 targets on a record are repeated each year from the year following the ending year on the previous record until the ending year entered in field 4 of the record.

The *TS* records covering all years are grouped together for a particular water right. The set of all *TS* records for a water right may be inserted any place within the set of *TS*, *TO*, *WS/OR*, *HP*, *SO*, *PX*, *ML*, and *SD* records that follow directly behind the *WR* or *IF* record for that right.

**WS** Record – Reservoir Storage Associated with a Water Right

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | WS | Record identifier |
| 2 | 3-8 | RES | A6 | AN | Reservoir identifier |
| 3 | 9-16 | WRSYS(sr,3) | F8.0 | + | Total storage capacity at top of the conservation pool. |
| | | | | | *Storage-Area Relationship* |
| 4 | 17-24 | EVCFA | F8.0 | + | Multiplier *A* for storage-area equation shown below. |
| 5 | 25-32 | EVCFB | F8.0 | + | Exponent *B* for storage-area equation shown below. |
| 6 | 33-40 | EVCFC | F8.0 | + | Constant *C* for storage-area equation shown below. |

$$\text{surface area} = A\,(\text{storage})^B + C$$

If fields 4, 5 & 6 are all blank, a table on *SV* and *SA* records is required to define the storage-area relation.

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| | | | | | *Optional Storage Specifications* |
| 7 | 41-48 | INACT | F8.0 | + | Storage capacity at top of the inactive pool. |
| 8 | 49-56 | BEGIN | F8.0 | Blank,0 | Reservoir is full to capacity (field 3) at the beginning. |
| | | | | + | Storage volume at the beginning of the simulation. |
| | | | | | *Evaporation Allocation Reservoirs* |
| 9 | 57-64 | IEAR | I8 | Blank,0 | Option not used. |
| | | | | + | *EA* record identifier (1, 2, 3, ...). 1 for first *EA* record. |
| 10 | 71-72 | SA | I8 | Blank,0 | A separate storage-area relationship is provided. |
| | | | | −1 | Use *SV/SA* records for first reservoir on *EA* record. |
| | | | | | *Downstream Versus Lakeside Diversions* |
| 11 | 79-80 | LAKESD | I8 | Blank,0 | Water supply diversions are accessible to hydropower. |
| | | = WRNUM(wr,11) | | −1 | Lakeside diversions do not generate hydropower. |
| | | or SN3(swr,sr) | | | |

Multiple reservoirs may be associated with a single water right. A *WS* record is required for each reservoir associated with a right. The optional hydropower *HP* and operating rules *OR* records are connected to a particular *WS* record and follow directly after the *WS* record. A *HP* record follows directly behind its *WS* record. The *OR* record follows directly behind the *HP* record. If there is no *HP* record, the *OR* record follows directly behind the *WS* record. A set of *WS/HP/OR* records may be placed anyplace in the group of supporting records that follow a *WR* or *IF* record.

Multiple rights may be associated with a particular reservoir. The total storage capacity in *WS* field 3, inactive storage capacity in field 7, and turbine/lakeside diversion switch in field 11 are connected to a water right and may vary with different rights at the same reservoir. Likewise, the parameters entered on *OR* records to define operating rules are associated with a particular water right and may vary between multiple rights at the same reservoir. Other data entered on *WS* and *HP* records are connected to a particular reservoir and are constant for that reservoir with no variation between multiple rights. Fixed reservoir data include *WS* fields 4, 5, 6 and *HP* fields 4, 5, 6, and *SV/SA*, *PV/PE*, and *TQ/TE* record tables. After being entered with one water right, *WS* fields 4, 5, 6 do not have to be repeated for other rights at the same reservoir.

**Explanation of WS Record Fields**

*Field 3*:  A type 1 (*WR* field 6) right refills a reservoir to the storage capacity entered in *WS* field 3 subject to water availability.  Multiple type 1 rights at the same reservoir may refill storage to various levels at different priorities.  The field 3 storage capacity also limits the amount of water that may be withdrawn by a right.  A diversion right has access to storage up to but not above the top of conservation pool.  The conservation storage capacity for a junior right must equal or exceed the storage capacity associated with more senior rights at the same reservoir.

*Fields 4, 5, 6*:  *WRAP-SIM* provides two options for inputting the storage volume versus surface area relationship for a reservoir: (1) a table provided on *SV* and *SA* records and (2) coefficients for the following equation provided in fields 4, 5, and 6 of the *WS* record:

$$\text{surface area} = A\,(\text{storage})^B + C$$

If *WS* record fields 4 and 6 are blank, a pair of *SV/SA* records must be provided for the reservoir. For multiple rights associated with the same reservoir, the storage-area input is provided only once, with the first right (*WR/IF* record) read.  There is only one storage-area relationship for a reservoir even if the reservoir is associated with multiple water rights.  Fields 4, 5, and 6 of the *WS* record are blank if the storage-area information is specified elsewhere.

*Field 7*:  Releases or withdrawals are curtailed whenever storage contents fall below the top of the inactive pool.

*Field 8*:  The reservoir is assumed full to capacity (field 3) at the beginning of the first month of the first year of the simulation unless an initial storage is entered in *WS* record field 8 or the beginning-ending-storage feature is activated by *JO* record field 5.

*Field 9*:  The integer identifier connects this reservoir to an *EA* record, used to define options for allocating net evaporation between component reservoirs used to model a multiple-owner reservoir.  An *EA* record is needed only if storage volumes accessed by the different owners are separate rather than shared in common.  An *EA* record is not needed for multiple owners with access to the same storage pool.  The integer 1 in *WS* record field 9 links this reservoir to the first *EA* record in the input file, a 2 links to the second *EA* record, a 3 links to the third *EA* record, and so forth.  There is no limit on the number of *EA* records that may be included in a dataset.

*Field 10*:  The reservoirs listed on an *EA* record may share the storage-area table provided by the *SV/SA* records for the first reservoir listed, or each reservoir may have its own storage-area relationship.  A negative integer for *SA* in field 10 indicates that since this reservoir is adopting the same *SV/SA* records as the first reservoir on its *EA* record, a separate storage-area relationship is not entered in either *WS* record fields 4, 5, 6 or as *SV/SA* records.

*Field 11*:  Field 11 is used for a diversion right to flag whether the diversion is available later in the priority loop for junior hydropower rights.  *LAKESD* specifies whether a water supply diversion is released through the turbines, incidentally generating hydroelectric energy, or withdrawn lakeside without being accessible for hydropower production.  *WS* record field 11 is relevant only for a senior water supply diversion met by releases from a reservoir at which a hydroelectric power plant for a more junior hydropower right is also located.

**HP** Record  –  Hydroelectric Power

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | HP | Record identifier |
| 2 | 3-8 | WRSYS(sr,9) | F6.0 | Blank,0 | Default efficiency = 0.85 |
|   |     |             |      | + | Energy efficiency for hydroelectric power plant. |
| 3 | 9-16 | WRSYS(sr,10) | F8.0 | Blank,0 | Tailwater discharge-elevation from TQ/TE records. |
|   |     |             |      | + | Constant tailwater elevation. |
| 4 | 17-24 | TELEV(res) | F8.0 | Blank,0 | Bottom power pool defined by INACT in WS field 7. |
|   |     |             |      | + | Turbine inlet invert elevation. |
| 5 | 25-32 | TQCAP(res) | F8.0 | Blank,0 | No limit on turbine discharge. |
|   |     |             |      | + | Turbine discharge capacity. |
| 6 | 33-40 | TPCAP(res) | F8.0 | Blank,0 | No limit on amount of secondary energy generated. |
|   |     |             |      | + | Maximum limit on energy production. |

A hydroelectric power right is activated by a water right type of 5 or 6 in *WR* record field 6.  A *HP* record is placed immediately behind the corresponding *WS* record.  A *HP* record is not required for a hydropower right if the default values are adopted for all of the HP record parameters.  For multiple hydropower rights at the same reservoir, *HP* record fields 4, 5, and 6 must be the same for all the rights, but do not have to be repeated on multiple *HP* records.  *HP* record fields 2 and 3 apply to individual rights, but only one pair of *TQ/TE* records can be assigned to a particular reservoir even if it is associated with multiple hydropower rights.

### Explanation of HP Record Fields

***Field 2***:  The efficiency is a fraction less than 1.0 representing the ratio of electrical energy to hydraulic energy used in the power equation.  The default efficiency is 0.85.

***Field 3***:  A constant tailwater elevation may be entered in *HP* record field 3 for computing the head used in the power equation.  If a *HP* record is not used or field 3 is blank, a tailwater rating table is entered on *TE/TQ* records.

***Field 4***:  Hydroelectric power is not generated if the average water surface elevation during the month falls below the limiting elevation specified in field 4.  The hydropower computational routine first determines whether the energy target can be met with flows already available without releases from storage specifically for hydropower generation.  Hydropower generation from these flows already available to the turbines is constrained by the turbine inlet invert elevation but not the inactive storage capacity of the hydropower reservoir.  If additional releases from storage are required, these releases are constrained by the inactive storage capacity as well as hydropower generation being constrained by the turbine inlet invert elevation.

Reservoir releases for any purpose are curtailed whenever storage falls below the inactive storage capacity entered in *WS* record field 7.  Subject to the *LAKESD* switch in *WS* record field

11, water supply diversions at the reservoir associated with rights that are senior to the hydropower right are allowed to flow through turbines contributing flow for the more junior hydropower right. Pass-through flows and water supply releases from upstream reservoirs for other senior rights also flow through the turbines. These flows associated with other rights senior to the hydropower right are constrained by their own inactive pool storage (*WS* record field 7). Reservoir releases for a hydropower right are likewise possible only if the storage contents exceed the inactive pool storage specified in *WS* record field 7. The turbine inlet invert elevation of *HP* record field 4 also constrains hydropower generation even if incidental flows are available from other senior water rights even without releases for the hydropower right.

*Field 5*: A maximum limit may be imposed on the flow volume/month that may be used to generate electric power. If field 5 is left blank, unlimited turbine discharge capacity is assumed.

*Field 6*: A maximum limit may be imposed on the electric energy/month that may be generated. If an energy production limit is specified, it must be greater than the monthly energy target developed based on adjusting the annual target entered in *WR* record field 3. Thus, the *HP* record field 6 limit affects only secondary energy generated in excess of the *WR* record field 3 firm energy target.

## OR Record Operating Rules for Secondary Reservoirs

An *OR* record follows the *WS* record or *WS/HP* records. *OR* records are used to specify multiple-reservoir system operating rules based on the storage zones defined by the figure on the next page and the rank index equation with the multiplier factor *M* from *OR* record fields 4 and 5 and addition factor *A* from fields 7 and 8. Defaults are adopted if there is no *OR* record or if the fields are blank.

Diversion, instream flow and hydropower requirements may be supplied by releases from multiple reservoirs. System operating rules are explained in Chapter 4 of the *Reference Manual*. For a diversion supplied by releases from two or more reservoirs, release decisions are governed by a *WR* record with type 2 or 3 specified in field 6 and pairs of *WS/OR* records for each reservoir in the system. Storage in each individual reservoir is refilled by a separate type 1 (*WR* field 6) right with its own *WR* and *WS* records. An *OR* record is not provided for the primary reservoir with storage refilled by the water right (type 1 right in *WR* record field 6) or at which the hydroelectric power plant is located for a hydropower right (type 5 or 6).

An *OR* record may also be used for a type 2 or type 3 water right with a single secondary (no storage refilling) reservoir with the diversion occurring at a location other than the control point of the reservoir. *OR* record field 6 activates the gravity flow or pump/pipeline options.

The *OR* record is not required if the control point has been defined by previously read *WR/WS* records and defaults are adopted for all of the variables on the *OR* record. If a multiple-reservoir system right is modeled with a set of *WS* records without accompanying *OR* records, storage zone 2 is eliminated by the *OR* record field 2 default of setting the capacity at the top of zone 2 equal to the inactive pool capacity. The multiplier factors (M) are 1.0 and addition factors (A) are 0.0 in the rank index equation. The control point location must have been previously assigned.

**OR** Record – Operating Rules for Secondary Reservoirs

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | OR | Record identifier |
| 2 | 3-8 | CP | A6 | AN | Control point identifier of reservoir location. |
|   |     |    |    | Blank,0 | Control point for reservoir is assigned by prior right. |
| 3 | 9-16 | WRSYS(sr,2) | F8.0 | + | Storage capacity at top of zone 2 (bottom of zone 1). |
|   |      |             |      | Blank,0 | Default = inactive storage from *WS* record field 7 |
| 4 | 17-24 | WRSYS(sr,5) | F8.0 | + | Zone 1 multiplier factor (M). |
|   |       |             |      | −1.0 | Multiplier factor set at zero. |
|   |       |             |      | blank,0 | Default = 1.0 |
| 5 | 25-32 | WRSYS(sr,4) | F8.0 | + | Zone 2 multiplier factor (M). |
|   |       |             |      | −1.0 | Multiplier factor set at zero. |
|   |       |             |      | blank,0 | Default = 1.0 |
| 6 | 33-40 | SN2(swr,sr) | I8 | −1 | Withdrawals through pump and pipeline conveyance as well as releases as river flow. |
|   |       |             |    | blank,0 | Releases only as gravity flow in river channels. |
| 7 | 41-48 | WRSYS(sr,6) | F8.0 | + | Zone 1 addition factor (A). |
|   |       |             |      | blank,0 | Default = 0.0 |
| 8 | 49-56 | WRSYS(sr,7) | F8.0 | + | Zone 2 addition factor (A). |
|   |       |             |      | blank,0 | Default = 0.0 |
| 9 | 57-64 | WRSYS(sr,8) | F8.0 | + | Monthly release limit. |
|   |       |             |      | blank,0 | Optional release limit feature is not used. |

$$\text{rank index} = M \left[ \frac{\text{content}}{\text{capacity}} \right] + A$$



Active Pool Zone 1

Active Pool Zone 2

Inactive
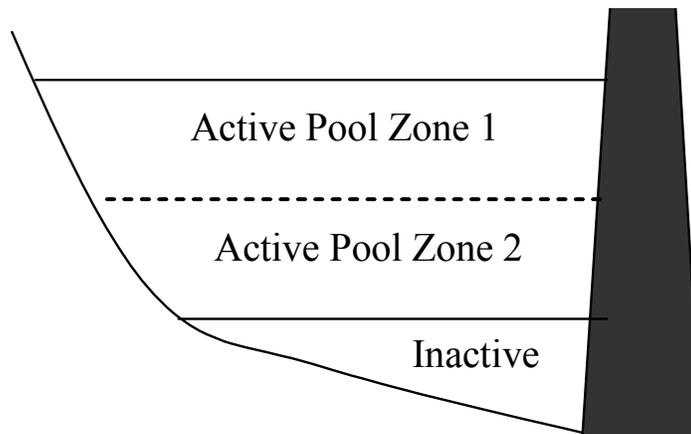
### Explanation of OR Record Fields

*Field 2*:  Field 2 may be left blank if the control point identifier of the reservoir location has been assigned to the reservoir by a water right read earlier in the DAT file.

*Field 3*:  Each reservoir of a multiple-reservoir system may optionally be divided into the two zones shown in the figure in conjunction with defining release rules.  Releases are not made from zone 2 of any reservoir until zone 1 has been emptied in all reservoirs.

*Fields 4, 5, 7, 8*:  The multiplier factors entered in fields 4 and 5 and the addition factors entered in fields 7 and 8 are used in the rank index equation.  If one or more reservoirs have water stored in their designated zone 1, the ranking index is computed for zone 1.  If all reservoirs are drawn-down to zone 2, the ranking index is computed for zone 2.  The rank index is computed each month to determine from which reservoir to release.  The release is made from the reservoir with the greatest value for the rank index.  The release is limited to the amount that empties the zone, switching to the next highest ranked reservoir as necessary.  The release is also constrained to not exceed the maximum release limit entered in Field 9.

*Field 6*:  Diversion, instream flow, or hydropower requirements at locations other than the control point of the reservoir may be supplied from releases or withdrawals from the reservoir. For the default SN2 of zero (blank field 6), a reservoir can release only for water use requirements at downstream locations accessible by gravity flow in the river below the reservoir. A −1 entered for SN2 in field 6 removes this location constraint, thus simulating pump and pipeline or canal conveyance to any location.

*Field 9*:  An optional constant volume/month limit on the release each month from this reservoir for this particular system water right may be entered in field 9.

### Sequencing of *WR* and *IF* Records and Associated *SO*, *ML*, *TO*, *FS*, *TS*, *BU*, *WS/HP/OR*, and *PX/AX* Records

*WR* and *IF* records may be in any order.  The set of all *WR* and *IF* records, along with their supporting records, follow the set of all *CP* records.  The set of records for each individual water right consists of a *WR* or *IF* record followed by optional *SO*, *ML*, *BU*, *TO*, *FS*, *TS*, *PX*, and/or set of *WS*, *HP*, and OR records.  The set of all supporting records associated with a particular water right must follow directly behind their *WR* or *IF* record.  However, the relative order of the *SO*, *ML*, *TO*, *FS*, *TS*, *BU*, *WS, HP, OR*, *PX* and *AX* records within the set is arbitrary other than:

- All *TS* records must be grouped together in chronological order by year.

- If multiple reservoirs are associated with a right, a separate *WS* record is required for each secondary reservoir.  The optional *HP* record follows its associated *WS* record. Each optional *OR* record follows immediately behind its *WS* record or *WS/HP* records.

*PX* and *AX* records may be placed essentially any place in the set of *SO*, *ML*, *TO*, *FS*, *TS*, *TSR*, *BU*, *WS/HP/OR* and *PX/AX* records that follow a *WR* or *IF* record.  An *AX* record is entered if and only if a −1 is entered in *PX* record field 3.  The *AX* record follows directly behind the *PX* record.

**PX** Record  –  Priority Sequence Circumvention Options

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | PX | Record identifier |
| | | | | | *Dual Simulation Options* |
| 2 | 8 | DUAL (wr) | I6 | blank, 0, or −9 | Water right is activated during all simulations. Flow depletion constraint feature is not applied. A −9 over-rides the default set in *JO* record field 11. |
| | | | | 1 | Right is activated only during the initial simulation. |
| | | | | 2 | Right is activated only during the second simulation and is not subject to stream flow depletion constraint. |
| | | | | 3, 33, 333 | Right is activated during both simulations. Stream flow depletions during the initial simulation serve as limits during the second simulation. |
| | | | | 4 | Right is activated only during the initial simulation. Stream flow depletion array is recorded. |
| | | | | 5, 55, 555 | Right is activated only during the second simulation. Preceding option 4 right depletions serve as limits. |
| | | | | | *Stream Flow Availability Multiplier Factor* |
| 3 | 9-16 | XAX | F8.0 | blank,0 | Not activating option is equivalent to XAX of 1.0. |
| | | | | F8.0 | Factor by which flow availability is multiplied. |
| | | | | −1 | Monthly factors are entered on following *AX* record. |
| | | | | | *Downstream Control Point Flow Availability Limit* |
| 4 | 24 | XCP(px) | I8 | blank,0 | Downstream control point limit is not activated. |
| | | | | 1 | XCPID and all downstream control points are excluded in determination of flow availability for wr. |
| | | | | 2 | Option 1 plus availability is limited to flow depletion. |
| | | | | 3 | Only control point XCPID is excluded. |
| | | | | 4 | Option 3 plus availability is limited to flow depletion. |
| 5 | 25-32 | XCPID | 2x,A6 | AN | Identifier of control point defining limit. |
| | | | | | *Transient-Priority Water Right Options* |
| 6 | 40 | XP(px) | I8 | blank,0 | Transient priority XP features are not used. |
| | | | | 1 | Return flow occurs later in the priority sequence. |
| | | | | 2 | Stream flow depletion, return flow, and storage are reversed later in the priority loop computations. |
| 7 | 48 | XPR(px) | I8 | blank,0,1 | End-of-month reservoir storage is restored to beginning-of-month storage for XP option 2 right. |
| | | | | 2 | End-of-month reservoir storage is not restored to beginning-of-month storage for XP option 2 right. |
| 8 | 49-56 | XPRIORITY | I8 | + | Priority number of $2^{nd}$ component of water right duo. |
| 9 | 63-64 | XPOUT(px) | I8 | blank,0,1 | Water right output is treated same as regular rights. |
| | | | | −1 | Water right records are not included in output file. |
| 10 | 65-80 | WRID1(px) | A16 | AN | Water right identifier for second component right. |
| 11 | 81-88 | WRID2(px) | A8 | AN | Water right group identifier for $2^{nd}$ component right. |
| 12 | 89-96 | WRID3(px) | A8 | AN | Water right group identifier for $2^{nd}$ component right. |

**AX** Record  –  Monthly Stream flow Availability Multiplier Factors

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | AX | Record identifier |
| | | | | | *Stream Flow Availability Multiplier Factors* |
| 2 | 3-8 | XA(px,1) | F6.0 | + | Multiplier factor for month 1 |
| 3-13 | 9-96 | XA(px,M)<br>M = 2, 12 | F8.0 | + | Multiplier factor for months 2 through 12 |
| | | | | | *Minimum and Maximum Limits* |
| 14 | 97-104 | XAMIN(px) | F8.0 | + | Minimum limit above which factors are applied. |
| 15 | 105-112 | XAMAX(px) | F8.0 | + | Maximum limit on stream flow availability. |

The water right modeling capabilities provided by a *PX* record and auxiliary *AX* record are discussed in the last section of Chapter 4 of the *Reference Manual*. The dual simulation, stream flow availability multiplier factor, control point limit, and transient water right options are four different features for modeling water management schemes involving circumvention of the normal water rights priority sequence. However, although motivated by schemes for evading the priority system, the four *PX* record methodologies are generic options that may serve other purposes as well. The four different options may be adopted independently of each other or used in various combinations.

### Dual Simulation Options (PX Record Field 2)

The dual simulation options are activated the same by either *SO* field 14 or *PX* field 2. A default dual option may be set in *JO* record field 11. The dual simulation allows stream flow depletions determined during an initial simulation to serve as upper limits on depletions during a second simulation. A second simulation is automatically performed if and only if *DUAL(wr)* option 3 or 5 is selected for one or more rights. Alternatively, the simulation may be performed once to develop a set of stream flow depletions, which are then incorporated into an input file as *TS* records for use in further simulations. Option 3 and 4 depletions may be written to the message file with *ICHECK=8* in *JD* field 4.

Although other types of applications are possible, the dual simulation options are designed primarily for situations where multiple water rights with different priorities are associated with the same reservoir or system of multiple reservoirs. Preventing senior right refilling of storage depleted by junior diversion rights is complicated by refilling occurring during future months after reservoir draw-downs. The dual simulation approach deals with this complexity based on repeating the simulation a second time. The initial simulation serves the sole purpose of developing arrays of stream flow depletions for specified senior rights that refill reservoir storage. These initial flow depletions become constraints that limit the amount of flow available to specified rights during the second simulation. The following five options may be activated by the variable *DUAL* in *PX* record field 2 (or *SO* field 14 or *JO* field 11).

Option 1: The water right is activated only during the initial simulation.

Option 2: The water right is activated only during the second simulation and is not subject to an initial simulation stream flow depletion constraint.

Options 3, 33, 333:   A dual simulation is automatically performed.   Stream flow depletions computed during the first simulation serve as upper limits on water availability during the second simulation.   The stream flow depletions computed during the initial simulation are written to the MSS file if *ICHECK*=8 on the *JD* record.

Option 4:  The water right is activated only during the initial simulation.  A stream flow depletion array is developed.  If an option 5 right follows this right, the depletions serve as upper limits on water availability for the option 5 right during the second simulation.  The stream flow depletions are written to the MSS file if *ICHECK*=8 on the *JD* record.

Options 5, 55, 555:   A dual simulation is performed with this water right being activated only during the second simulation.  The stream flow depletion array from the preceding option 4 right serves as an upper limit on flow depletions for this option 5 right.

With dual options 3 and 5, stream flow depletion limits are applied in the same manner as the constant monthly and annual depletion limits activated by *SO* record fields 3 and 4 and monthly-varying limits activated by *ML* records.  The only difference is that the limits are determined by computing stream flow depletions in an initial simulation.  Option 3 rights use their own stream flow depletion array during the second simulation that is repeated automatically.  If option 5 is activated for a particular water right, there must be another right with option 4 activated in the input file before the option 5 right.  The stream flow depletion array assigned to an option 5 right is from the last right preceding the option 5 right for which a depletion array is generated, based on the sequence order in which the *WR* records are entered in the input file.

Options 33, 333, 55, and 555 are variations of options 3 and 5 in which limits are based on accumulating stream flow depletions rather than depletions in each individual month.  With options 33 and 55, for any month, for a particular right, the total cumulative depletions since the beginning of the second simulation can not exceed the corresponding cumulative depletions occurring in the initial simulation.

With options 333 and 555, for type 1 and 7 rights (*WR* record field 3) with reservoir storage, the limit during the second simulation is the accumulative stream flow depletions since the reservoir was last full.  During the second simulation, the accumulation of initial simulation depletions is zeroed any time the reservoir contents are full to capacity.  For water right types other than types 1 and 7 with storage, the options 333 and 555 limits applied during the second simulation are the first simulation depletion for the current month plus any excess depletion from the immediately preceding month.  Unused depletions are carried into the next month but no further.

Option 4 rights may be used to write flow depletions to the MSS file even if the automated second simulation is not of interest.  The stream flow depletion array written to the MSS file may be manually inserted into an input file as a set of *TS* records for use in subsequent simulations.

### Stream Flow Availability Multiplier Factor (PX Record Field 3 and AX Record)

As discussed in *Reference Manual* Chapter 4, this option is designed for modeling two or more water rights having the same priority.  The constant factor (*XAX*) entered in *PX* record field 3 or monthly factors (*XA*) entered in the *AX* record are used to allocate available stream flow.  The factors will typically be greater than zero and less than 1.0.  The optional minimum and maximum stream flow availability volumes in *AX* record fields 14 and 15 may be combined with

the multiplier factors in adjusting stream flow availability.  The amount of stream flow available to a water right is determined in the water rights priority loop computations as follows.

- The available stream flow volume ($A_1$) is first determined in the normal manner and then adjusted by the *PX/AX* record parameters as follows.

- If *XAMIN* is not zero, the adjusted available stream flow is set at $A_1$ as long as $A_1$ does not exceed *XMIN*.

- If $A_1$ exceeds *XAMIN*, the multiplier factor *XAX* or *XA*(month) is applied as follows

    adjusted available stream flow = $XAMIN + (A_1 - XAMIN) \times XAX$

- If *XAMAX* is not zero, the adjusted available stream flow is set at *XAMAX* if the volume computed by the equation above exceeds *XAMAX*.

If *XAMIN* and *XAMAX* are not activated in *AX* record fields 14 and 15, the algorithm consists simply of multiplying the available river flow by a factor.  A similar procedure using a constant rather than monthly varying factors is activated by the *AF* record connected to the *EA* record.

### Control Point Limit Options (PX Record Fields 4 and 5)

The amount of stream flow available to a water right is determined within *SIM* as the lesser of the stream flow availability array at the control point of the right and at each control point located downstream.  However, the control points considered may be altered by options activated by *PX* record fields 4 and 5.  A control point is selected by entering its identifier *XCPID* in *PX* record field 5.  The control point *XCPID* specified in *PX* record field 5 must be located downstream of the control point of the water right specified in *WR* record field 2. Computational options that may be activated by a selection entered for *XCP* in *PX* record field 4 are as follows.

Option 1: Control point *XCPID* and all control points located downstream of it are omitted from consideration in determining the amount of stream flow available to the water right.

Option 2: Option 1 is activated along with an additional feature that limits flow availability to not exceed the flow depletion by senior rights at *XCPID* adjusted for channel losses.

Option 3: *XCPID* is the only control point omitted from consideration in determining river flow availability for the right.  The depletion at *XCPID* is not applied as a maximum limit.

Option 4: *XCPID* is the only control point omitted from consideration in determining river flow availability for the right, and the depletion at *XCPID* is applied as a maximum limit.

The increase (*XAV*) in the amount of stream flow available to the water right resulting from activating this option is written to the OUT file and may be tabulated as a *TABLES* 2XAV table. With options 2 and 4, *XAV* is limited to not exceed flow depletions by senior rights at control point *XCPID* increased to account for channel losses between the right and *XCPID*.

In adjusting downstream flows for the depletion incurred by the right, the decreases in flow at and below *XCPID* omit the effect of the additional stream flow depletion generated by the XCP feature.  Another right with a backup right *BU* record may be created to offset this increase.  The increase in stream flow depletion replaces the shortage as the quantity to be added to the diversion target of the backup right.  The last section of *Reference Manual* Chapter 4 describes a strategy for modeling subordination agreements by combining *PX* and *BU* record options.

### Transient Water Right Options (PX Record Fields 6 − 12)

The transient water right options governed by *PX* record fields 6 through 12 involve changes with respect to location in the priority loop computations. A *WR/PX* record combination creates a pair of computational water rights. The first and second components of the water right duo are assigned priorities from *WR* field 5 and *PX* field 8, respectively. The *PX* record activates two types of XP (dual switching priority) water rights.

1. With XP option 1 in *PX* field 6, return flows may occur later in the priority loop than the corresponding diversion. This option may be used to control which other rights have first access to return flows based on the priority placement of the return flows. The second internal component right does nothing but the return flow. If the return flow priority entered in *PX* field 8 is junior to the priority in *WR* field 5, the return flow occurs in the same month as its diversion. Otherwise, the return flow occurs in the next month which is the next time its priority is reached in the priority based simulation computations.

2. *PX* field 6 XP option 2 is designed for modeling of the effects of subordination agreements. A computational right is activated and deactivated at different points in the computations based on assigned priorities. The objective is to constrain water availability for other rights bracketed by the two priorities. A right is activated based on the senior priority in *WR* field 5. Its stream flow depletion, return flow, and storage change are later reversed automatically within the model as a second component right at the priority in *PX* field 8. Stream flow depletions are returned to the stream as return flows. Return flows are reversed as stream flow depletions. In typical subordination applications, the actual water right will be modeled with another *WR* record with its actual junior priority.

*__Field 6__*: XP is a switch for activating either options 1 or 2 described above. Option 1 simply delays the return flow in the water rights priority-based simulation. Option 2 reverses the stream flow depletion, return flow, and depending on XPR (field 7) the change in storage.

*__Field 7__*: The default is for the second automatically created component right to restore the end-of-month reservoir storage to the initial beginning-of-month storage. This implies that actual storage refilling is controlled by another more junior set of *WR/WS* records associated with the same reservoir. Optionally, the effects on reservoir storage of the *WR/WS/PX* record water right may be treated just like a regular *WR/WS* record right.

*__Field 8__*: *XPRIORITY* is the priority number of the second component right of the *WR/PX* right duo. The priority number for the first component right is provided in *WR* record field 8. For XP (field 3) option 2, the *PX* record priority should be junior to the *WR* record priority. For XP (field 3) option 1, either priority may be greater but the return flow will occur the next time that the *PX* record priority is reached in the water right priority loop computations.

*__Field 9__*: The default is for the XP right to be treated as any other right in specifying which rights are included in the output file. A −1 omits the XP right from the water right output. XP option 2 flow depletions and return flows are never included in the cumulative control point output data.

*__Field 10, 11, 12__*: Identifiers for the first component right are provided in *WR* record fields 14-16. Identifiers for the second component of the water right duo are provided in *PX* fields 10-12.

**Sequencing of *SV/SA, PV/PE,* and *TQ/TE* Records in DAT File**

The *SV, SA, PV, PE, TQ, and TE* records have the same format. A *SV* or *PV* or *TQ* record must be followed by the corresponding *SA* or *PE* or *TE* record. A complete set of all *PV-PE* records grouped together follows the complete set of all *SV-SA* records. Likewise, an entire set of *TQ-TE* records follows the complete set of all *PV-PE* records.

**SV** Record – Storage Volumes for Reservoir Storage versus Area Table

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | SV | Record identifier |
| 2 | 3-8 | RES | A6 | AN | Reservoir identifier |
| 3-14 | 9-104 | TARA(I) I=1,TL | TL(F8.0) | + | Reservoir storage volumes corresponding to surface areas in same fields of the following *SA* record |

**SA** Record – Surface Areas for Reservoir Storage versus Area Table

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | SA | Record identifier |
| 2 | 3-8 | RES | 6x | | Field not used |
| 3-14 | 9-104 | TARB(I) I=1,TL | TL(F8.0) | + | Reservoir surface areas corresponding to storage volumes in same fields of the preceding *SV* record |

The *SV-SA, PV-PE,* and *TQ-TE* tables are allowed a maximum of TL pairs of values set by *JO* record field 10 with a default TL of 12.

Storage volume (*SV* record) versus surface area (*SA* record) tables are used in the reservoir net evaporation-precipitation computations. A storage-area relationship may be defined optionally with a pair of *SV-SA* records or by equation coefficients provided on the *WS* record.

A storage volume versus water surface elevation (*PV-PE* records) table is required for each reservoir associated with hydropower rights for use in computing head. *PV* and *PE* records may also be provided for non-hydropower reservoirs for use in determining water surface elevations by linear interpolation. *SIM* writes water surface elevations to the reservoir/hydropower output record for all reservoirs with *PV-PE* records. The *TABLES* 2WSE record tabulates the reservoir water surface elevations.

Tailwater rating tables (*TQ-TE* records) are used only for computing head in hydroelectric power computations. The optional *TQ* and *TQ* records are provided only for reservoirs associated with hydropower rights for which a constant tailwater elevation is not input on the *WS* record.

**PV** Record  –  Storage Volumes for Storage versus Elevation Table for Hydropower Right

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | PV | Record identifier |
| 2 | 3-8 | RES | A6 | AN | Reservoir identifier |
| 3-14 | 9-104 | TARA(I) I=1,TL | TL(F8.0) | + | Reservoir storage volumes corresponding to surface elevations in same fields of the following *PE* record |

**PE** Record  –  Surface Elevations for Storage versus Elevation Table for Hydropower Right

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | PE | Record identifier |
| 2 | 3-8 | RES | 6x | | Field not used |
| 3-14 | 9-104 | TARB(I) I=1,TL | TL(F8.0) | + | Reservoir surface elevations corresponding to storage volumes in same fields of the preceding *PV* record |

**TQ** Record  –  Turbine Discharges for Flow versus Elevation Table for Hydropower Right

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | TQ | Record identifier |
| 2 | 3-8 | RES | A6 | AN | Reservoir identifier |
| 3-14 | 9-104 | TARA(I) I=1,TL | TL(F8.0) | + | Turbine flow corresponding to tailwater elevations in same fields of the following *TE* record |

**TE** Record  –  Tailwater Elevations for Discharge versus Elevation Table for Hydropower Right

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | TE | Record identifier |
| 2 | 3-8 | RES | 6x | | Field not used |
| 3-14 | 9-104 | TARB(I) I=1,TL | TL(F8.0) | + | Tailwater elevations corresponding to turbine flows in same fields of the preceding *TQ* record |

**Sequencing of MS, DI/IS/IP, and EA/EF Records in DAT File**

*MS*, *DI/IS/IP*, and *EA/EF* records are connected to reservoirs.  The sets of *MS*, *DI/IS/IP*, and *EA/EF* records are placed in the DAT file after the complete grouping of all *SV/SA*, *PV/PE*, and *TQ/TE* records and before the *ED* record.  All *MS* records are grouped together.  All sets of *DI/IS/IP* records are grouped together.  All pairs of *EA/EF* records are grouped together.  However, the relative placement of the *MS* versus DI/IS/IP versus *EA/EF* groups are arbitrary.  For example, the *EA/EF* records may be either before or after the *MS* and/or *DI/IS/IP* records.  Likewise, the set of all *MS* records for any number of reservoirs may be placed before or after or between the set of all *DI/IS/IP* records and the set of all *EA/EF* records.

**MS** Record – Monthly Storage Limit

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | MS | Record identifier |
| 2 | 3-8 | RES | A6 | AN | Reservoir identifier |
| 3-14 | 9-104 | STMON(M) M=1,12 | 12F8.0 | + | Maximum storage volume limits for months 1 through 12. |
| 15 | 105-112 | STMON(13) | F8.0 | + | Maximum release volume during a time period. |

A *MS* record is entered for a reservoir to model a seasonal rule curve operating policy, which typically involves allocation of storage capacity between conservation and flood control pools by raising and lowering the designated top of conservation pool elevation.  The conservation storage capacity specified on the *MS* record may vary during the 12 months of the year.

The storage capacities *STMON(M)* in fields 3-14 on the *MS* record serve as upper limits constraining *WR/WS* record storage in each of the 12 months of the year.  *FC* record flood control operations discussed in the *Supplemental Manual* allow flood storage above these levels.  In each period, unless over-ruled by flood control operations, the beginning-of-period and end-of-period storage is limited to not exceed the *MS* record storage capacity for that month.  In refilling storage, the storage capacity is the lesser of the *WS* record and *MS* record storage capacities.  If the storage carried over from the previous month is above the specified capacity for the current month, releases are made to lower the storage content.  The amount of such release is limited by the release capacity entered in field 15.

Reservoir releases made for the sole purpose of lowering the storage content to the seasonally varying storage capacity can not exceed the release discharge capacity *STMON(13)* in field 15.  In *SIM*, the release capacity is a volume per month.  In *SIMD*, the release capacity is a volume per period which may be a day or other sub-monthly time interval.

**DI** Record  −  Drought Index Reservoirs

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | DI | Record identifier |
| 2 | 7-8 | NDI | I6 | + | Drought index integer identifier |
| 3 | 11-12 | EMPTY (NDI) | I4 | blank,0 | Reservoir emptying option is not used. |
| | | | | −1 | Reservoir(s) is emptied at beginning of every month. |
| | | | | 1,2,3, ... 12 | The month in which emptying occurs each year. |
| 4 | 15-16 | NR | I4 | + | Number of reservoirs (Not to exceed 12) |
| | | | | −1 | All reservoirs |
| 5-16 | 17-112 | DIRES (NDI,I) | 12(2x,A6) | AN | Reservoir identifiers (NDI = number of *DI* records,  I=1,12) |

**IS** Record  −  Drought Index Storage

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | IS | Record identifier |
| 2 | 7-8 | NS | I6 | + | Number of storage-percentage pairs (not to exceed TL) |
| 3-12 | 9-104 | DISTO(I) | TL(F8.0) | + | Reservoir storage corresponding to *IP* record DIPER |

**IP** Record  −  Drought Index Percentages

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | IS | Record identifier |
| 2 | 7-8 | | 6x | | Field 2 is not used. |
| 3-12 | 9-104 | DIPER(I) | TL(F8.0) | + | Percentages corresponding to *IS* record DISTO |

The sets of all *DI/IS/IP* records are grouped together somewhere after the *SV/SA/PV/PE/TQ/TE* records and before the *ED* record.  For each drought index, an *IS* record must follow its *DI* record.  The *IP* record follows the *IS* record.

*DINDEX(wr)* in *WR* record field 10 and *IF* record field 8 connect water rights to drought indices defined by *DI/IS/IP* records.  A storage versus target adjustment relationship is defined by the *IS/IP* records with no more than TL (*JD* record field 11, default=12) pairs of storage and index percentages.  Water right targets are multiplied by factors linearly interpolated from the *IS/IP* table.  Each drought index is based on either the total storage in one to 12 specified reservoirs or all the reservoirs in the model.

*STODI* in *JO* record field 8 allows the drought index to be based alternatively on either beginning-of-period storage, latest end-of-period storage, or the average of the two.  A drought index is computed once at the beginning of each month if based on beginning-of-period storage. If end-of-month or average storage is used, the drought index is recomputed in the water rights loop each time a right uses the index.  The latest end-of-month storage computed in the water right priority sequence reflects other senior rights, but does not reflect junior rights.

**EA** Record – Net Evaporation-Precipitation Allocation

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | EA | Record identifier |
| 2 | 7-8 | NEA | I6 | + | *EA* record integer identifier which may be blank since *SIM* automatically numbers. NEA = 1, 2 , 3, ... |
| | | | | | *Allocation Method* |
| 3 | 16 | NEAF (NEA) | I8 | blank,0,1 | Incremental based on water right priorities. |
| | | | | 2, 22 | Based on beginning-of-month storage content. |
| | | | | 3, 33 | Based on factors from the following *EF* record. |
| | | | | 4 | Incremental combined with factors from *EF* record. |
| | | | | | *Reservoirs* |
| 4-23 | 17-176 | EARES (NEA,I) | 20 (2x,A6) | AN | Reservoir identifiers for from 2 to 20 reservoirs. I = 1, 20 |

**EF** Record – Net Evaporation-Precipitation Allocation Factors

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | EF | Record identifier |
| 2 | 3-8 | EAO(NEA) | I6 | blank,0,1 | Any individual reservoir; beginning storage. |
| | | | | 2 | Sum of storage in all reservoirs; beginning storage. |
| | | | | 3 | Any individual reservoir; EAF factors; for NEAF=4. |
| | | | | 4 | All reservoirs; EAF factors; for NEAF=4 only. |
| 3 | 9-16 | EAL(NEA) | F8.0 | blank,0 | Default = 0.0 |
| | | | | + | Fractional (0.0 to 1.0) storage limit switch. |
| 4-23 | 17-176 | EAF (NEA,I) | 20F8.0 | + | Factors for the reservoirs listed on the *EA* record used with *EA* field 3 NEAF options 3, 33, and 4. |

**AF** Record – Stream flow Availability Allocation Factors

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | AF | Record identifier |
| 2 | 3-8 | AFMIN | F6.0 | + | Minimum available stream flow for any reservoir. |
| 3 | 9-16 | AFMAX | F8.0 | + | Maximum available stream flow for any reservoir. |
| 4-23 | 17-176 | AFX (NEA,I) | 20F8.0 | + | Factors for the reservoirs listed on the *EA* record by which available stream flow is multiplied. |

The *EA/EF/AF* records are placed in the DAT file somewhere after the sets of *SV/SA*, *PV/PE*, and/or *TQ/TE* records and before the *ED* record. All *EA/EF/AF* records are grouped together.

*EA* records are used in situations where multiple water supply entities hold rights to separate storage capacity in the same reservoir. The storage capacity owned by each entity may be modeled as a separate reservoir, with its own *WR* and *WS* records. The *EA* record allows the component separate *computational* reservoirs to share the same storage-area relationship, in the form of total storage volume in all of the component reservoirs versus total water surface area, for use in the computation of net evaporation less precipitation volumes. Each *EA* record represents a multiple-owner reservoir modeled as from two to 20 component reservoirs. Each component reservoir has its own *WR* and *WS* records. *WS* record field 2 identifiers of component computational reservoirs that compose the actual multiple-owner reservoir are listed in fields 4-23 of the *EA* record. *WS* record field 9 connects the *WR/WS* records to an *EA* record.

The *EA* record evaporation allocation routines are applied only to type 1 or 7 rights (*WR* field 6). However, any number of other types of water rights may be associated with the same reservoir listed on an *EA* record subject to restrictions outlined in Chapter 4 of the *Reference Manual*.

*SIM* numbers the *EA* record data sets in sequential order (1, 2, 3, ...) with no limit on the maximum allowable number of *EA* records representing different multiple-owner reservoirs. The optional *NEA* in field 2 must conform to this numbering system; otherwise, an error message is activated. The *EA* record *NEA* identifiers connect to and match the *IEAR* in field 9 of the *WS* record of the component reservoirs.

The storage volume versus surface area relationship provided on *SV/SA* records must be input for the first component reservoir listed on the *EA* record but does not have to be repeated for the other reservoirs. *WS* record field 10 flags the reuse of the *SV/SA* records entered for the first reservoir listed on the *EA* record. The component reservoirs will normally share the same storage-area relationship, but separate and different relationships may be entered for each reservoir. If storage-area relationships are provided by coefficients entered in *WS* record fields 4-6, the coefficients must be entered for each reservoir.

An *EF* record follows directly behind an *EA* record if and only if allocation method options 3 or 4 are selected as *NEAF* in *EA* record field 3. Each *EF* record *EAF(NEA,I)* factor corresponds to a reservoir on the *EA* record. These multiplier factors are applicable only during months of the simulation with storage above levels defined by *EAO* and *EAL* in *EF* record fields 2 and 3.

As each component reservoir is modeled in the water right priority loop, its end-of-month storage may necessarily be approximated by beginning-of-month storage in the evaporation computations. In order to assure that the combined total evaporation is precisely correct, for options 2 and 3, the evaporation for the last reservoir listed on the *EA* record is computed as the exact total evaporation minus the sum of the evaporation allocated to the other reservoirs. Thus, the last reservoir listed on the *EA* record should be junior to the other reservoirs, and no factor is entered on the *EF* record for the last reservoir listed.

Options 22 and 33 are identical to options 2 and 3 with the exception of not applying the feature described in the preceding paragraph for assuring the correct total evaporation. Options 22 and 33 treat all component reservoirs including the last reservoir listed on the *EA* record the same.

The following alternative methods for allocating net evaporation-precipitation between the component reservoirs are selected by *NEAF* in *EA* record field 3.

*Option 1* assigns the most senior right the evaporation computed prior to considering any other junior rights. Each subsequent right is allocated its incremental additional evaporation as the rights are considered in the simulation in priority order. Thus, evaporation allocated to the component reservoir associated with a particular right is independent of other component reservoirs associated with rights with junior priorities.

*Options 2 and 22* allocate net evaporation between reservoirs in proportion to their beginning-of-month storage. A factor for each reservoir is computed as its beginning-of-month storage divided by the total beginning-of-month storage in all of the *EA* record reservoirs. If the beginning-of-month storage is zero in all reservoirs, evaporation is divided equally between the reservoirs.

*Options 3 and 33* allocate net evaporation between the reservoirs based on multiplying the total evaporation by the *EAF* factors provided on an *EF* record. The computations switch to option 2 described above based on beginning-of-month storage ratios in any month in which the beginning-of-month storage is below the limit specified by *EAO* and *EAL* in *EF* record fields 2 and 3. If the beginning-of-month storage is zero in all reservoirs, the *EAF* factors are applied.

*Option 4* first computes incremental net evaporation in the same manner as option 1 but then multiplies the result by the factor from the *EF* record. If all the *EAF* factors on the *EF* record are 1.0, option 4 is the same as option 1 assuming either *EAL* is zero or *EAO* is either 3 or 4. In any month in which the beginning storage is below the limit *EAL* in *EF* record field 3, the computations either switch to option 2 (if *EAO* is 1 or 2) or the factors are set at 1.0 (if *EAO* is 3 or 4) depending on *EAO* in *EF* record field 2.

The *EAL* limit of *EF* record field 3 defines a beginning-of-period storage limit below which the *EAF* factors are no longer applied. The storage limit is computed as the storage capacity (*WS* record field 3) multiplied by *EAL* from *EF* field 3. The *EAO* option of field 2 specifies whether the limit is associated with the storage of each individual reservoir or the total sum of the storage of all the component reservoirs. With *EAO* = 1 or 3, application of the factors is curtailed any time the beginning-of-period storage of any one of the reservoirs falls below the *EAL* limit. With *EAO* = 2 or 4, the factors are no longer used if the total sum of the storage in all reservoirs falls below the *EAL* limit. With *EAO* options 1 and 2, whenever storage falls below the limit, the algorithm switches to allocating net evaporation based on beginning storage content, which is equivalent to *NEAF* option 2. With *EAO* options 3 and 4, which are applicable only with *NEAF* option 4, the EAF factors are set at 1.0 if storage falls below the limit

The optional *AF* record is motivated by situations in which multiple reservoir owners share the same priority. The priority system governs access to available stream flow as reflected in the water rights computation loop priority sequence. If two or more of the multiple reservoir owners actually have the same priority, allocation of available stream flow may be specified by the model-user through the *AF* record. The available stream flow is computed in the normal manner and then adjusted by the parameters from the *AF* record. Minimum MIN and maximum MAX adjusted flow availability volumes may be entered in fields 2 and 3. The multiplier factors AF for each reservoir in fields 4−23 are applied to available flow volumes exceeding the minimum. The *AF* record computational algorithm is essentially the same as the procedure activated by the parameters *XAX*, *XMIN*, and *XMIN* from the *PX* and *AX* records.

**IN and EV Records in Standard Default Format**

**IN** Record  −  Inflows, Naturalized Stream Flows at a Control Point

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | IN | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| 3 | 9-12 | NYR | I4 | + | First year for an *IN* record repeated for multiple years |
|   |      |     |    | blank,0 | *IN* record is for one year only; it is not repeated |
| 4 | 13-16 | PYR | I4 | + | Year    (last year to repeat if field 3 is not zero or blank) |
| 5 | 17-24 | INFLOW(cp,1) | F8.0 | + | Naturalized stream flow for Month 1 |
| 6 | 25-32 | INFLOW(cp,2) | F8.0 | + | Naturalized stream flow for Month 2 |
| 7 | 33-40 | INFLOW(cp,3) | F8.0 | + | Naturalized stream flow for Month 3 |
| 8 | 41-48 | INFLOW(cp,1) | F8.0 | + | Naturalized stream flow for Month 4 |
| 9 | 49-56 | INFLOW(cp,5) | F8.0 | + | Naturalized stream flow for Month 5 |
| 10 | 57-64 | INFLOW(cp,6) | F8.0 | + | Naturalized stream flow for Month 6 |
| 11 | 65-72 | INFLOW(cp,7) | F8.0 | + | Naturalized stream flow for Month 7 |
| 12 | 73-80 | INFLOW(cp,8) | F8.0 | + | Naturalized stream flow for Month 8 |
| 13 | 81-88 | INFLOW(cp,9) | F8.0 | + | Naturalized stream flow for Month 9 |
| 14 | 89-96 | INFLOW(10) | F8.0 | + | Naturalized stream flow for Month 10 |
| 15 | 97-104 | INFLOW(11) | F8.0 | + | Naturalized stream flow for Month 11 |
| 16 | 105-112 | INFLOW(12) | F8.0 | + | Naturalized stream flow for Month 12 |

**EV** Record  −  Net Reservoir Evaporation-Precipitation Rates for a Control Point

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | IN | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| 3 | 9-12 | NYR | I4 | + | First year for an *EV* repeated for multiple years |
|   |      |     |    | blank,0 | *EV* record is for one year only; it is not repeated |
| 4 | 13-16 | PYR | I4 | + | Year   (last year to repeat if field 3 is not zero or blank) |
| 5 | 17-24 | EVAPR(cp,1) | F8.0 | + | Net evaporation-precipitation for Month 1 |
| 6 | 25-32 | EVAPR(cp,2) | F8.0 | + | Net evaporation-precipitation for Month 2 |
| 7 | 33-40 | EVAPR(cp,3) | F8.0 | + | Net evaporation-precipitation for Month 3 |
| 8 | 41-48 | EVAPR(cp,1) | F8.0 | + | Net evaporation-precipitation for Month 4 |
| 9 | 49-56 | EVAPR(cp,5) | F8.0 | + | Net evaporation-precipitation for Month 5 |
| 10 | 57-64 | EVAPR(cp,6) | F8.0 | + | Net evaporation-precipitation for Month 6 |
| 11 | 65-72 | EVAPR(cp,7) | F8.0 | + | Net evaporation-precipitation for Month 7 |
| 12 | 73-80 | EVAPR(cp,8) | F8.0 | + | Net evaporation-precipitation for Month 8 |
| 13 | 81-88 | EVAPR(cp,9) | F8.0 | + | Net evaporation-precipitation for Month 9 |
| 14 | 89-96 | EVAPR(10) | F8.0 | + | Net evaporation-precipitation for Month 10 |
| 15 | 97-104 | EVAPR(11) | F8.0 | + | Net evaporation-precipitation for Month 11 |
| 16 | 105-112 | EVAPR(12) | F8.0 | + | Net evaporation-precipitation for Month 12 |

**IN and EV Records in HYD File Format**

In the old *WRAP2/WRAP3* format, now specified as Option 5 in *JO* record field 5, the records are stored in a HYD file (filename root.HYD).  *IN* records for all control points for a year are followed by a corresponding set of *EV* records for all control points for the year. *IN/EV* records for all control points are grouped together by year.  All the records for a year are followed by a complete set of records for the next year.

First IN Record for Each Year  −  Inflows

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | IN | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| 3 | 9-16 | PYR | I8 | + | Year |
| 4 | 17-24 | Q(1) | F8.0 | + | Naturalized stream flow for Month 1 |
| 5 | 25-32 | Q(2) | F8.0 | + | Naturalized stream flow for Month 2 |
| 6 | 33-40 | Q(3) | F8.0 | + | Naturalized stream flow for Month 3 |
| 7 | 41-48 | Q(4) | F8.0 | + | Naturalized stream flow for Month 4 |
| 8 | 49-56 | Q(5) | F8.0 | + | Naturalized stream flow for Month 5 |
| 9 | 57-64 | Q(6) | F8.0 | + | Naturalized stream flow for Month 6 |

Second IN Record for Each Year  −  Inflows

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | IN | Record identifier |
| 2 | 3-8 | | 6X | | not used |
| 3 | 9-16 | | 8X | | not used |
| 4 | 17-24 | Q(7) | F8.0 | + | Naturalized stream flow for Month 7 |
| 5 | 25-32 | Q(8) | F8.0 | + | Naturalized stream flow for Month 8 |
| 6 | 33-40 | Q(9) | F8.0 | + | Naturalized stream flow for Month 9 |
| 7 | 41-48 | Q(10) | F8.0 | + | Naturalized stream flow for Month 10 |
| 8 | 49-56 | Q(11) | F8.0 | + | Naturalized stream flow for Month 11 |
| 9 | 57-64 | Q(12) | F8.0 | + | Naturalized stream flow for Month 12 |

First EV Record for Each Year  −  Reservoir Evaporation Rates

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | EV | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| 3 | 9-16 | PYR | I8 | + | Year |
| 4 | 17-24 | EV(1) | F8.0 | + | Reservoir evaporation rate for Month 1 |
| 5 | 25-32 | EV(2) | F8.0 | + | Reservoir evaporation rate for Month 2 |
| 6 | 33-40 | EV(3) | F8.0 | + | Reservoir evaporation rate for Month 3 |
| 7 | 41-48 | EV(4) | F8.0 | + | Reservoir evaporation rate for Month 4 |
| 8 | 49-56 | EV(5) | F8.0 | + | Reservoir evaporation rate for Month 5 |
| 9 | 57-64 | EV(6) | F8.0 | + | Reservoir evaporation rate for Month 6 |

Second EV Record for Each Year  −  Same format as indicated above.

*Chapter 3 SIM Input*

## Alternative Formats for IN and EV Records

Sequences of monthly flow volumes representing natural or some specified condition of river basin development are entered on inflow *IN* records. Sequences of monthly reservoir surface net evaporation less precipitation depths are entered on evaporation *EV* records. The *IN* and *EV* records are organized by year and control point. The ordering of control points must be consistent for all of the years of *IN* records and *EV* records but is otherwise arbitrary. The years must be in chronological order starting with the earliest year and ending with the last.

Field 3 of the *IN* and *EV* records contains the variable *NYR* (first year) which signals the program to repeat the 12 monthly values on the record from the year *NYR* (field 3) through the year *PYR* (field 4). If field 3 is blank or zero, the *IN* or *EV* record represents only one year. If records are not repeated for multiple years, field 4 (*PYR*) may also be left blank after the first year since the records must be in chronological sequence. An error check confirms that any years entered are in the correct chronological sequence, but zeros (blanks) are ignored.

*INEV* in *JO* record field 2 specifies the manner in which the *IN* and *EV* records are organized. The standard default set of input files include a FLO (or INF) file for storing *IN* records and a EVA file for storing *EV* records. The *IN* and *EV* records may also be stored at the end of the DAT file following the *ED* record. Optionally, *SIM* will also read *EV* and *IN* records in an old format used in early WRAP versions stored in a HYD file. The default record format and file organization are described first followed by a description of the old approach still maintained as an option. There are two record grouping options for storing the *IN* and *EV* records in FLO and EVA files or the DAT file. The alternative groupings are by year and by control point.

*JO* record field 2 *INEV* options 1, 3, and 5 require that records be grouped by year. A group of records for all control points for the year 2002 will follow a similar set of records for all control points for the year 2001. Typically, developing a complete time series of *IN* and/or *EV* records covering all years of the entire period-of-analysis for each individual control point is more convenient. Options 2 and 4 allow this more convenient format but require much more computer memory. A *SIM* simulation is performed chronological by year. With Options 1, 3, and 5, *SIM* reads the *IN* and *EV* records for only one year in an iterative annual loop. With Options 2 and 4, all *IN* and *EV* records are read at the beginning of the simulation, requiring much more memory.

| Grouping by Year | | | | Grouping by Control Point | | |
|---|---|---|---|---|---|---|
| IN | CP-1 | 2001 | | EV | CP-1 | 2001 |
| IN | CP-2 | 2001 | | EV | CP-1 | 2002 |
| IN | CP-3 | 2001 | | EV | CP-1 | 2003 |
| IN | CP-1 | 2002 | | EV | CP-2 | 2001 |
| IN | CP-2 | 2002 | | EV | CP-2 | 2002 |
| IN | CP-3 | 2002 | | EV | CP-2 | 2003 |
| IN | CP-1 | 2003 | | EV | CP-3 | 2001 |
| IN | CP-2 | 2003 | | EV | CP-3 | 2002 |
| IN | CP-3 | 2003 | | EV | CP-3 | 2003 |

*IN* and *EV* records are stored in text files. As an alternative, with option 6 specified for INEV in *JO* record field 2, the naturalized flows and net evaporation-precipitation depths are read from a binary DSS file with the filename rootHYD.DSS that can be created using *OF* record field 6.

**Options for Organizing Monthly Naturalized Flows and Net Evaporation Depths**

At least one *IN* record or equivalent DSS record is required to execute *WRAP-SIM*. However, *EV* records are not required. An entry of −1 or −2 for the *JO* record field 2 INEV switch activates a FLO file without a corresponding EVA file. The INEV options are as follows.

The organization and format of hydrology datasets can be conveniently converted using the program *HYD*. *WRAP-HYD* includes options for converting files with flows and evaporation-precipitation rates organized in either of the alternative formats to another selected option.

*Option 1: INEV = 0 or 1 in JO Record Field 2*

With the default format, the *IN* and *EV* records are stored in separate files, with filename extensions FLO and EVA, respectively. The records are in the standard default format shown earlier. In the FLO and EVA files, the records for all control points are grouped together by year. All the records for a year are followed by a complete set of records for the next year. A *JO* record field 2 entry of −1 is used to activate a FLO file without an EVA file if there are no *EV* records.

*Option 2: INEV = 2 in JO Record Field 2*

Option 2 is identical to option 1 except the *IN* and *EV* records are grouped by control point. All records for all years for the first control are grouped together before the records for the second control point. A *JO* record field 2 entry of −2 is used to activate a FLO file without an EVA file if there are no *EV* records.

*Option 3: INEV = 3 in JO Record Field 2*

Option 3 is identical to Option 1 except the records are stored at the end of the DAT file following the *ED* record. The set of all *IN* records for a particular year is followed by the set of all *EV* records for that year.

*Option 4: INEV = 4 in JO Record Field 2*

Option 4 is identical to Option 2 except the records are stored at the end of the DAT following the *ED* record. The set of all *IN* records is entered first followed by the set of all *EV* records.

*Option 5: INEV = 5 in JO Record Field 2*

The *IN* and *EV* records are stored in a single hydrology file, with the filename root.HYD. Pairs of records with six months on each are in the format shown on page 97. In the HYD file, the records for all control points are grouped together by year. All the records for a year are followed by a complete set of records for the next year.

*Option 6: INEV = 6 in JO Record Field 2*

Naturalized monthly stream flow volumes and net evaporation-precipitation depths are stored in binary format in a single DSS file with the filename rootHYD.DSS.

**FD** Record  –  Flow Distribution

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | FD | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier for ungaged CP |
| 3 | 11-16 | DSG | 2x,A6 | AN | Source gaged control point |
| 4 | 17-24 | NG | I8 | + | Number of gaged cp's above ungaged site (blank = 0) |
|  |  |  |  | –1 | Ungaged CP is downstream of source CP |
| 5-no limit | 25-no limit | UGID(I) I=1,MAXGAG | 2x,A6 | AN | Identifiers of upstream gaged control points<br>No limit on the maximum number of identifiers. |

**FC** Record  –  Coefficients for Flow Distribution Equation

| field | columns | Variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | FC | Record identifier |
| 2 | 3-8 | COEF1 | F6.0 | + | Coefficient *a*  (may be drainage area ratio) |
| 3 | 9-16 | COEF2 | F8.0 | + or – | Coefficient *b* (default = 1.0) |
| 4 | 17-24 | COEF3 | F8.0 | + or – | Coefficient *c* (default = 0.0) |
|  |  |  |  |  | $Q_{ungaged} = a \, Q_{gaged}{}^{b} + c$ |

**WP** Record  –  Watershed Parameters

| field | column | Variable | format | value | description |
|-------|--------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | WP | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| 3 | 9-16 | DA | F8.0 | + | Drainage area |
| 4 | 17-24 | CN | F8.0 | + | Curve number |
| 5 | 25-32 | MP | F8.0 | + | Mean precipitation |
| 6 | 33-40 | DAF | F8.0 | + | Multiplier to convert drainage area to square miles |

*FD*, *FC*, and *WP* records are stored in a flow distribution file with filename extension DIS.  A *FC* record must follow directly behind its *FD* record.  Otherwise, the *FD/FC* and *WP* records may be in any order in the DIS file.  A DIS file always ends with an *ED* record.  The end-of-data *ED* record is required as the final record in the DIS file.

## Explanation of FD, FC, and WP Records

A flow distribution DIS file is required and is automatically opened (activated) if one or more control point *CP* records in the DAT file specify an INMETHOD option in field 6 or EWA option in field 9 that requires *FD*, *FC*, and *WP* record information provided in the DIS file. Flow distribution options 2 through 8 in *CP* record field 6 require a DIS file. The evaporation-precipitation adjustment activated as a default in *JD* record field 10 or set for individual control points in *CP* record field 9 may also require information from *FD* and *WP* records.

The methods for distributing naturalized stream flows from gaged (known flow) to ungaged (unknown flow) control points and the evaporation-precipitation adjustment methodology are described in Chapter 3 of the *Reference Manual*. A *FD* record is required for each ungaged control point for which flows are synthesized. Flows are transferred from the source (gaged) control point (*FD* field 3) to the ungaged location (*FD* field 2). *FD* records are also required if pertinent options are specified (*JD* field 10 and *CP* field 9) for computing adjustments to evaporation-precipitation depths for reservoir site runoff. Either *FD* record field 2 or 3 control points may be used for adjusting net evaporation-precipitation depths. Upstream control points (*FD* fields 5-19) define incremental watersheds for either application.

A *FC* record follows the *FD* record if the flow synthesis option 3 is specified for this control point in *CP* record field 6. The *FC* record provides values for the coefficients a, b, and c for the equation:

$$Q_{ungaged} = a\, Q_{gaged}{}^{b} + c$$

A watershed parameter *WP* record is provided for each gaged and ungaged control point involved in applying flow distribution methods 4 through 8 specified in *CP* record field 6. The watershed parameters are drainage area, curve number, and mean precipitation. Only those parameters required by the selected optional method specified on the *CP* record need to be provided on the *WP* records.

*SIM* uses drainage area units of square miles in performing computations within the model. The watershed drainage area entered in *WP* record field 3 is by default in units of square miles. However, if the area is entered in *WP* record field 3 in units other than square miles, a unit conversion factor DAF may be entered in *WP* record field 6. The area on the *WP* record is multiplied by this factor to convert to square miles. The unit conversion multiplier DAF in *WP* field 6 applies to this and all subsequent *WP* records until a new DAF is entered on another *WP* record. The default *DAF* is 1.0.

The watershed drainage area, curve number CN, and mean precipitation entered in *WP* record fields 3, 4, and 5 are by default for the total watershed above the control point identified in field 2. However, the parameter INWS in *CP* record field 11 allows the three parameters to be assigned to the incremental watershed defined by the *FD* record rather than to the total watershed.

**FA** Record – Flow Adjustments

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | FA | Record identifier (optional) |
| 2 | 3-8 | ID | A6 | AN | Control point identifier (optional) |
|   | 9-12 | - | 4x | - | not read |
| 3 | 13-16 | PYR | I4 | + | Year (optional) |
| 4 | 17-24 | FA(1) | F8.0 | + | Stream flow adjustment for month 1 |
| 5 | 25-32 | FA(2) | F8.0 | + | Stream flow adjustment for month 2 |
| 6 | 33-40 | FA(3) | F8.0 | + | Stream flow adjustment for month 3 |
| 7 | 41-48 | FA(4) | F8.0 | + | Stream flow adjustment for month 4 |
| 8 | 49-56 | FA(5) | F8.0 | + | Stream flow adjustment for month 5 |
| 9 | 57-64 | FA(6) | F8.0 | + | Stream flow adjustment for month 6 |
| 10 | 65-72 | FA(7) | F8.0 | + | Stream flow adjustment for month 7 |
| 11 | 73-80 | FA(8) | F8.0 | + | Stream flow adjustment for month 8 |
| 12 | 81-88 | FA(9) | F8.0 | + | Stream flow adjustment for month 9 |
| 13 | 89-96 | FA(10) | F8.0 | + | Stream flow adjustment for month 10 |
| 14 | 97-104 | FA(11) | F8.0 | + | Stream flow adjustment for month 11 |
| 15 | 105-112 | FA(12) | F8.0 | + | Stream flow adjustment for month 12 |

Adjustments to the naturalized river flows are entered on *FA* records stored in a flow adjustment file with the filename root.FAD. The FAD file is activated by *JO* record field 3.

The flow adjustments on *FA* records are positive or negative numbers which are added to the stream flows read from *IN* records or a hydrology DSS file. Stream flow adjustments from *FA* and *CI* records are treated the same in the simulation with the following exception. Constant inflow *CI* records provide a set of 12 monthly adjustments that are repeated for all years. A different *FA* record is provided for each year, allowing the adjustments to vary between years. The adjustments on either *CI* or *FA* records are entered at a specified control point and are cascaded downstream within *SIM* in the normal manner accounting for channel losses.

*FA* records may be entered for any number of control points. If *FA* records are entered for a control point, the *FA* records must cover the entire hydrologic period-of-analysis with a *FA* record provided for each year. The *FA* records are grouped in the FAD file by year. If records are included for more than one control point, the FAD file begins with *FA* records for all control points for the first year, followed by *FA* records for all control points for the second year, and ends with a set of *FA* records for all control points for the last year of the hydrologic period-of-analysis.

**CHAPTER 4**
**PROGRAM TABLES**

The program *TABLES* reads *SIM*, *SIMD*, and *SALT* input and output files, performs various computations, and develops an assortment of tables, which are written to an output file. *TABLES* provides flexible post-simulation capabilities for computing reliability and frequency relationships and organizing, summarizing, and displaying simulation results as a set of user specified tables. These tables may be viewed directly in the text file created by *TABLES* or transported to a spreadsheet or word processor program for graphics or report preparation. *TABLES* also converts simulation results to HEC-DSS files to be read by *HEC-DSSVue* for plotting or other purposes. Though designed primarily for managing *SIM*, *SIMD*, and *SALT* simulation results, simulation input may also be displayed with *TABLES*.

This chapter covers the application of *TABLES* with *SIM* input data and simulation results. All *SIM*-related *TABLES* routines are covered here except conditional reliability modeling. The additional *TABLES* features associated with the simulation programs *SIMD* and *SALT* as well as conditional reliability modeling connected to *SIM*/*SIMD* are covered in the *Supplemental Manual*.

## Input and Output Files

An execution of *TABLES* begins with an interactive routine in which filename roots are assigned, typically through the *WinWRAP* interface. Filenames are in the format *root.ext* with a user-specified *root* and a standard extension *ext* denoting the type of file. The *TABLES* output file is the only WRAP input or output file that is not restricted to a standard filename extension. The default extension for the *TABLES* output file is TOU, but other three character extensions may be used instead. All files listed in Table 4.1 may have the same filename root. Optionally, the TIN and TOU files may have filename roots that are different from both each other and the *SIM* files.

The *TABLES* input TIN file specifies the tables and/or other types of information to be developed and stored in the *TABLES* output TOU file. This chapter focuses on the input records entered in a TIN file. The data from which the tables and data listings are compiled are read from *SIM* input and/or output files. Most applications involve *TABLES* reading simulation results from a *SIM* OUT file, but various *TABLES* options involve reading data from other *SIM* files as well.

## Program Organization

The Fortran program *TABLES* consists of a main program and a number of subroutines. The main program opens files, checks the identifier on each record of the TIN file, and calls the appropriate subroutines. The *SIM* input and output files are read and the specified tables and data listings are developed and written to the *TABLES* output file by the subroutines. Each subroutine is associated with specific types of tables or data listings and is activated by one or more types of input records read from the TIN file. Thus, *TABLES* is very modular. Each input record entered in the TIN file builds a set of tables or data listings independently of the other records in the TIN file.

*TABLES* reads one record of the TIN input file (filename extension TIN); develops the set of tables specified; stores the tables in the TOU output file (extension TOU); and then goes on to the

next record of the input file. The input records are handled in sequential order. Thus, erroneous *TABLES* TIN file records are easy to locate. If the program terminates prematurely due to input data problems, the erroneous record in the TIN file is located simply by observing from the message file trace the last record read. *TABLES* also writes various error and warning messages to the monitor and/or message TMS file to help in detecting and correcting blunders in the TIN file.

Table 4.1
TABLES Input and Output File Types
_____

### *TABLES* Input Files Pertinent to this Manual

| | |
|---|---|
| root3.TIN | required ***T****ABLES **in*put file with specifications regarding tables to be developed |
| root1.DAT | *SIM/SIMD* input DAT file |
| root1.OUT | *SIM/SIMD* output OUT file |
| root1.HRR | *SIM/SIMD* output HRR file |
| root1.ZZZ | *SIM/SIMD* output ZZZ file |
| root2.DIS | *SIM/SIMD* input DIS file |

### *TABLES* Output Files Pertinent to this Manual

| | |
|---|---|
| root4.TOU | ***T****ABLES* main ***ou****t*put file (optional filename extension with default TOU) |
| root4.TMS | ***T****ABLES **m*essage file |
| root4.DSS | Hydrologic Engineering Center ***D****ata **St*orage ***S****ystem* file created by *TABLES* |

### Additional *TABLES* Input Files Addressed in the Supplemental Manual

| | |
|---|---|
| root1.CRM | *SIM/SIMD **c*onditional ***r****eliability **m*odeling output file |
| root1.SUB | *SIMD* sub-monthly time step simulation results |
| root1.SFF | ***s****torage-****f****low-****f****requency* file created by *5CR1* record and read by *5CR2* record |
| root1.AFF | ***a****nnual **f*lood ***f****requency* file created by *SIMD* with peak flows and storage |
| root1.SAL | salinity simulation results file produced by program *SALT* |

_____

The types of *TABLES* input records are listed in Table 4.2 with the four-character identifiers that are placed at the beginning of each record. Headings for the tables created by several of these records are shown as Tables 4.3 through 4.8. Examples in the *Reference Manual* and *Fundamentals Manual* illustrate the format and content of various types of tables and data sets.

Some of the *TABLES* input records in the TIN file activate subroutines that simply rearrange and tabulate, with appropriate table headings, selected data read from *SIM* input or output files. The subroutines also include various computational algorithms. In some cases, summing and other simple arithmetic combining of data are involved. Other subroutines include more complex arithmetic or sorting operations. For example, a 1SRT record calls a subroutine containing a water rights sorting algorithm. A 1CPT record sorts control points in upstream-to-downstream order. A 2REL record computes period and volume reliabilities. A 2FRE record develops frequency statistics for naturalized, regulated, or unappropriated stream flow, reservoir storage, or instream flow shortages. A 2RES record activates a subroutine that develops reservoir drawdown-frequency and storage-reliability tables and storage tabulations with storage converted from volume units to

percentages of storage capacity. A 2BUD record activates relatively extensive computations to develop water budgets for control points and the entire river basin.

Table 4.2
Input Records and Associated Tables

_____

<u>Miscellaneous Records</u>

TITL   – titles or headings                                    UNIT  – units for table headings
COMM or **** – comments                                        TEST  – checks of *SIM* output file
PAGE  – title page                                             ENDF  – end of input data file
FILE   – binary OUT file and DSS file

<u>Type 1 Records − Tables Developed from *SIM* Input DAT File</u>

1REC  – listing of specified input records
1SUM  – water rights summary by control point, type of use, type of right, or group
1SRT  – listing of water rights sorted by priority, type of use, control point, or water right type
1LEN  – removes comments written to the right of column 128 of the input records
1CPT  – listing of control point information in upstream-to-downstream order

<u>Type 2 Records − Tables Developed from *SIM* Output OUT File</u>

<u>Time Series Tables in Optional Formats or HEC-DSS File</u>

IDEN  – control point, water right, reservoir, and water right group identifiers
2NAT  – naturalized stream flow
2REG  – regulated stream flow
2UNA  – unappropriated stream flow
2CLO  – channel loss
2CLC  – channel loss credits
2RFR  – return flow entering at this control point
2URR  – regulated flow at this control point from upstream reservoir releases
2CPI  – control point inflows excluding secondary reservoir releases
2STO  – reservoir storage
2EVA  – reservoir evaporation-precipitation volume
2EVR  – reservoir evaporation-precipitation rates
2EPD  – adjusted reservoir evaporation-precipitation depth
2DEP  – stream flow depletion
2TAR  – diversion target
2SHT  – diversion shortage
2DIV  – diversion
2RFL  – return flow
2XAV  – increase in available stream flow resulting from *PX* record cp limit option
2ASF  – available stream flow
2IFT  – instream flow target
2IFS  – instream flow shortage
2ROR  – releases from other reservoirs

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Table 4.2 Input Records and Associated Tables (Continued)

_____

2HPS  – hydropower shortage or secondary energy
2HPE  – energy generated
2RID  – inflows to reservoir from stream flow depletions
2RIR  – inflows to reservoir from releases from other reservoirs
2RAH  – releases accessible to hydropower
2RNA  – releases not accessible to hydropower
2WSE  – reservoir water surface elevation

Reliability and Frequency Tables

2REL  – reliability summary by control point, water right, water right group, or reservoir
2FRE  – frequency table for stream flow, storage, or instream flow shortage
2FRQ  – frequencies for specified stream flow, storage, or instream flow shortage
2RES  – reservoir percentage of storage capacity, draw-down duration, and storage reliability

Summary Tables and Water Budget Tables

2SCP  – monthly or annual summary table for a control point
2SWR  – monthly or annual summary table for a water right
2SRE  – monthly or annual summary table for a reservoir
2SGP  – monthly or annual summary table for a water right group
2SBA  – monthly or annual summary table for the entire river basin(s)
2BUD  – water budget for control points and/or the entire river basin(s)

Type 3 Records − Input Records Developed from *SIM* Output OUT File

3REG  – records of regulated stream flows
3NAT  – records of naturalized stream flows
3UNA  – records of unappropriated stream flows
3DEP  – records of stream flow depletions
3U+D  – records of unappropriated flows plus stream flow depletions
3EPD  – records of adjusted reservoir evaporation-precipitation depth

Type 4 Records − Tables Developed from *SIM*
System Release/Hydropower (HRR) File or Priority Sequence Flow (ZZZ) File

4SWR  – system reservoir releases for selected water rights from HRR file
4SGP  – system reservoir releases for selected water right groups from HRR file
4ZZF  – frequency tables for flows from ZZZ file
4ZZZ  – times series tables or DSS records for flows from ZZZ file

Other *TABLES* TIN File Record Types Covered in the Supplemental Manual

Type 5 − conditional reliability modeling results from *SIM* or *SIMD* CRM file
Type 6 − sub-monthly time step reliability and frequency tables from *SIMD* SUB file
Type 7 − flood frequency analyses from *SIMD* AFF file
Type 8 − salinity simulation results from *SALT* SAL file

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Table 4.3
Headings for Water Rights Summary Specified by 1SUM Record
(Heading for first column may be either use, control point, water right type, or group.)

| USE | NUMBER OF RIGHTS | PERMITTED DIVERSIONS (AC-FT/YR) | NUMBER OF RESERVOIRS | RESERVOIR STORAGE (AC-FT) | PRIORITIES RANGE FROM | TO |
|---|---|---|---|---|---|---|

Table 4.4
Annual Rows with Monthly Columns Format Headings for Tables Specified by
Time Series Records such as the 2NAT, 2REG, 2UNA, 2DEP, 2DIV, 2SHT, 2IFS,
2CLO, 2CLC, 2STO, and Other Similar Records

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|

Table 4.5
Headings for Reliability Summary Specified by 2REL Record

| NAME | TARGET DIVERSION (AC-FT/YR) | MEAN SHORTAGE (AC-FT/YR) | **RELIABLITY** PERIOD (%) | VOLUME (%) | ++++PERCENTAGE OF MONTHS++++ WITH DIVERSIONS EXCEEDING PERCENTAGE OF PERMITTED DIVERSION 100% 95% 90% 75% 50% 25% 1% | ------PERCENTAGE OF YEARS------ 100% 98% 95% 90% 75% 50% |
|---|---|---|---|---|---|---|

Table 4.6
Headings for Frequency Tables Specified by 2FRE Record
(Heading for first column may be either control point, water right, or reservoir.)

| CONTROL POINT | MEAN | STANDARD DEVIATION | PERCENTAGE OF MONTHS WITH FLOWS EQUALING OR EXCEEDING VALUES SHOWN 100% 99% 98% 95% 90% 75% 60% 50% 40% 25% 10% MAXIMUM |
|---|---|---|---|

Table 4.7
Headings for Monthly Summary Specified by 2SWR Record

| YEAR | MONTH | AVAILABLE STREAMFLOW (AC-FT) | STREAMFLOW DEPLETION (AC-FT) | EOP STORAGE (AC-FT) | EVAP (AC-FT) | SYSTEM RELEASES (AC-FT) | TARGET DIVERSION (AC-FT) | ACTUAL DIVERSION (AC-FT) | SHORTAGE (AC-FT) |
|---|---|---|---|---|---|---|---|---|---|

Table 4.8
Headings for Annual Summary Specified by 2SBA Record

| YEAR | NATURALIZED STREAMFLOW (AC-FT) | RETURN FLOW (AC-FT) | FLOW DEPLETION (AC-FT) | UNAPPROPRIATED FLOW (AC-FT) | EOP STORAGE (AC-FT) | EVAP (AC-FT) | TARGET DIVERSION (AC-FT) | ACTUAL DIVERSION (AC-FT) | DIVERSION SHORTAGE (AC-FT) |
|---|---|---|---|---|---|---|---|---|---|

## Input Records and Associated Tables

The tables or data sets to be developed are specified by records in an input file with the filename extension TIN. Each type of table is associated with an input record that begins with a four-character record identifier, followed by parameters providing instructions associated with that particular type of table or data listing. All records are optional; there are no required records. No limits are placed on the number or order of the records, with the exception of title TITL records that are limited to a maximum of five records and must be located at the beginning of the input file. Any number of each type of record, except the TITL records, can be placed in any order in the TIN file.

### *Miscellaneous Records*

TITL records provide titles or headings to be reproduced on the cover page and at the top of each type 2 or type 3 table. Zero to five TITL records may be used.

COMM or **** records provide a means to insert comments or notes at any location in the input file. Comment records are not read or used in any way by the program.

The FILE record indicates that the *SIM* OUT or CRM output file is in binary machine language. The formatted versus unformatted form of the *SIM* output file is controlled by *JD* record field 7. The FILE record also optionally creates and provides information for a DSS file.

UNIT records specify unit labels to include in table headings other than the default *AC-FT* for volume and *MW-HR* for hydroelectric energy. The unit headings entered on a UNIT record are adopted for all records following the UNIT record. Without a *UNIT* record, the defaults of *AC-FT* and *MW-HR* are adopted. Units pertain only to table headings, not actual computations. *TABLES* computations are manipulations of the *SIM* simulation results performed without reference to units.

The TEST record activates tests of the *SIM* output OUT file that are described in the *Reference Manual* Chapter 7. The TEST record is designed to be used only in rare instances in which *TABLES* is not able to read the OUT file for unknown reasons.

The ENDF record denotes the end of the input file. Any records following the ENDF record will not be read. Although an ENDF record is not required, a message is printed on the monitor screen, as a reminder, if the input file has no ENDF record. Routinely used records may be conveniently stored behind the ENDF record when not used in particular executions of *TABLES*.

### *Type 1 Records − Tables are developed from data from a SIM input file.*

1REC, 1SUM, 1SRT, 1LEN, and 1CPT records specify listings and tabulations of data which are read from *SIM* input files. The four-character identifiers for type 1 records begin with the numeral one (1REC, 1SUM, 1SRT, 1LEN, 1CPT) signifying that the source of data is a *SIM* input DAT file. All four records create tables from data read from the main *SIM* DAT file. The 1CPT record also includes an option that reads watershed areas from a flow distribution DIS file.

Inclusion of a 1REC record in a *TABLES* input file results in a listing of specified *SIM* input records. The 2-character identifiers of the *SIM* input records are used to define records to be listed.

A 1SUM record results in a summary table of water rights data by control point, type of use, water right type, or water right group. This table includes number of rights, diversion amounts, number of reservoirs, storage capacity, and range of priorities. The heading for a 1SUM record by type of use is shown as Table 4.3. The types of water use listed in the first column may be replaced with control points, water right types, or water right groups.

A 1SRT record creates a listing of water rights sorted in priority order or a listing sorted by type of use, control point, water right type, or water right group in priority order.

The 1CPT record activates a set of routines that reorder control points in upstream-to-downstream order and list information read from the *CP* records. Two alternative definitions of *upstream-to-downstream order* may be selected. With one option, the sequencing is based on each control point being listed earlier than any other control point located downstream of it. With the other option, a first sequence goes from a most-upstream control point to the basin outlet, and each subsequent sequence extending from a most-upstream control point to a previously ordered stream. With either option, most-upstream control points are selected in the order they are found in the original *CP* records in the *SIM* input file. The 1CPT record provides several options for writing information to the *TABLES* output file. One option is to reproduce the *CP* records in upstream-to-downstream order. The *CP* records created by *TABLES* are identical to those read from the *SIM* input file except their order is changed to upstream-to-downstream. Other options consist of listing various sets of information from the *CP* records. Watershed area read from *WP* records in the DIS file may also be included in the tabulations.

### *Type 2 Records − Tables are developed from data from a SIM output OUT file.*

Type 2 records result in tables being developed from the *SIM* simulation results contained in the water right, control point, and reservoir/hydropower records of a *SIM* OUT file as listed in Tables 5.3, 5.4, and 5.5 of the *Reference Manual*. A *SIM* water right output record contains data for an individual water right. A control point record contains data summed for all the water rights located at the control point or data, such as regulated or unappropriated flows, not associated with a particular water right. A reservoir/hydropower record contains data for a reservoir including hydroelectric energy generation data if a power plant is located at the reservoir. Reservoir data are also included on the control point and water right output records.

### *Time Series Tables and Data Sets*

The *SIM* simulation results described in *Reference Manual* Chapter 5 are tabulated as a standard set of time series tables by 2NAT, 2REG, 2UNA, 2CLO, 2CLC, 2RFR, 2URR, 2CPI, 2STO, 2EVA, 2DEP, 2DIV, 2TAR, 2SHT, 2RFL, 2XAV, 2ASF, 2ROR, 2IFT, 2IFS, 2HPS, 2HPE, 2RID, 2RAH, 2RNA, 2EPD, 2EVR, and 2WSE records. These *TABLES* input records all have the same format. The time series tables created by these records also all have the same format. The simulation results may be tabulated directly or optionally as moving averages or after other arithmetic adjustments. The time series are converted by *TABLES* to three optional formats:

- tables with annual rows and monthly columns with headings shown in Table 4.4
- tabulations in a columnar format designed for transporting to Microsoft Excel
- records in a HEC-DSS file designed to be read by HEC-DSSVue

*Reliability and Frequency Tables*

A 2REL record creates a table of volume and period reliabilities including the percentage of time that certain percentages of demand are met. A 2REL summary may be developed for either selected water rights, water right groups, control points, or reservoir/hydropower projects. Separate 2REL records would be used to obtain separate reliability summary tables for selected water rights, control points, and hydroelectric power reservoirs, respectively. Volume reliability is the mean volume supplied (or hydroelectric energy generated) divided by the corresponding mean target diversion volume (or target energy production), expressed as a percentage. Period reliability is the percentage of time during which either 100% or a specified percentage of the target demand is met. The 2REL table expresses period reliabilities in terms of the percentage of the months and the percentage of the years during the simulation for which the water right diversion or hydroelectric energy generated equaled or exceeded specified percentages of the diversion or hydroelectric energy target. The format of this table is illustrated by Table 4.5. Fixed percentages of target amounts are tabulated in the heading, and the computed exceedance frequencies are shown on each row of the table. Reliability indices are discussed in *Reference Manual* Chapter 5.

The 2FRE record determines the mean, standard deviation, and frequency relationship for naturalized flows, regulated flows, unappropriated flows, or reservoir storage associated with specified control points, or the reservoir storage or instream flow shortage associated with specified water rights, or the storage or water surface elevation for specified reservoirs. The flow or storage amount is computed for each of the exceedance frequencies shown in Table 4.6 based optionally on relative frequency counts or the log-normal or normal probability distributions. The exceedance frequencies are measures of the percentage-of-time, probability, or likelihood that the flow or storage variable equals or exceeds the amounts shown in the table.

The 2FRQ record also develops an exceedance frequency relationship for naturalized flows, regulated flows, unappropriated flows, or reservoir storage associated with a specified control point or the reservoir storage or instream flow shortage associated with a specified water right, or the storage or water surface elevation for specified reservoirs.. The frequencies associated with up to seven user-specified flow or storage amounts are computed based on relative frequency counts.

The 2FRQ and 2FRE records both provide frequency relationships for the same variables but differ as follows. The 2FRE record determines flows for the set frequencies shown in Table 4.6. Conversely, the 2FRQ record determines frequencies for flows specified by the user as input on the 2FRQ record. Whereas, a single 2FRE table may include rows of information for multiple control points or water rights, each 2FRQ table is limited to a single specified control point or water right. Of course, any number of 2FRQ records may be included in the input file. Examples of tables created with 2FREQ and 2FRQ records may be found in the *Reference Manual* and *Fundamentals Manual*. Frequency analysis methods are discussed in Chapter 5 of the *Reference Manual*.

The 2RES record builds three tables for specified reservoirs: (1) tabulations of end-of-period reservoir storage as a percentage of a user-specified storage capacity, (2) draw-down duration summary, and (3) storage reliability summary. Sets of 2RES records are used to specify the reservoirs to be included in the tabulation and, for each reservoir, the storage capacities $C_1$ and $C_2$ at the top and bottom, respectively, of the conservation pool or zone. The end-of-period storages S are

read from the reservoir/hydropower record of the *SIM* output file. Percentage storage content tabulations are particularly useful for reviewing simulation results for multiple-reservoir system operations. The storage content as a percentage of capacity is computed as follows:

$$\text{storage as percentage of capacity} = \left( \frac{S - C_2}{C_1 - C_2} \right) 100\%$$

The 2RES draw-down duration table is developed in terms of the number of months for which the storage draw-down equaled or exceeded specified percentages of storage capacity of the defined zone. The storage reliability table expresses the percentage of months in which end-of-month storage contents equaled or exceed tabulated percentages of storage capacity of the defined zone.

### *Summary Tables*

2SCP, 2SWR, 2SGP, and 2SRE records result in summary tables of key variables for specified control points, water rights, water right groups, or reservoirs, respectively. These tables consist of either a monthly or annual tabulation of the data items contained on the *SIM* control point, water right, or reservoir/hydropower output records. The heading for a monthly summary table created by a 2SWR record is shown as Table 4.7. Each row of data in the table corresponds to a month in the hydrologic period-of-analysis.

A 2SGP record results in a summation of certain data on the *SIM* water right output records of multiple rights with the same group identifier in fields 12 or 13 of the *WR* input records. This water right group summary table has the summation of the stream flow depletions, diversions, and diversion shortages associated with all water rights with the specified group identifier.

A 2SBA record results in a basin summary table, with the headings shown in Table 4.8. The naturalized, regulated, and unappropriated stream flows in the 2SBA table are the maximum of the values found at any of the control points. The other tabulated data are the summation of values for all of the control points. A monthly table has an additional column for the month and 12 times as many rows as the annual table of Table 4.8.

### *Water Budget Tables*

A 2BUD record develops a monthly control point water budget table and/or a period-of-analysis river basin water budget table. Monthly computations are performed for all control points in developing the total river basin water budget table. The water budgets are tabulations of the individual components of inflows to and outflows from the control point or river basin along with changes in reservoir storage. The following water budget equation is confirmed.

$$\text{sum of all inflows} - \text{sum of all outflows} = \text{change in storage}$$

The 2SCP, 2SWR, 2SGP, and 2SRE records described above tabulate simulation results from a *SIM* output file with only minor computations. The 2BUD routine uses *SIM* input and output data in the relatively extensive computations that are required to develop all components of a complete detailed monthly water budget for individual control points. The monthly data are also used to develop a period-of-analysis river basin water budget summary table.

**TABLES**

*Type 3 Records − Input records are developed from data from a SIM output file.*

Type 3 records instruct *TABLES* to read naturalized flows, regulated flows, unappropriated flows, stream flow depletions, and/or evaporation-precipitation depths from a *SIM* output file and convert these data to records in the format of *SIM IN* or *TS* records. The resulting time series written to the *TABLES* output file are in the same format as *IN* or *TS* records except the model user selects any two-character identifier for the first two characters of each record, which could be *IN*, *TS*, blanks, or any other two characters. Records are developed for all control points included in the *SIM* output file. The records created by *TABLES* may contain either of the following:

- naturalized stream flows (3NAT record)
- regulated stream flows (3REG record)
- unappropriated stream flows (3UNA record)
- stream flow depletions (3DEP record)
- summation of stream flow depletions plus unappropriated flows (3U+D record)
- evaporation-precipitation depths from reservoir output records (3EPD record)

Each record created by *TABLES* contains a user-specified two-character record identifier (such as *TS* or *IN*), control point identifier, year, and 12 monthly stream flow values for the specified year and location. Options allow the records, for multiple years and locations, to be grouped either by control point or by year. With the first option, all the *IN* records for all years are grouped together for a given control point followed by a set of *IN* records for all years for the next control point, and so forth. With the other optional format, the *IN* records for all control points are grouped together for a given year are followed by a group of all control points for the next year. Inputted multiplier factors can be used for converting units or otherwise scaling the stream flows.

A 3NAT record creates stream flow records in the format of *SIM* input *IN* or *TS* records containing the naturalized stream flows read from the *SIM* output file for all control points. 2REG, 3UNA and 3DEP records are identical to the 3NAT record except regulated flows (3REG record), unappropriated flows (3UNA record), or the total stream flow depletions at each control point (3DEP record) are written on the records instead of naturalized stream flows (3NAT). A 3U+D record is the same as the others except the summation of unappropriated flows and stream flow depletions is computed and written to the output records. A 3U+D record must be used with caution because it combines unappropriated flows which are relevant to a particular control point with stream flow depletions which affect flows at all downstream control points as well as the control point at which the depletions occur. The 2EPD record requires *SIM* reservoir output records.

Type 3 records facilitate use of adjusted stream flows from *SIM* simulation results as input to either *SIM* or another model. For example, regulated flows computed by *SIM* for a particular water management strategy may be treated as *TS* record instream flow requirements for other executions of *SIM*. Yield analyses at a single control point may be performed for previously computed unappropriated flows converted to *IN* records.

The *HYD OI* record described in Chapter 5 provides similar capabilities for converting *SIM* OUT file simulation results to input records. *HYD* also provides capabilities for cascading flows considering channel losses and various other flow volume and evaporation-precipitation depth manipulations involving simulation results read from the *SIM* output OUT file.

*Type 4 Records − Tables are developed from data from either a SIM HRR or ZZZ file.*

Type 4 records result in tables being developed from the data contained in the *SIM* special purpose HRR and ZZZ output files. 4SWR or 4SGP records organize data contained in a *SIM* hydropower and multi-reservoir system release file with filename extension HRR. 4ZZF and 4ZZZ records organize simulation results from a priority sequence flow file with filename extension *ZZZ*.

4SWR or 4SGP records tabulate monthly or annual system releases from all reservoirs associated with a water right (4SWR) or group of water rights (4SGP). In the HRR file, reservoir releases each month of the simulation for a given water right are listed as a row, which may contain releases from multiple reservoirs associated with that water right. The 4SWR and 4SGP records create tables with releases from each reservoir listed as columns. The 4SWR record deals with a specific water right. The 4SGP record results in a table for a group of water rights in which the total monthly releases for all rights in the group from each reservoir for that group are listed in a column. *JO* record field 4 of the *SIM* DAT file specifies whether or not a HRR file is created. Water right identifiers are written to the HRR file by default unless group identifiers are specified in *JO* record field 4. The same water rights are included in both the OUT and HRR output files.

A *ZZ* record in a *SIM* DAT file activates a feature described in *Reference Manual* Chapter 6 that tabulates regulated flows, available flows, and reservoir releases at specified control points in a ZZZ file as each water right is simulated in the priority sequence. The *TABLES* 4ZZF and 4ZZZ record routines read the flows from the ZZZ file. The 4ZZF record builds frequency tables similar to the 2FRE record. The 4ZZZ record organizes the flows as tables in the TOU file or DSS file records in the same manner as type 2 time series records.

### Format and Content of Input Records in TIN File

Program *TABLES* reads *SIM* input and output files and builds a set of user-specified tables and data listings which are written to the TOU output file. Another *TABLES* input file with the filename extension TIN is required containing the records described by this chapter which specify the tables to be built. The following instructions outline the format and content of each type of record used to define the tables and other information to be developed by *TABLES*. The *WinWRAP* interface program provides a built-in editor for creating and editing *TABLES* input TIN files. The TIN file also may be created with Microsoft WordPad or any other editor.

The first four characters of each record consists of the record identifier. TITL records are placed at the beginning of the file. No more than five TITL records can be used. The ENDF record is the last record read. Any records placed after an ENDF record will not be read. With the exceptions of the TITL and ENDF records, the records can be placed in any order, and any type of record can be used any number of times. All records are optional. There are no required records.

*Format of Input Variables Serving as Alphanumeric Identifiers*

*TABLES* may incorporate all water rights, control points, or reservoirs included in the *SIM* OUT file in its tables without having to list them on the TIN file records. Alternatively, several of the TIN file records include options allowing identifiers of water rights, groups of water rights,

control points, or reservoirs to be listed in order to include a smaller sub-set of all those included in the OUT file. Only eight identifiers (character variables) can be entered on one record, but records may be repeated allowing a total of up to 80 identifiers to be listed. Control point and reservoir identifiers may contain a maximum of six characters and are entered in 8-character fields in the format 8(2x,A6). Water right group identifiers may contain a maximum of eight characters and are entered in 8-character fields in the format 8A8. Water right identifiers may contain a maximum of 16 characters and are entered in 16-character fields in the format 8A16.

Character variables (A format) input to Fortran programs are often right justified to prevent the trailing blanks from being read. However, the WRAP programs incorporate a read feature that automatically deletes the trailing blanks for water right identifiers and most other alphanumeric identifiers. Thus, right or left justification is not required, though the identifiers must be contained within their appropriate fields.

*Alternative Fixed Field Width and Comma Delimited Formats*

This *Users Manual* presents input format in terms of fixed-width fields. The *WinWRAP* built-in TIN file editor creates records in the standard fixed-width field format. For example, an integer with an I4 format is right justified in a 4-character wide field. However, an alternative option applicable to numeric data allows use of a comma to shorten a field. A comma may be used to shorten the width of a field, but the number of characters in a field can not exceed the width specified in this manual. The 2STO record in Table 2.7 of Example 2 from Chapter 2 of the *Reference Manual* is reproduced below in the standard fixed-field-width format.

(A4,I4,I4,I4,I4,I4,A8)

```
2STO   1   1   1   0   1      CP1
```

Alternatively, this record could be written in comma-delineated format as follows.

```
2STO1,1,1,0,1,      CP1
```

Both fixed-width and comma-delineated data may be combined in the same record as illustrated below.

```
2STO   1   1 1,   0 1,      CP1
```

A comma ends the field being truncated. Commas are used only to shorten the field widths of numeric data in integer (I) or real number (F) formats. Alphanumeric data for character (A format) variables and spacers (X format) must abide by the fixed field width format.

### *Legend for Format Column of Following Tables*

| | |
|---|---|
| A4 | Alphanumeric (AN) label (character variable) in a field that is 4 characters wide. |
| 8A8 | Up to 8 alphanumeric labels in fields that are 8 characters wide. |
| 2x | Two blank spaces. |
| 2x,A6 | Two blank spaces , followed by a 6-character wide alphanumeric label. |
| I8 | Integer number right justified in field of 8 characters. |
| I4 | Integer number right justified in field of 4 characters. |
| F8.0 | Real number in field of 8 digits either right justified or with decimal included. |

**TITL** Record − Titles or Headings

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | TITL | Record identifier |
| 2 | 5-78 | TITLE | A76 | AN | Title or heading |

From zero to five TITL records are entered as the first records of the input file. The alphanumeric information provided on these records is printed on the cover page and at the top of each table.

**COMM** or **\*\*\*\*** Record − Comments

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | \*\*\*\*\* or \*\* or COMM | Record identifier |
| 2 | 5-no limit | | | AN | Comments or notes |

Any number of comment records can be inserted anyplace in the input file to provide notes or comments. The comment records are not read or used in any way by the program.

**PAGE** Record − Title Page

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | PAGE | Record identifier - Prints title page |

An optional cover page inserted at the beginning of the *TABLES* output TOU file provides miscellaneous information identifying the dataset but in no way affects the computations or any of the tables generated. The cover page is not be written unless the TIN file contains type 2 records.

**TEST** Record − Test of *SIM* Output File for Problems

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | TEST | Record identifier |

The TEST record is used to check the OUT file only if *TABLES* terminates for unknown reasons that could be related to reading the OUT file. The TEST record activates a series of error checks of the *SIM* output OUT file which are described in the *Reference Manual* Chapter 7. The OUT file must be in the default text format, not the optional unformatted binary version.

*TABLES*

**ENDF** Record  −  End of Input File

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | ENDF | Record identifier |

Records placed after the ENDF record are not read.

**FILE** Record  −  Binary *SIM* OUT Output File and *TABLES* DSS Output File Options

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | FILE | Record identifier |
| | | | | | *Format of SIM OUT or CRM Output File* |
| 2 | 8 | OUTFORM | I4 | blank, 0 | Default text file version of SIM OUT or CRM file. |
| | | | | 1 | Binary machine language version of OUT or CRM file. |
| | | | | | *DSS Message File Options* |
| 3 | 12 | DSSMES | I4 | −1 | Messages are written only if *TABLES* is terminated due to some DSS related problem. |
| | | | | 1 | Messages that DSS file has been opened or closed. |
| | | | | blank, 2 | Error or warning messages if DSS problems occur. |
| | | | | 3 | Trace of all DSS records written to DSS files. |
| | | | | 4 | Trace of all DSS records read from DSS files. |
| | | | | 7 | Beginning level of debugging messages. |
| | | | | 8 | Intermediate level of debugging messages. |
| | | | | 9 | Maximum level of debugging messages. |
| | | | | | *Label of First Month in DSS File* |
| 4 | 14-16 | DSSMON | 1x,A3 | blank | Default is for first month to be January. |
| | | | | AN | First month in DSS file (JAN, FEB, MAR, ... , DEC) |

OUT and/or DSS files may be used with *TABLES* without a FILE record. The OUT file is opened by any type 2 record. A DSS file will be created automatically even without a FILE record for the DSS options (PT = 4 or 5) in field 3 of the time series records (pages 123-125) or 4ZZZ record. A DSS output file is also activated similarly by sub-monthly time series and 8SAL records covered in the *Supplemental Manual*. The defaults for the FILE record parameters OUTFORM, DSSMES, and DSSMON will be adopted automatically without a FILE record.

***Field 2***: The formatted text versus unformatted binary form of the *SIM* OUT or CRM output file is controlled in *SIM* by *JD* record field 7. The FILE record is required as a flag that the OUT file is in binary machine language. If the *SIM* output file is in text format, the FILE record is not required.

***Fields 3 and 4***: FILE record fields 3 and 4 provide the same information for a *TABLES* DSS output file as *OF* record fields 7 and 8 provide for a *SIM* DSS input or output file. Information is provided for a Hydrologic Engineering Center (HEC) Data Storage System (DSS) output file created by *TABLES*. The beginning month in field 4 may alternatively be provided in the UNIT record field 4.

**UNIT** Record – Information for Table Headings

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | UNIT | Record identifier |
| 2 | 5-9 | UNIT | A5 | AN | Volume units printed in table headings. Without a |
|   |     |      |    | blank | *UNIT* record, the default is AC-FT. |
| 3 | 10-14 | UNHP | A5 | AN | Hydropower units printed in table headings. |
|   |      |      |    | blank | Without a *UNIT* record, the default is MW-HR. |
| 4 | 15-19 | MONTH1 | A5 | blank | Default is to begin headings with the month JAN. |
|   |       |        |    | AN | First month in the table headings may be entered as either JAN (default), FEB, MAR, APR, MAY, JUN, JUL, AUG, SEP, OCT, NOV, or DEC. |
| 5 | 20-24 | NEWPAGE | I5 | blank,0,+ | Each table starts a new page. |
|   |       |         |    | $-1, -$ | No page breaks. |

Several table headings include volume and/or energy units.  If a *UNIT* record is not used, the defaults are:

$$UNIT = \text{AC-FT}$$
$$UNHP = \text{MW-HR}$$

If a *UNIT* record is included in the data set with blank entries for *UNIT* and/or *UNHP*, their values are blanks.  The units entered on the *UNIT* record are printed in the table headings but do not affect the data in the tables.  Program *TABLES* organizes and manipulates data from *SIM* input and output files without considering units in its computations.

The listing of months in the table headings is controlled by field 4.  If field 4 is left blank, the 12 monthly columns begin with January.  The 12-month year may start in any other month as specified by an entry in field 4.

The variable *NEWPAGE* in field 5 is a switch specifying whether or not page breaks are inserted after each table.  If *NEWPAGE* is zero (blank field 5) or positive, a page break is placed after each table causing the next table to begin a new page.  A negative integer entered in field 5 results in omission of the page breaks.

A *UNIT* record is applicable to all subsequent records in the *TABLES* input data set.

*Chapter 4 TABLES*

*TABLES*

## 1REC Record – Listing of Specified WRAP Input Records

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 1REC | Record identifier |
| 2 | 5-8 | KK | I4 | blank, 0 | List specified records |
|   |     |    |    | non-zero | List all records except specified records |
| 3 | 9-12 | NUM | I4 | + | Number of record identifiers to follow |
| 4-20 | 13-80 | REC | 17A4 | AN | Identifiers of specified WRAP input records (REC(I),I=1,NUM) |

## 1SUM Record – Water Rights Summary

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 1SUM | Record identifier |
| 2 | 8 | KK | I4 | blank, 0 | Summary by control point with only totals printed |
|   |   |    |    | 1 | Summary by control point |
|   |   |    |    | 2 | Summary by type of use |
|   |   |    |    | 3 | Summary by water right type |
|   |   |    |    | 4 | Summary by groups as defined by GO record |

## 1SRT Record – Listing of Sorted Water Rights

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 1SRT | Record identifier |
| 2 | 8 | KK | I4 | blank, 0 | Listing of rights in priority order |
|   |   |    |    | 1 | Listing of rights by control point in priority order |
|   |   |    |    | 2 | Listing of rights by type-of-use in priority order |
|   |   |    |    | 3 | Listing of rights by water right type in priority order |
|   |   |    |    | 4 | Listing or rights by GO record group in priority order |
| 3 | 12 | IFF | I4 | blank, 0 | Instream flow rights are not included in the table. |
|   |   |    |    | 1, + | Instream flow rights are included in the table. |

## 1LEN Record – Limiting Record Length to 128 Characters

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 1LEN | Record identifier |

Comments are often added to the right of data fields, particularly for *WR* records.  The 1LEN routine copies a DAT file to a TOU file with all records limited to 128 characters, removing comments written to the right.

**1CPT** Record – Upstream-to-Downstream Sequencing of Control Points

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 1CPT | Record identifier |
| 2 | 8 | KK | I4 | blank,0 | Reproduction of CP records in rearranged order |
|   |   |   |   | 1 | Listing of only control point identifiers, CPID(cp,1) |
|   |   |   |   | 2 | Listing of cp and next downstream cp identifiers |
|   |   |   |   | 3 | Listing of cp and next upstream cp identifiers |
|   |   |   |   | 4 | Listing of INMETHOD and CL from CP records |
|   |   |   |   | 5 | Option 4 listing with DA from WP records added |
|   |   |   |   | 6 | data from options 2-5 combined: CPID(cp,1), INMETHOD, CL, DA, CPID(cp,2), NUP, upstream cps |
|   |   |   |   | 7 | No written output.  ICP(I) array for 2BUD record. |
| 3 | 16 | OO | I8 | blank,0,1 | Order based on listing cp before all downstream cp's |
|   |   |   |   | 2 | Order based on full-length stream tributaries |
| 4 | 17-24 | LIM | I8 | −1, − | List only control points with INMETHOD = 0 or 1 |
|   |   |   |   | blank,0,+ | Include all control points in the output listing |
| 5 | 25-32 | CPLIM | 2x,A6 | AN | Include only cps located downstream of this cp |
|   |   |   |   | blank | Include all control points |

The control points are rearranged in upstream-to-downstream order.  For order option (OO) of 1 (blank field 3), the sequencing is based on each control point being listed earlier than any other control point located downstream of it.  This is the order required by *WRAP-SALT*.  With OO = 2, the first sequence goes from a most-upstream control point to the basin outlet, and each subsequent sequence goes from a most-upstream control point to a previously ordered stream.  With either option, most-upstream control points are selected in the order they are found in the original *CP* records in the *WRAP-SIM* input file.

The *LIM* option activated by field 4 allows the listing to be limited to only primary control points defined by *INMETHOD* of 0 or 1 in *CP* record field 6 indicating that naturalized flows are input on *IN* records. Entering a control point identifier in field 5 activates the option of limiting the control points considered to only those located downstream of the *CPLIM* control point.

KK in field 2 specifies the information to be included in the output.  For KK=0, the *CP* records are reproduced, with only their order being changed.  KK option 6 results in a listing of control points with each line having the following variables listed in the order shown below:

|  |  |
|--|--|
| CPID(cp,1) | control point identifier (*CP* record field 2) |
| INMETHOD | method for obtaining naturalized flows (*CP* record field 6) |
| CL(cp) | channel loss factor (*CP* record field 9) |
| DA(cp) | drainage area (*WP* record field 3) |
| CPID(cp,2) | identifier of next downstream control point (*CP* record field 3) |
| NUP(cp) | number of control points located immediately upstream |
| UPID(cp,L) | listing of identifiers of upstream control points (L=1,NUP(cp)) |

Options 1-5 provide some but not all of the option 6 data listed above.  The drainage area is read from *WP* records in the DIS file.  The other data are read from *CP* records in the DAT file.

**Time Series of SIM Simulation Results in OUT File Read by TABLES**

Program *TABLES* reads the *SIM* output OUT file that contains the monthly time series variables described in Chapter 5 of the *Reference Manual* and listed below. The *SIM* output records are for control points (ID=0), water rights (ID=1), or reservoir/hydropower projects (ID=2). Water right groups (ID=3) refer to the summation within *TABLES* of data read for the water rights included in a specified group, as defined by the group identifiers on the *WR* input records that are reproduced in the water right output records.

Table 4.10
SIM Output Record Fields Read by TABLES

| Time Series Input Record | Control Point ID = 0 | Water Right ID = 1 | Reservoir/Hydropower ID = 2 | WR Group ID = 3 |
|---|---|---|---|---|
| 2NAT | CP field 9 | | | |
| 2REG | CP field 10 | | | |
| 2UNA | CP field 7 | | | |
| 2CLO | CP field 12 | | | |
| 2CLC | CP field 11 | | | |
| 2RFR | CP field 8 | | | |
| 2URR | CP field 13 | | | |
| 2CPI | field 10 – 13 + 6 | | | |
| 2STO | CP field 5 | WR/IF field 6 | R/H field 5 | Applicable |
| 2EVA | CP field 4 | WR/IF field 5 | R/H field 4 | Applicable |
| 2DEP | CP field 6 | WR/IF field 7 | | Applicable |
| 2TAR | CP field 3 | WR/IF field 4 | | Applicable |
| 2SHT | CP field 2 | WR/IF field 3 | | Applicable |
| 2DIV | field 3 – field 2 | field 4 – field 3 | | Applicable |
| 2RFL | | WR field 13 | | Applicable |
| 2XAV | | WR field 14 | | |
| 2ASF | | WR/IF field 8 | | |
| 2ROR | | WR/IF field 9 | | |
| 2IFT | | IF field 11 | | |
| 2IFS | | IF field 12 | | |
| 2HPS | | | R/H field 2 | |
| 2HPE | | | R/H field 3 | |
| 2RID | | | R/H field 6 | |
| 2RIR | | | R/H field 7 | |
| 2RAH | | | R/H field 8 | |
| 2RNA | | | R/H field 9 | |
| 2EPD | | | R/H field 10 | |
| 2EVR | | | R/H field 11 | |
| 2WSE | | | R/H field 12 | |

The following list consists of the *TABLES* input record identifiers tabulated in the first column of Table 4.10 above and brief descriptions of the corresponding variables from the *SIM* simulation results OUT file. The variables in the *SIM* OUT file output record fields read by

*TABLES* are defined in detail in *Reference Manual* Chapter 5. All of the variables are time series of monthly amounts. All are monthly volumes except for 2EPD and 2EVR record monthly evaporation-precipitation depths and 2WSE record reservoir water surface elevations. The *TABLES* time series input record for each variable has the format outlined on pages 124-125.

**2NAT** Naturalized stream flows read from *IN* records or computed with flow distribution methods.

**2REG** Regulated stream flows computed by *SIM* as defined in the *Reference Manual* Chapter 5.

**2UNA** Unappropriated stream flows as defined in the *Reference Manual* Chapter 5.

**2CLO** Channel losses for the river reach below a control point.

**2CLC** Channel loss credits for the river reach below a control point.

**2RFR** Return flows returning here are the summation of return flows from all diversions and hydropower and IF releases that reenter the stream system at this control point.

**2URR** This portion of the regulated flow consists of the summation of releases from reservoirs located at this control point and upstream control points that were made to meet water right requirements at other control points located downstream.

**2CPI** Inflow to control point excluding 2URR record reservoir releases.

**2STO** End-of-month reservoir storage may be for an individual water right or reservoir or summation of storage for all reservoirs assigned to a same control point.

**2EVA** Reservoir net evaporation-precipitation volume may be for an individual water right or reservoir or summation for all reservoirs assigned to that same control point.

**2DEP** A stream flow depletion is the amount of water appropriated by a water right to meet diversion requirements and/or refill reservoir storage while accounting for net evaporation.

**2TAR** Diversion (type 1, 2, 3), hydropower (type 5, 6), or storage (type 7) targets are set with *WR*, *UC*, *SO*, *TO*, *DI*, *FS*, *BU*, *TS*, and other *SIM* input records. For an *IF* record right with a storage option activated (*IFMETH* = 3 or 4), the target is a reservoir release target.

**2SHT** For *WR* record right, amount of failure to meet diversion, energy, or storage target. Secondary energy is recorded as a negative hydropower shortage. For an *IF* record right, the shortage is the failure amount in meeting an *IFMETH* 3 or 4 reservoir release target.

**2DIV** The actual diversion (type 1, 2, 3), hydropower production (type 5, 6), or storage refilling (type 7) amount is not included in the *SIM* output file but rather is computed by *TABLES* as the target minus the shortage. For *IF* record rights, release from an *IFMETH* 3 or 4 reservoir is reported. An intermediate target and shortage may be selected on *SO* record.

**2RFL** Diversion return flow for water right is the volume returned to the stream system.

**2XAV** Increase in available stream flow resulting from *PX* record control point limit option.

**2ASF** The amount of stream flow that is available to a water right is computed as each right is considered in turn in the water rights priority loop.

**2ROR** For a multiple-reservoir water right, releases from secondary reservoirs are made following rules specified on *OR* records to meet the target requirements of the right.

**2IFT** Instream flow targets are specified by *IF* records and supporting records.

**2IFS**  An instream flow shortage is the amount by which the regulated flow falls below the instream flow target.

**2HPS**  The hydroelectric energy shortage (positive number) or secondary energy (negative number) associated with the most junior hydropower right at the reservoir. Shortage is amount of failure to meet energy production target. Secondary energy is defined in *Reference Manual*.

**2HPE**  The accumulative total energy generated by the most junior right at the reservoir. The portion of the hydroelectric energy target that was supplied.

**2RID**  Stream flow depletions associated with a reservoir include all the water taken from stream flow to meet water right requirements at the reservoir.

**2RIR**  Reservoir inflows from other reservoirs consist of releases from secondary reservoirs to meet water right requirements at that reservoir.

**2RAH**  Releases from the reservoir that can be used to generate hydropower.

**2RNA**  Releases from the reservoir that are not accessible to the turbines for use in generating hydropower as defined by the parameter *LAKESD* on the *SIM WS* record.

**2EPD**  Evaporation-precipitation depths used to compute volumes are based on *EV* records but are subject to adjustments as specified by *JD* record field 10 and *CP* record fields 8 and 9.

**2EVR**  Evaporation-precipitation depths read from *EV* records prior to the adjustments reflected in the 2EPD records.

**2WSE**  End-of-month reservoir water surface elevation from interpolation of *PV/PE* records.

## Alternative Formats for TABLES Time Series Output

The *TABLES* input record types described on the following three pages convert the time series variables listed above to alternative formats. The time series data may be written to the tables in the TOU file and/or a DSS file directly as the variables defined above as read from the simulation results in the *SIM* OUT file. Optionally, moving averages or moving totals of the data for a user-specified number of months may be computed. The data or its moving averages or totals may be adjusted by multiplying by a specified factor and/or adding a given constant. The original or adjusted data is written to the TOU file and/or the DSS file in the following formats.

- A text file with the filename extension TOU has each time series organized into a table with annual rows and monthly columns with headings illustrated by Table 4.4. Each variable considered is presented in separate tables. This format is designed for report preparation and convenient viewing of simulation results.

- A text file with the filename extension TOU has each time series variable of interest tabulated as one column of a single table. This format is designed for convenient conversion to a Microsoft Excel spreadsheet for plotting or further computations. Either the monthly data or annual totals may be tabulated.

- A binary file with the filename extension DSS has each time series variable of interest stored as a HEC-DSS record. This format is designed to allow the data to be read by HEC-DSSVue for plotting or further computations. Either the monthly data or annual totals may be tabulated.

## Time Series Records

The following types of input records build tables in the same optional formats, with the only difference being the selection of variable to be tabulated. The items in parenthesis indicate whether the variable is associated with a control point, water right, and/or reservoir/hydropower.

**2NAT** Record   – Naturalized Stream Flow (control points)

**2REG** Record   – Regulated Stream Flow (control points)

**2UNA** Record   – Unappropriated Stream Flow (control points)

**2CLO** Record   – Channel Loss (control points)

**2CLC** Record   – Channel Loss Credits (control points)

**2RFR** Record   – Return Flow Entering at this Control Point (control points)

**2URR** Record   – Upstream Reservoir Releases (control points)

**2CPI** Record   – Control Point Inflows excluding Secondary Reservoir Releases (control points)

**2STO** Record   – Reservoir Storage (control points, water rights, reservoirs)

**2EVA** Record   – Reservoir Evaporation-Precipitation Volume (control points, water rights, reservoirs)

**2DEP** Record   – Stream Flow Depletion (control points, water rights)

**2TAR** Record   – Diversion Target (control points, water rights)

**2SHT** Record   – Diversion Shortage (control points, water rights)

**2DIV** Record   – Diversion (control points, water rights)

**2RFL** Record   – Return Flow (water rights)

**2XAV** Record   – Increase in Available Stream Flow Resulting from *PX* Record CP Limit Option (water rights)

**2ASF** Record   – Available Stream Flow (water rights)

**2ROR** Record   – Releases from Other Reservoirs (water rights)

**2IFT** Record   – Instream Flow Target (instream flow rights)

**2IFS** Record   – Instream Flow Shortage (instream flow rights)

**2HPS** Record   – Hydropower Shortage (+) or Secondary Energy (–) (reservoir/hydropower)

**2HPE** Record   – Energy Generated (reservoir/hydropower)

**2RID** Record   – Inflows to Reservoir from Stream Flow Depletions (reservoir/hydropower)

**2RIR** Record   – Inflows from Releases from Other Reservoirs (reservoir/hydropower)

**2RAH** Record   – Releases Accessible to Hydropower (reservoir/hydropower)

**2RNA** Record   – Releases Not Accessible to Hydropower (reservoir/hydropower)

**2EPD** Record   – Adjusted Evaporation-Precipitation Depths (reservoir/hydropower)

**2EVR** Record   – Evaporation-Precipitation Depths from *EV* Records (reservoir/hydropower)

**2WSE** Record   – Reservoir Water Surface Elevation (reservoir/hydropower)

**Time Series** Records  –  All Record Types Listed on Preceding Page

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | page 123 | Record identifier from the list on the preceding page. |
| 2 | 8 | TA | I4 | blank,0 | Do not develop annual row/monthly column table. |
|   |   |   |   | 1 | Develop table with annual rows and monthly columns. |
| 3 | 12 | PT | I4 | blank,0 | Do not activate either HEC-DSS or text file option. |
|   |   |   |   | 1 | Develop columns of monthly data in text file. |
|   |   |   |   | 2 | Develop columns of annual totals or means in text file. |
|   |   |   |   | 3 | Develop columns of 12 monthly means in text file. |
|   |   |   |   | 4 | Develop HEC-DSS monthly time series records. |
|   |   |   |   | 5 | Develop HEC-DSS annual time series records. |
| 4 | 16 | MORE | I4 | 0 | Write columns; next record starts a new table. |
|   |   |   |   | 1 | Add more columns to existing table or start first table. |
| 5 | 20 | ID | I4 | 0 | Develop tables for default ID or for control points. |
|   |   |   |   | 1 | Develop tables for water rights. |
|   |   |   |   | 2 | Develop tables for reservoirs. |
|   |   |   |   | 3 | Develop tables for water right groups. |
| 6 | 24 | NUM | I4 | blank,0 | Tables for all control points (ID=0), rights (ID=1), or reservoirs (ID=2).  NUM cannot be zero if ID=3. |
|   |   |   |   | − | Develop tables for the NUM control points, rights, reservoirs, or right groups listed on a previous record. |
|   |   |   |   | + | Number of control points, water rights, reservoirs, or water right groups to follow on IDEN records. |
| 7 | 28 | DECIMAL | 3x,A1 | blank | Standard number of digits. |
|   |   |   |   | 0,1,2,3,4 | Number of digits to the right of the decimal. |
| 8 | 32 | MAT | I4 | blank,0 | Moving average/total option is not adopted. |
|   |   |   |   | 1 | Moving averages are computed for TIME months. |
|   |   |   |   | 2 | Moving totals are computed for TIME months. |
| 9 | 33-36 | TIME | I4 | + | Number of months for moving averages or totals. |
| 10 | 37-44 | XF | F8.0 | +, −, blank | Multiplier factor.  Default multiplier factor = 1.0 |
| 11 | 45-52 | AF | F8.0 | +, −, blank | Addition factor.  Default addition factor = 0.0 |

### Explanation of Time Series Input Record Fields

*Field 1*:  One of the 29 alternative record identifiers listed on page 123 is entered in field 1. Variables are selected by this record identifier.

*Field 2*:  Types of tables or datasets to be created are selected in fields 2 and 3.  There is no *TABLES* output if fields 2 and 3 are both blank.  A set of one or more tables with rows for years and columns for months and annual totals or means is created by entering the integer 1 in field 2. The tables are written to the *TABLES* output file which has a default filename extension TOU.

***Field 3***:   Either columns of data may be written to the TOU file or HEC-DSS records may be written to the DSS file.  The data may include either monthly amounts or annual means/totals.

A TOU file table activated by entering a 1, 2, or 3 in field 3 consists of a single column for each variable with multiple variables being included as separate columns in the same table.  This format is designed to be read by Microsoft Excel or other spreadsheet programs for plotting or additional computational manipulations.  The column may contain either the entire time series of monthly data (PT=1 in field 3), annual totals or means for each year of the simulation (PT=2), or a set of 12 means for each of the 12 months of the year (PT=3).  The parameter *MORE* in field 4 controls whether another column is added to the current table or a new table is started.

Options 4 and 5 in field 3 consist of storing the monthly or annual time series as binary records in a HEC-DSS file, accessible to graphing and other capabilities provided by HEC-DSSVue.  HEC-DSS references data records by their pathnames, which consist of six parts in the format /A/B/C/D/E/F/.  The pathname is assigned automatically by *TABLES* as indicated below.

> A  –    filename root of *TABLES* output files
> B  –    identifier of control point, water right, reservoir, or water right group
> C  –    record identifier for *TABLES* input record such as 2REG, 2DIV, 2WSE, etc.
> D  –    date of the beginning of the time series such as 01JAN1938
> E  –    time interval = MON or YEAR for *SIM* results (*SIMD* includes sub-monthly.)
> F  –    CP, WR, Res, or WRG (control point, water right, reservoir, water right group)

***Field 4***:   Field 4 is relevant only if a columnar tabulation is activated by entering a 1, 2, or 3 in field 3.  Each variable is tabulated as a single column in a table.  The parameter *MORE* in field 4 specifies whether to place another column in the current table or to create another new table.  Each table can include any number of columns up to a limit of 100 columns.  At least one record must have a *MORE* of zero in order to write the table.

***Field 5***:   The time series variables are associated with either control points (ID=0), water rights (ID=1), reservoirs (ID=2), and/or water right groups as indicated in Table 4.10.  For variables associated with only one ID, field 5 may be left blank.  For variables that may be associated with more than one ID, an ID selection is entered in field 5.  Summation of data for all water rights in a group (ID=3) may be tabulated by 2STO, 2EVA, 2DEP, 2TAR, 2SHT, or 2DIV records.

***Field 6***:   The default is to include all of the control points (ID=0), water rights (ID=1), or reservoirs (ID=2) found in the *SIM* OUT file.  Optionally, *NUM* control points, water rights, reservoirs, or water right groups may be selected by listing identifiers on one to ten supplemental IDEN records.  Water right groups may be selected only by listing them.  A negative value for *NUM* may be entered in field 6 to indicate that the list read from a previous record is to be repeated.  IDEN records are used if and only if *NUM* is a positive integer.

***Field 7***:   The data in the tables or tabulations created by *TABLES* may be recorded with either zero, 1, 2, 3, or 4 digits to the right of the decimal point.  A blank field 7 results in a standard default number of digits to the right of the decimal that varies between variables and with the magnitude of the number.  *SIM* writes diversion targets and shortages in the OUT file with 3 digits to the right of the decimal (to nearest 0.001 unit).  Net evaporation depths are recorded to the nearest 0.0001 unit.  Reservoir water surface elevations in the *SIM* output file have three digits to the right of the decimal.  The other variables in the OUT file have 2 digits to the right of

the decimal (to nearest 0.01 unit). The model-user will normally not want to record the simulation results in the *TABLES* output with more digits to the right of decimal than provided in the *SIM* output. The format of the *SIM* output OUT file records and variables is described in Chapter 5 of the *Reference Manual*.

***Fields 8 and 9***: A non-zero *MAT* in field 8 results in the monthly time series data being converted to either moving averages or moving totals for *TIME* months, where the number of months *TIME* is entered in field 9. A moving total is the summation of amounts during the *TIME* most recent months including the current month. A moving average is the moving total divided by *TIME* months. The averages or totals are computed for the data in *TIME* months, including the current month and the *TIME*−1 preceding months. For the first *TIME* months of the time series, the moving totals or averages reach back to the beginning of the simulation. After totaling or averaging the data read from the OUT file, all other *TABLES* operations and the format of the output remain unchanged. A line is added to the heading for annual row/monthly column tables indicating that the data in the table are moving averages or totals.

***Fields 10 and 11***: The time series data are multiplied by *XF* (default *XF*=1.0) and added to *AF* (default *AF*=0.0) to serve various purposes. For example, *XF* may be a unit conversion factor. Reservoir storage may be converted to draw-down with $XF = -1.0$ and $AF$ = storage capacity.

### Identifiers of Control Points, Reservoirs, Water Rights, and Water Right Groups for Time Series (Page 123), 2REL, 2FRE, 2SCP, 2SWR, 2SGP, and 2SRE Records

Options for specifying the selection of water rights, reservoirs, and control points for inclusion in the *SIM* OUT file are outlined in Chapter 2. The *TABLES* input records contain default options for including in the *TABLES* output all control points, water rights, and/or reservoirs found in the *SIM* OUT file. Alternatively, subsets thereof may be selected for inclusion in the tables and datasets created and written by *TABLES* to the TOU or DSS files.

The time series records listed on page 123 and the 2REL, 2FRE, 2SCP, 2SWR, 2SGP, and 2SRE records share a common scheme for listing identifiers of selected control points (IDCP array), reservoirs (IDRES), water right groups (IDEN8), or water rights (IDEN16) to be included in the tabulations created by *TABLES*. The variable *NUM* is the number of identifiers to be listed. The default *NUM* of zero results in inclusion of all control points, water rights, or reservoirs contained in the *SIM* OUT file. Alternatively, from one to 80 of the control points, water rights, or reservoirs included in the *SIM* OUT file may be selected for inclusion in the tables created by *TABLES*. Up to 8 identifiers may be entered on a single record. Up to 80 identifiers on 10 records may be entered as a group. Any number of record groups may be included in the TIN file.

Identifiers do not have to be repeated for multiple time series, 2REL, 2FREQ, 2SCP, 2SWR, and/or 2SRE records. The last identifiers read during an execution of *TABLES* are stored in memory as the IDCP, IDRES, IDEN8, and IDEN16 arrays. Each of the four arrays contains the last set of identifiers of its type entered. A negative value for *NUM* specifies that the identifiers read from previous records are to be repeated. For example, a *NUM* of −45 tells *TABLES* to use the first 45 identifiers in the IDCP, IDRES, IDEN8, or IDEN16 array, as appropriate, from a previous TIN file input record. Identifiers may be listed on 2SCP, 2SWR, 2SGP, and 2SRE records, on IDEN records connected to time series (page 123), 2REL, or 2FRE records, or on IDEN records connected to an initial IDEN record providing the type and number of identifiers.

**IDEN** Record – Type and Number of Identifiers  (Used only if NUM is not already specified.)

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | IDEN | Record identifier |
| 2 | 8 | TID | I4 | blank, 0 | *Type of Identifiers* Control points |
|  |  |  |  | 1 | Water rights |
|  |  |  |  | 2 | Reservoirs |
|  |  |  |  | 3 | Water Right Groups |
| 3 | 11-12 | NUM | I4 | + | Number of identifiers on following IDEN records |

**IDEN** Records – Identifiers of Control Points, Water Rights, Water Right Groups, or Reservoirs

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | IDEN | Record identifier |
| 2-9 | 5-68 | IDCP(I) IDRES(I) IDEN8(I) | 8(2x,A6) 8(2x,A6) 8A8 | AN | Identifiers of control points (ID=TID=0), reservoirs (ID=TID=2), water rights (ID=TID=1), water right groups (ID=TID =3).  Used for positive NUM=NID. |
|  | 5-132 | IDEN16(I) I = 1, NUM | 8A16 |  | Eight identifiers per record on up to ten records for a total of up to 80 identifiers. |

If *NUM* is greater than zero on time series records listed on page 123, 2REL, or 2FRE records, the *NUM* identifiers are listed on one or more IDEN records following directly behind the time series, 2REL, or 2FRE record.  The supplemental IDEN records contain only the *CD* of IDEN and control point, water right, water right group, or reservoir identifiers (up to eight per record, up to 80 on ten records).  IDEN records follow if and only if *NUM* is a positive non-zero integer.

If *NUM* is a positive non-zero integer, the control point, water right, group, or reservoir identifiers are listed directly on the end of 2SCP, 2SWR, 2SGP, and 2SRE records, with the fields before the identifiers left blank on the second and subsequent records if more than 8 identifiers are listed.

A negative value for *NUM* specifies that the identifiers read from previous records are to be repeated.  The prior record or records supplying identifiers are either IDEN records or 2SCP, 2SWR, 2SGP, and 2SRE records.  Identifiers entered once may be used any number of times.

The first form of IDEN record shown above providing values for *TID* and *NID* is not used if IDEN records with the identifiers follow directly behind a time series, 2REL, or 2FREQ record providing values for *TID=ID* and *NID=NUM*.  However, alternatively, a set of IDEN records for each pertinent type of identifier may be placed at the beginning of the TIN file or at least earlier in the TIN file than the time series, 2REL, 2FREQ, 2SCP, 2SWR, 2SGP, or 2SRE records, with *TID* and *NID* defined on an initial IDEN record.  After identifiers are entered into computer memory, negative integers are entered for *NUM* on all later records using the identifiers.

**2REL** Record – Water Supply Diversion or Hydroelectric Energy Reliability Summary

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 2REL | Record identifier |
| 2 | 7-8 | MON | I4 | blank,0 | All months are included in the computations. |
|   |   |   |   | + | The month for which the analysis is performed. |
| 3 | 12 | RFLAG | I4 | blank,0 | N = number of months with non-zero targets |
|   |   |   |   | 1,+ | N = (years)(12 months/year)   for   $R_P = (n/N) \times 100\%$ |
| 4 | 16 | ID | I4 | 0 | Table includes selected control points. |
|   |   |   |   | 1 | Table includes selected water rights. |
|   |   |   |   | 2 | Table includes selected hydropower reservoirs. |
|   |   |   |   | 3 | Table includes selected water right groups. |
| 5 | 19-20 | NUM | I4 | blank,0 | Include all control points (ID=0), water rights (ID=1), or reservoirs (ID=2) in table. |
|   |   |   |   | + | Number of water rights, reservoirs, water right groups, or control points to follow on IDEN record(s). |
|   |   |   |   | − | NUM identifiers from previous record are repeated. |
| 6 | 21-28 | TAR | F8.0 | blank,0 | Optional supplemental table is not created. |
|   |   |   |   | + | Annual diversion or hydropower target. |
|   |   |   |   | −1, − | Adopt total of targets from *SIM* output file. |

## Explanation of 2REL Record Fields

***Field 2****:*  If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MON* in field 2, reliabilities are computed for the specified month.  For example, reliabilities for meeting a diversion target in August (*MON* = 8) may be computed. The default is to include is all months in the computations.

***Field 3***:  Period reliability computations may be based either on using the simulation results from only the months with non-zero targets or using all months including those with zero target.

***Field 4***:  *TABLES* reads the data for control points (ID=0) from the control point output records in the *SIM* OUT file.  For control points, reliabilities are for the summation of the diversions for all the rights located at the control point.  The data for water rights (ID=1) and water right groups (ID=3) are from water right records in the *SIM* OUT file.  For water right groups, the computed reliabilities are for the aggregation or summation of the diversions for all the water rights included in the group. The data for the hydropower reservoirs (ID=2) are from the reservoir/hydropower records.

Reliabilities are for either water supply diversions or hydroelectric energy production.  Control point (ID=0) output records include only diversions.  For hydropower reservoirs (ID=2), reliabilities are computed only for electric energy generation for the most junior right at the reservoir.  For water rights (ID=1) and water right groups (ID=3), reliabilities may be computed for either water supply diversions or hydropower generation.  However, inclusion of both diversions and hydropower in the same reliability table may be confusing and normally should be avoided.

If only one hydropower right is associated with a particular reservoir, the energy produced and associated reliability is the same for the water right and reservoir. However, if two or more hydropower rights are associated with the same reservoir, the reliability table reflects the total cumulative energy target and energy produced for the most junior right at the reservoir. Water right output records and corresponding reliability computations reflect the total cumulative energy target and energy production associated with an individual water right.

The 2REL record reliability table necessarily reflects target and shortage data from the simulation results read by *TABLES* from the *SIM* OUT file. The targets and shortage in the *SIM* OUT file may be affected by the parameter *ISHT* entered in *SO* record field 9. Hydropower rights may be included or excluded depending on the parameter *OUTWR* in *JD* record field 6.

*Field 5*: A blank or zero field 5 results in all of either the control points (ID=0 in field 4), water rights (ID=1), or reservoir/hydropower projects (ID=2) included in the *SIM* output file being included in the reliability table. The *all* option is not applicable for water right groups (ID=3).

Optionally, lists of control points, water rights, reservoir/ hydropower projects, or water right groups may be entered in IDEN records. Time series (page 123), 2REL, and 2FRE records employ IDEN records in identically the same way. With a positive non-zero *NUM*, one or more IDEN records follow immediately behind the time series, 2REL, or 2FRE record.

A negative value for NUM in field 5 indicates that the list read from previous records is to be repeated. The IDEN, 2SCP, 2SWR, 2SGP, and 2SRE records enter identifiers into memory in the same format that may be then used repeatedly with negative entries for *NUM*.

Any number of tables may be created using multiple 2REL records. Water right identifiers *IDEN16* are unique for individual rights; so diversions and shortages are not aggregated. If multiple rights in the *SIM* OUT file have the same identifier, only the first right with *IDEN16* is used. Reliabilities for aggregated rights are determined using group *IDEN8* identifiers.

*Field 6*: A positive number entered for *TAR* in field 7 adds an extra table showing the diversion target, diversion, shortage, and volume reliability for the total of all the control points, water rights, reservoirs, or groups included in the reliability table, based on the total diversion target *TAR*. A −1 in field 7 also activates the supplemental table, but the summation of the pertinent targets from the *SIM* output file is adopted rather than a user-specified target *TAR*.

The supplemental table allows a target to be input for use in computing volume reliability for the aggregate of all of the rights in the 2REL table. Several water right *WR* records with associated *SO, TO, FS, BU, DI, WS*, and other supporting records may be combined to represent a particular water use requirement. A 2REL record will create a table containing a line for each component *WR* record. However, model users may be interested in the combined reliability of the total water use requirement rather than the individual reliabilities associated with its component *WR* records. The complexity of interpreting the overall reliability from the component rights in the reliability table depends upon the options applied in building the targets in *SIM*. The totals line at the bottom of the 2REL table is applicable if the table contains a number of separate rights, but may not meaningfully reflect certain combinations of intermediate targets built with combinations of *WR/SO/TO/FS/BU/TS/DI* records. Thus, the supplemental table may be added.

**2FRE** Record  –  Flow-Frequency or Storage-Frequency Relationships

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 2FRE | Record identifier |
| 2 | 7-8 | Variable | I4 | 1 | Naturalized flows (ID=0) |
| | | | | 2 | Regulated flows (ID=0) |
| | | | | 3 | Unappropriated flows (ID=0) |
| | | | | 4 | Reservoir storage associated with control point (ID=0) |
| | | | | –4 | Reservoir storage associated with a control point with only totals included in table (ID=0) |
| | | | | 5 | Reservoir storage associated with a water right (ID=1) |
| | | | | –5 | Reservoir storage associated with a water right with only totals included in table (ID=1) |
| | | | | 6 | Reservoir storage associated with a reservoir (ID=2) |
| | | | | −6 | Reservoir storage associated with a reservoir with only totals included in table (ID=2) |
| | | | | 7 | Reservoir water surface elevation (ID=2) |
| | | | | 8 | Instream flow shortage for an *IF* record right (ID=1) |
| 3 | 11-12 | MON | I4 | blank, 0 | All months are included in the computations. |
| | | | | + | The month for which the analysis is performed. |
| 4 | 15-16 | NUM | I4 | 0 | Include all control points, rights, or reservoirs in table. |
| | | | | + | Number of control points, rights, or reservoirs. |
| | | | | − | NUM identifiers from previous record(s) are repeated. |
| 5 | 20 | TABLE | I4 | blank, 0, 1 | Frequency table is created in standard row format. |
| | | | | 2 | Frequency results are tabulated as columns. |
| 6 | 24 | METHOD | I4 | blank, 0, 1 | Relative frequency  $P = (n/N)\ 100\%$ |
| | | | | 2 | Log-normal probability distribution. |
| | | | | 3 | Normal probability distribution. |
| 7 | 28 | MAT | I4 | blank, 0 | Moving average/total option is not adopted. |
| | | | | 1 | Moving averages are computed for TIME months. |
| | | | | 2 | Moving totals are computed for TIME months. |
| 8 | 32 | TIME | I4 | + | Number of months for moving averages or totals. |
| 9 | 33-40 | XF | F8.0 | +, −, blank | Multiplier factor.  Default multiplier factor = 1.0 |
| 10 | 41-48 | AF | F8.0 | +, −, blank | Addition factor.  Default addition factor = 0.0 |

## **Explanation of 2FRE Record Fields**

***Field 2***:  Naturalized, regulated, and unappropriated flows (variables 1, 2, 3) are read from the control point records in the *SIM* OUT file.  End-of-month reservoir storage (variables 4, 5, 6) may be read from either control point, water right, or reservoir/hydropower output records.  End-of-month reservoir water surface elevations (variable 7) are read from reservoir/hydropower

output records.  Instream flow shortages (variable 8) are read from water right records in the OUT file. The variables recorded in the *SIM* water right, control point, and reservoir/hydropower output records are precisely defined in Chapter 5 of the *Reference Manual*.

Any number of control points, water rights, or reservoirs may be included in a frequency table. Storage frequency tables also include the total storage associated with each frequency for all the control points, rights, or reservoir included in the table.  A –4, –5, or –6 specifies that only the storage totals are included in the table without listing the individual control points or rights.

*Field 3*:  If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MON* in field 2, frequencies are computed for only the specified month.  The default is to include is all months in the analysis.

*Field 4*:  A blank or zero field 4 results in all of either the control points (variables 1, 2, 3, 4, or −4 in field 2), water rights (variables 5, −5, or 8), or reservoirs (variables 6 or 7) being included in the frequency table.  Optionally, lists of *NUM* control points, water rights, or reservoirs may be entered on IDEN records for inclusion in the frequency table.  Identifiers shared by several record types are discussed on page 126.  The parameter *NUM* is identical in 2FRE record field 4, 2REL record field 5, and field 6 of the time series records.

*Field 5*:  Two alternative formats are available for displaying the results of the frequency computations.  The option 2 columnar format contains a few more frequencies, is convenient for transport to a spreadsheet, and is limited to not exceed a maximum of 100 columns.

*Field 6*:  Three alternative methods are available for computing flow or storage volumes or elevations (field 2 variable) associated with specified exceedance frequencies.  Option 1 is based on sorting the N amounts in ranked order and applying linear interpolation and the relative frequency formula to assign exceedance frequencies (P) based on rank (n).

$$P \;\; = \;\; \frac{n}{N}(100\%)$$

For a specified exceedance frequency (90% for example), if a particular flow value in the simulation results is equaled or exceeded exactly that percentage of the time, that value is selected.  Otherwise, linear interpolation is applied to the two flow values bracketing the specified frequency.

Options 2 and 3 are based on the log-normal and normal probability distribution functions.  The parameters are the mean and standard deviation of the data (normal distribution) or logarithms of the data (log-normal distribution).  Frequency factors for the Gaussian (normal) probability distribution function for the selected exceedance frequencies are built into *TABLES*.

The 2FRE record log-normal and normal distribution options are not available with the 2FRQ record.  The 2FRQ record frequencies are computed with the relative frequency formula.

*Fields 7 and 8*:  Fields 7 and 8 of the 2FRE record are identical to fields 8 and 9 of the time series records described on pages 123-125.  The moving total/average computations activated by the parameters *MAT* and *TIME* are identically the same for data used to develop frequency tables as applied to the data tabulated in time series tables.

*Fields 9 and 10*:  The multiplier *XF* and addition *AF* factors in 2FRE record fields 9 and 10 are the same as *XF* and *AF* in fields 10 and 11 of the time series records described on pages 123-125.

**2FRQ** Record  –  Frequency for Specified Flow or Storage

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 2FRQ | Record identifier |
| 2 | 8 | Variable | I4 | 1 | Naturalized flows (ID=0) |
| | | | | 2 | Regulated flows(ID=0) |
| | | | | 3 | Unappropriated flows (ID=0) |
| | | | | 4 | Reservoir storage associated with a control point(ID=0) |
| | | | | 5 | Reservoir storage associated with a water right (ID=1) |
| | | | | 6 | Reservoir storage associated with a reservoir (ID=2) |
| | | | | 7 | Reservoir water surface elevation (ID=2) |
| | | | | 8 | Instream flow shortage for an *IF* record right (ID=1) |
| 3 | 12 | MONTH | I4 | 0,blank | All months are included in the computations. |
| | | | | + | The month for which the analysis is performed. |
| 4 | 16 | NM | I4 | + | Number of flows or storages entered for *TABLES* to determine frequencies  (NM may range from 1 to 7) |
| 5 | 17-24 | IDEN | 2x,A6 | AN | Identifier of control point (field 2 variables 1-4), water |
| | 17-32 | IDEN16 | A16 | | water right (variables 5, 8), or reservoir (variables 6, 7) |
| 6-12 | 25-80 | QF(I) | 7F8.0 | + | Streamflow (variables 1,2,3), storage (variables 4,5,6), |
| | 33-88 | I=1,NM | | | elevation (7), or instream flow shortage (variable 8) |

A 2FRE record creates a frequency table with the set of pre-defined frequencies shown in Table 4.6. A 2FRQ record frequency table contains computed frequencies for up to 7 specified flow, storage, elevation, or instream flow shortage amounts.

### **Explanation of 2FRQ Record Fields**

*Field 2*:  Field 2 is the same in both the 2FRQ and 2FRE records except the 2FRQ record does not include the total summation of reservoir storage.

*Field 3*:  Field 3 is identical for both the 2FRQ and 2FRE records.  If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MONTH* in field 2, frequencies are computed for only the specified month. The default is to include is all months in the analysis.

*Fields 4, 5, and 6-12*:  A 2FRQ record frequency table contains computed frequencies for up to 7 flow or storage amounts (field 2 variable) specified in fields 6−12 for a single control point, water right, or reservoir specified in field 5.  The number *NM* of flow or storage amounts is entered in 2FRQ record field 4.

**2RES** Records – Reservoir Content, Draw-Down Duration, and Storage Reliability

First 2RES Record

| field | Columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-4 | CD | A4 | 2RES | Record identifier |
| 2 | 8 | TABLE | I4 | 0 | All three tables are created. |
| | | | | 1 | Storage contents as a percentage of capacity table. |
| | | | | 2 | Storage draw-down duration table is created. |
| | | | | 3 | Storage reliability table is created. |
| | | | | 4 | Both draw-down and reliability tables are created. |
| 3 | 11-12 | MONTH | I4 | 0,blank | All months are included in the computations. |
| | | | | + | The month for which the analysis is performed. |
| 4 | 15-16 | NUM | I4 | + | Number of reservoir identifiers in following fields. |
| 5-24 | 17-176 | IDEN(res) res=1,20 | 20(2x,A6) | AN | Reservoir identifiers |

Second 2RES Record – Total Storage Capacity  (required)

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-4 | CD | A4 | 2RES | Record identifier |
| 2-4 | 5-16 | | 12X | | Blank or comments (not read by *TABLES*) |
| 5-24 | 17-176 | C1(res) res=1,20 | 20F8.0 | + | Total storage capacity in each reservoir ($C_1$). |

Third 2RES Record – Inactive Storage Capacity  (optional)

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-4 | CD | A4 | 2RES | Record identifier |
| 2-3 | 5-16 | | 12X | | Blank or comments (not read by *TABLES*) |
| 5-24 | 17-176 | C2(res) res=1,20 | 20F8.0 | + | Inactive storage capacity in each reservoir or bottom of the storage zone being considered ($C_2$). |

The third 2RES record is generally optional, with all $C_2$ defaulting to zero.  However, the third record is required even if the $C_2$ are zero if followed by another set of 2RES records.

## Explanation of 2RES Records

A set of 2RES records results in storage contents being read from reservoir records in the *SIM* output file.  A maximum of 20 reservoirs can be included.  The reservoir identifiers are provided on the first 2RES record.  The $C_1$ storage capacities are provided on the required second 2RES record.  The $C_2$ storage capacities are provided on the optional third record.  $C_2$ is assumed zero for all reservoirs if the third 2RES record is not provided.  The third 2RES record is required if followed by another set of 2RES records.  $C_1$ and $C_2$ are the storage capacities at the top and bottom of the storage zone being considered.  Typically, $C_1$ will be the total conservation storage capacity and $C_2$ will be either zero or the inactive storage capacity.  However, the pool zone may be defined to fit the application.

The set of 2RES records develop three different tables selected by the entry for *TABLE* in field 2 of the first record.

The first type of table is a tabulation of end-of-period reservoir storage contents expressed as a percentage of a user-specified storage capacity, with one column per reservoir.

$$\text{storage as percentage of capacity} \; = \; \left( \frac{S - C_2}{C_1 - C_2} \right) 100\%$$

where S is the end-of-month storage content and $C_1$ and $C_2$ are the capacities at the top and bottom of the storage zone being considered.  The percentage storage tabulation is useful is comparing the relative storage of reservoirs in a system of multiple reservoirs.

The second table is a storage draw-down duration relationship expressed in terms of the number of months for which the draw-down equaled or exceeded specified percentages of storage capacity of the zone defined by the equation above.

The third table is a storage reliability relationship expressed in terms of the percentage of months for which the contents equaled or exceeded specified percentages of storage capacity of the zone defined by the equation above.

If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MONTH* in field 3 of the first *2RES* record, tables are constructed for the specified month.  The default is to consider all months in the analysis of simulation results.

**2SCP** Record – Summary Tables for Control Points

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 2SCP | Record identifier |
| 2 | 8 | MNAN | I4 | 0<br>1<br>2 | Annual table<br>Monthly table<br>Both annual and monthly tables |
| 3 | 9-12 | NUM | I4 | blank ,0<br>+<br>– | Develop tables for all control points.<br>Number of control points to follow.<br>NUM identifiers from previous record are repeated. |
| 4-11 | 13-76 | IDCP(I)<br>I = 1,NUM | 8(2x,A6) | AN | Identifiers of the selected control points for which to develop summary tables. |

**2SWR** Record – Summary Tables for Water Rights

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 2SWR | Record identifier |
| 2 | 5-8 | MNAN | I4 | 0<br>1<br>2 | Annual table<br>Monthly table<br>Both annual and monthly tables |
| 3 | 9-12 | NUM | I4 | blank,0<br>+<br>– | Develop tables for all water rights.<br>Number of water rights to follow.<br>NUM identifiers from previous record are repeated. |
| 4-11 | 13-140 | IDEN16(I)<br>I = 1,NUM | 8A16 | AN<br>blank | Identifiers of water rights for which to develop tables.<br>If NUM is zero or negative |

2SCP, 2SWR, 2SGP, and 2SRE records are essentially the same except *IDCP and IDRES* denote control point and reservoir identifiers which may have a maximum of six characters, *IDEN8* denotes water right group identifiers which may consist of up to eight characters, and *IDEN16* is for water right identifiers which may be up to 16 characters long. Time series, 2REL, 2FREQ, 2SCP, 2SWR, and 2SRE records enter identifiers into memory that may be repeated with a negative *NUM*.

Water right groups must be listed explicitly on the 2SGP record. *NUM* cannot be zero if tables are created for one or more water right groups.

*TABLES* reads the data for 2SCP and 2SBA tables from the control point records in the *SIM* output file. The data for the 2SWR and 2SGP tables are from the water right records in the *SIM* output file. The data for the 2SRE table are from the reservoir/hydropower records in the *SIM* output file.

**2SGP** Record − Summary Tables for Water Right Groups

| field | columns | Variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 2SGP | Record identifier |
| 2 | 5-8 | MNAN | I4 | 0 | Annual table |
| | | | | 1 | Monthly table |
| | | | | 2 | Both annual and monthly tables |
| 3 | 9-12 | NUM | I4 | + | Number of water right groups to follow. |
| | | | | − | NUM identifiers from previous record are repeated. |
| 4-11 | 13-140 | IDEN8(I) I = 1, NUM | 8A8 | AN | Identifiers of water right groups for which to develop tables. |
| | | | | blank | If NUM is negative |

**2SRE** Record − Summary Tables for Reservoirs

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 2SRE | Record identifier |
| 2 | 5-8 | MNAN | I4 | 0 | Annual table |
| | | | | 1 | Monthly table |
| | | | | 2 | Both annual and monthly tables |
| 3 | 9-12 | NUM | I4 | 0 | Develop tables for all reservoirs. |
| | | | | + | Number of reservoirs to follow. |
| | | | | − | NUM identifiers from previous record are repeated. |
| 4 | 13-76 | IDRES(I) I = 1, NUM | 8(2x,A6) | AN | Identifiers of reservoirs for which to develop summary tables. |
| | | | | blank | If NUM is zero or negative. |

**2SBA** Record − Aggregate Summary Table for the Entire River Basin

| field | column | variable | format | value | description |
|-------|--------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 2SBA | Record identifier |
| 2 | 8 | MNAN | I4 | 0 | Annual table |
| | | | | 1 | Monthly table |
| | | | | 2 | Both annual and monthly tables |

**2BUD** − Water Budgets for Control Points and the Entire River Basin System

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 2BUD | Record identifier |
| | | | | | *Control Point Location* |
| 2 | 5-12 | CPBUD | 2x,A6 | blank | Water budget is for the river basin outlet(s). |
| | | | | AN | Control point for the water budget. |
| | | | | | *Time Period Covered by Water Budget* |
| 3 | 13-16 | YRFIRST | I4 | + | First year of water budget computations. |
| | | | | blank,0 | First year of *SIM* simulation is adopted. |
| 4 | 17-20 | YRLAST | I4 | + | Last year of water budget computations. |
| | | | | blank,0 | Last year of *SIM* simulation is adopted. |
| | | | | | *Approach for Sequencing Control Points* |
| 5 | 24 | ICPI | I4 | 1 | ICP(I) array is created by preceding 1CPT record. |
| | | | | blank,0, −1 | 1CPT record ICP(I) array is not used.  Control points are in upstream-downstream order in *SIM* input file. |
| | | | | | *Beginning-of-Computations Storage Volume* |
| 6 | 28 | BEGSTO | I4 | blank, zero | Beginning storage is zero or preceding end-of-year. |
| | | | | 1 | *SIM* beginning reservoir storage BRS file is read. |
| | | | | 2 | Storage is estimated from *SIM* output file variables. |
| | | | | | *Adjustments for Negative Inflow* |
| 7 | 32 | NEGINF | I4 | blank,0,1 | No adjustments are made to negative inflows. |
| | | | | 2 | Adjustments based on beginning-of-period storage. |
| | | | | 3 | Negative inflow volumes are set to zero. |
| | | | | | *Water Budget Tables to be Written to TOU File* |
| 8 | 36 | CPOUT | I4 | blank,0,−1 | Control point water budget table is not created. |
| | | | | 1 | Water budget table is created for one control point. |
| | | | | 2 | Water budget table is created for all control points. |
| 9 | 40 | BASIN | I4 | blank,0,1 | River basin water budget table is created for outlet(s). |
| | | | | 2 | Basin budget table for control point in field 9. |
| | | | | −1 | River basin water budget table is not created. |

The 2BUD record water budget computations performed by *TABLES* are described in Chapter 5 of the *Reference Manual*.  Water budgets are developed by *TABLES* based on reading the simulation results from a *SIM* output OUT file containing output records for all control points included in the *SIM* DAT file.  Additional information is also read from the *SIM* DAT file.  The water budget computations are performed by control point in upstream-to-downstream sequence. Two different types of water budget tables may be developed, river basin and individual control point.  Computations are performed for all control points in the process of developing the river basin water budget table.  Results associated with individual control points are recorded in the individual control point water budget table.  The computations step sequentially through time and, for each month, are performed by control point in upstream-to-downstream order.  The resulting water budget tables include the variables defined in *Reference Manual Chapter 5*.

### Explanation of 2BUD Record Fields

___Field 2___:  With field 2 blank, the default is to develop a river basin water budget for the one or more outlets defined by the *CP* records in the *SIM* DAT file.  Thus, the default basin water budget is for the entire river system encompassing all of the control points in the *SIM* dataset.  If a control point identifier is entered in 2BUD record field 9, the computations stop at that control point.  All control points located downstream are omitted from the computations.  Thus, the basin water budget is valid for a control point specified in field 9 only if all control points listed prior to that control point in the sequencing are located upstream.  Depending on CPOUT in field 8, the optional control point water budget table may include either only the basin outlet specified by field 2 or all of the control points in the *SIM* dataset.

___Fields 3 and 4___:  The time period covered by the water budget may be specified by first and last years.  The default is to adopt the *SIM* period-of-analysis for the water budget.  The water budget time period must be contained within the *SIM* simulation period-of-analysis but may be shorter.

___Field 5___:  The *SIM* output file must contain all control points.  The water budget computations are performed by control point in upstream-to-downstream sequence.  A control point is considered only after computations are completed for all control points located upstream.  A 1CPT record may be placed before the 2BUD record to create an ICP(I) array stored in computer memory that defines the upstream-to-downstream ordering of control points.  The default option 1 is selected in 1CPT record field 3.  If the control points are already in upstream-to-downstream order in the *SIM* DAT file, the 1CPT record is not needed.

___Field 6___:  If the time period covered by the water budget starts after the start of the *SIM* simulation period, the end-of-year storage preceding the budget start year automatically provides the reservoir storage at each control point at the beginning of the water budget computations.  Otherwise, the beginning-of-simulation storages from a BRS file created by *SIM* may be read.  The other option is to compute the beginning storage volumes BSTO(cp) using end-of-month storage (ST), stream flow depletion (DEP), net evaporation-precipitation (EP), and diversion (DT-DS) volumes for the first month of the simulation read from the *SIM* output file as follows.

$$BSTO(cp) \ = \ ST - DEP + EP + DT - DS$$

In some cases, the beginning-of-simulation storage may depend upon other reservoir releases not included in the *SIM* output file and the above equation.  The BRS file option is advantageous in this regard, since the BRS file will always contain the exact beginning storages from *SIM*.

___Field 7___:  Negative values may result from the computation of the inflows flowing into a control point.  The default option 1 carries the negative inflows forward in the computations without adjustment.  Option 2 limits the adjustment of negative inflow loads to not exceed the volume in reservoir storage at the beginning of the month.  The negative inflow volume is changed to zero or as close to zero as the storage volume allows.  Option 3 consists of setting the negative inflow to zero, which has the effect of creating additional water volume.

___Fields 8 and 9___:  Two types of water budget tables may be created and written to the TOU file, a river basin summary table and a control point table.  The default is to develop only the budget for the entire river basin.  Optionally, water budgets may be created for one or all control points.

**3NAT** Record  −  Naturalized Stream Flows
**3REG** Record  −  Regulated Stream Flows
**3UNA** Record  −  Unappropriated Stream Flows
**3DEP** Record  −  Stream Flow Depletions
**3U+D** Record  −  Unappropriated Flows plus Stream Flow Depletions
**3EPD** Record  −  Net Evaporation-Precipitation Depths

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 3NAT | Record identifier for naturalized stream flows |
| | | | | 3REG | Record identifier for regulated stream flows |
| | | | | 3UNA | Record identifier for unappropriated stream flows |
| | | | | 3DEP | Record identifier for stream flow depletions |
| | | | | 3U+D | Record identifier for summation of stream flow depletions plus unappropriated stream flows |
| | | | | 3EPD | Record identifier for net evaporation depths |
| 2 | 5-8 | CDOUT | 2x,A2 | AN | Two-character identifier at beginning of each record |
| 3 | 9-12 | HEC | I4 | blank, zero | Stream flow records grouped by control point |
| | | | | 1 | Stream flow records grouped by year |
| 4 | 13-20 | INFAC | F8.0 | blank,0 | Default INFAC=1.0 |
| | | | | + | Factor by which stream flows are multiplied |

The 3NAT, 3REG, 3UNA, 3DEP, 3U+D, and 3EPD records have the same format. The specified data are read from control point output records in the *SIM* output file except for the 3EPD record that reads reservoir output records. *TABLES* converts the data to the format of *SIM IN* or *TS* input records. Any two-character identifier, including but not limited to *IN* or *TS* or blank, may be written at the beginning of each record created as specified by field 2 of the input record. The multiplier in field 4 may be a unit conversion factor or otherwise used to scale the flows.

Each record written to the *TABLES* output file contains 12 flows for the 12 months of the year. Records are created for all years and all control points or reservoirs in the *SIM* output file. The records may be ordered with all years grouped together for a control point followed by all years for the next control point (default of *HEC* = 0 in field 3). Alternatively, records for all control points may be grouped together for each year (*HEC* = 1 in field 3).

| Grouped by Control Point (*HEC* = 0) | | Grouped by Year (*HEC* = 1) | |
|---|---|---|---|
| CP1 | 1990 | CP1 | 1990 |
| CP1 | 1991 | CP2 | 1990 |
| CP1 | 1992 | CP3 | 1990 |
| CP2 | 1990 | CP1 | 1991 |
| CP2 | 1991 | CP2 | 1991 |
| CP2 | 1992 | CP3 | 1991 |
| CP3 | 1990 | CP1 | 1992 |
| CP3 | 1991 | CP2 | 1992 |
| CP3 | 1992 | CP3 | 1992 |

The program *HYD OI* record provides more comprehensive capabilities serving this same purpose.

**4SWR** Record  −  Hydropower and Reservoir Release Table for a System Water Right

| field | column | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-4 | CD | A4 | 4SWR | Record identifier |
| 2 | 8 | MNAN | I4 | 0 | Annual table |
|   |   |   |   | 1 | Monthly table |
|   |   |   |   | 2 | Both annual and monthly tables |
| 3 | 12 | NUM | I4 | + | Number of water rights to follow (1 to 30) |
| 4-8 | 13-92 | IDEN(I) I=1,5 | A16 | AN | Water right identifiers for which to develop reservoir release tables (maximum of 5/record and six records) |

**4SGP** Record  −  Hydropower and Reservoir Release Table for a Water Right Group

| field | column | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-4 | CD | A4 | 4SGP | Record identifier |
| 2 | 5-8 | MNAN | I4 | 0 | Annual table |
|   |   |   |   | 1 | Monthly table |
|   |   |   |   | 2 | Both annual and monthly tables |
| 3 | 9-12 | NUM | I4 | + | Number of water right groups to follow (1 to 30) |
| 4-8 | 13-52 | IDEN(I) I=1,5 | 8X,A8 | AN | Identifiers of water rights groups for which to develop reservoir release tables (maximum of 5/record) |

The 4SWR and 4SGP records are the only *TABLES* records that result in data being read from a *SIM* hydropower and reservoir release HRR output file.  System water rights included in a HRR file are hydropower (type 5 and 6), type 2 and 3 rights, and/or rights with multiple reservoirs.  *TABLES* reorganizes the reservoir releases from the HRR file with each reservoir associated with the water right (4SWR record) or group of rights (4SGP record) having a column of monthly releases.  The 4SWR record results in a table for a specified water right in which monthly releases from each reservoir for that right are listed in a column.  The 4SGP record results in a table for a specified group of water rights in which the total monthly releases for all rights in the group from each reservoir for that group are listed in a column.

A 4SWR record may develop tables for each of up to 30 water rights.  Up to 5 rights are listed in fields 4-8, and up to six records may be used.  Fields 2 and 3 are not read on the second and subsequent records.  Likewise, up to 30 groups of water rights may be listed on up to six 4SGP records with 5 groups per record.

Creation by *SIM* of a *HRR* file is activated by *JO* record field 4.  Either water right identifiers or group identifiers are selected in *JO* record field 4 for writing to the HRR file.  The water rights included to the HRR file are the same as those included in the OUT file.  4SWR/4SGP tables may use significant computer time searching for identifiers in the *HRR* output file.  *TABLES* run times may be reduced by minimizing the number of water rights output by *SIM*.

**4ZZF** Record  –  Frequency Table for Flows in Water Rights Priority Loop

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 4ZZF | Record identifier. |
| 2 | 8 | VAR | I4 | 1 | Reservoir releases. |
| | | | | 2 | Regulated flows. |
| | | | | blank, 0, 3 | Available flows. |
| 3 | 12 | MON | I4 | blank, 0 | All months are included in the computations. |
| | | | | + | The month for which the analysis is performed. |
| 4 | 16 | NUM | I4 | blank, 0 | Tables for all control points included in ZZZ file. |
| | | | | − | Develop tables for the NUM control points already listed with preceding record. |
| | | | | + | Number of control points to follow on IDEN records. |

The *ZZ* record activates a *SIM* feature described in Chapter 6 of the *Reference Manual* that tabulates regulated flows, available flows, and reservoir releases at specified control points in a ZZZ file as each water right is simulated in the priority sequence.  Flows are tabulated each month at the beginning of the *SIM* simulation and after each water right is simulated in the priority sequence.  *TABLES* 4ZZZ and 4ZZF record routines read the flows from the ZZZ file.  The 4ZZF record builds frequency tables similar to the 2FRE record.

Frequencies are determined for flows at the beginning of the *SIM* simulation and after each water right is simulated in the priority sequence.  The table created by a 4ZZF record includes all water rights recorded in any month for any control point found in the *SIM* ZZZ output file, but *SIM ZZ* record options allow limiting the water rights included in the ZZZ file.  Flows for all ZZZ file rights are not necessarily recorded in any one month due to the *ZZ* record limit options.  *TABLES* repeats flows for multiple rights until finding the next more senior right with recorded flows.

### Explanation of 4ZZF Record Fields

*Field 2*:  Each frequency table is developed for either reservoir releases (VAR=1), regulated flows (VAR=2), or available flows (VAR=3).  One of the three variables is selected, with the default being available flows.  Sets of two or three 4ZZF records may be included in the TIN file to build frequency tables for two or three variables.  A separate table is created for each variable.

*Field 3*:  If a 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, or 12 is entered for *MON* in field 2, frequencies are computed for only the specified month.  The default is to include is all months in the analysis.

*Field 4*:  4ZZF field 4 is identical to 4ZZZ field 6.  The default is to include tables for each of the control points found in the *SIM* ZZZ file.  Optionally, *NUM* control points may be selected by listing control point identifiers on one to ten supplemental IDEN records.  A negative value for *NUM* may be entered in field 6 to indicate that the list read from a previous record is to be repeated.  IDEN records are used if and only if *NUM* is a positive integer.  Each frequency table is for a single control point, with multiple tables created for multiple control points.

**4ZZZ** Record  –  Flows in Water Rights Priority Loop

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-4 | CD | A4 | 4ZZZ | Record identifier. |
| 2 | 8 | TA | I4 | blank, 0 | Do not develop annual row/monthly column table. |
|   |   |   |   | 1 | Table with annual rows and monthly columns. |
| 3 | 12 | PT | I4 | blank, 0 | Do not activate either DSS or text file option. |
|   |   |   |   | 1 | Develop columns of monthly data in text file. |
|   |   |   |   | 2 | Columns of annual totals or means in text file. |
|   |   |   |   | 3 | Develop columns of 12 monthly means in text file. |
|   |   |   |   | 4 | Develop DSS monthly time series records. |
|   |   |   |   | 5 | Develop DSS annual time series records. |
| 4 | 16 | MORE | I4 | 0 | Write columns; next record starts a new table. |
|   |   |   |   | 1 | Add columns to existing table or start first table. |
| 5 | 20 | VAR | I4 | 1 | Reservoir releases. |
|   |   |   |   | 2 | Regulated flows. |
|   |   |   |   | blank, 0, 3 | Available flows. |
| 6 | 24 | NUM | I4 | blank, 0 | Tables for all control points included in ZZZ file. |
|   |   |   |   | − | Develop tables for the NUM control points already listed with preceding record. |
|   |   |   |   | + | Number of control points to follow on IDEN records. |
| 7 | 25-40 | RIGHT | A16 | AN | Water right identifier entered any place in field. The term begin, Begin, or BEGIN is entered for flows at the beginning of the priority sequence. |

The *SIM ZZ* record and associated *TABLES* 4ZZZ and 4ZZF record routines discussed in *Reference Manual* Chapter 6 are designed to track the effects of each water right in a *SIM* dataset on the regulated flows and available (still unappropriated) flows at specified control points. *SIM* records the flows in a ZZZ file as each water right is simulated in the priority sequence. *TABLES* reads the ZZZ file. The 4ZZZ record organizes the flows as tables in the TOU file or as DSS file records in a similar manner as the time series records described on pages 133-135.

Any number of 4ZZZ records may be entered in the TIN file. Each 4ZZZ record tabulates data from the ZZZ file for the single flow variable selected in 4ZZZ record field 5 for flows which occur immediately after simulation of the water right specified in field 7 or at the beginning of the water rights priority simulation loop. Each table is for a specified control point (field 6).

## Explanation of 4ZZZ Record Fields

*Field 2*: Types of tables to be created are selected in fields 2 and 3. There is no *TABLES* output if fields 2 and 3 are both blank. A set of one or more tables with rows for years and columns for months and annual totals is created in the TOU file by entering the integer 1 in 4ZZZ field 2.

***Field 3***:  Either columns of data may be written to the TOU file or HEC-DSS records may be written to the DSS file.  The data may include either monthly flows, means, or annual totals.

A TOU file table activated by entering a 1, 2, or 3 in 4ZZZ record field 3 consists of a single column for each control point with multiple control points being included as separate columns in the same table.  This format is designed to be read by spreadsheet programs for plotting or additional computational manipulations.  The column may contain either the entire time series of monthly flow data (PT=1 in field 3), annual totals for each year of the simulation (PT=2), or a set of 12 means for each of the 12 months of the year (PT=3).  The parameter *MORE* in field 4 controls whether another column is added to the current table or a new table is started.

Options 4 and 5 in field 3 consist of storing the monthly or annual time series as binary records in a DSS file, accessible to graphing and other capabilities provided by HEC-DSSVue.  The HEC-DSS data storage system references data records by their pathnames, which consist of six parts in the format /A/B/C/D/E/F/.  The pathname is assigned automatically by *TABLES* as indicated below.

> A – filename root of *TABLES* output files
> B – control point identifier
> C – ZZ_RES_REL or ZZ_REG_FLOW or ZZ_AVAIL_FL
> D – date of the beginning of the time series such as 01JAN1938
> E – time interval = MON or YEAR for *SIM* results
> F – water right identifier from 4ZZZ record field 7

***Field 4***:  Field 4 is relevant only if a columnar tabulation is activated by entering a 1, 2, or 3 for PT in field 3 and multiple control points are indicated by NUM in field 6.  Each control point is tabulated as a single column in a table.  The parameter *MORE* in field 4 specifies whether to place another column in the current table or to create another new table.  Each table can include any number of control point columns up to a limit of 100 columns.  At least one record must have a *MORE* of zero in order to write the table.

***Field 5***:  One of three variables must be selected.  The time series variable tabulated is either reservoir releases (VAR=1), regulated flows (VAR=2), or available flows (VAR=3).  The default (blank field 5) is available flows (VAR=3).  Multiple 4ZZZ records may be included in the TIN file to build tables for all three variables.  Reservoir releases are a component of regulated flows.

***Field 6***:  The default is to include tabulations for each of the control points found in the *ZZZ* file.  Optionally, *NUM* control points may be selected by listing control point identifiers on one to ten supplemental IDEN records.  A negative value for *NUM* may be entered in field 6 to indicate that the list read from a previous record is to be repeated.  IDEN records are used if and only if *NUM* is a positive integer.

***Field 7***:  The water right identifier is entered in field 7.  The flows tabulated by *TABLES* are those at the field 6 control point occurring immediately after this water right was simulated by *SIM* in the water right priority sequence.  Multiple 4ZZZ records may be included in the TIN file to build tables of flows occurring after multiple water rights, but each individual table is for a single water right.  The flows at the beginning of the simulation each month prior to simulating any of the water rights are also included in the ZZZ file and are selected by entering the term *Begin*, *begin*, or *BEGIN* in 4ZZZ record field 7.

Table 4.9
**Quick Reference Chart for Selected TABLES Records**

columns

| 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | page |
|---|---|----|----|----|----|----|----|----|----|----|------|
| TITL | | | | | | | | | | | 116 |
| COMM | | | | | | | | | | | 116 |
| PAGE | | | | | | | | | | | 116 |
| FILE | | | | | | | | | | | 116 |
| ENDF | | | | | | | | | | | 116 |
| UNIT | | | | | | | | | | | 117 |

Job Type 1 Records – Tables from SIM Input File Data

| 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | page |
|---|---|----|----|----|----|----|----|----|----|----|------|
| 1REC | KK | NUM | REC | REC | REC | REC | REC | REC | REC | REC | 118 |
| 1SUM | KK | | | | | | | | | | 118 |
| 1SRT | KK | | | | | | | | | | 118 |
| 1CPT | | | | | | | | | | | 119 |

Job Type 2 Records – Tables from SIM Output OUT File Data

| 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | page |
|---|---|----|----|----|----|----|----|----|----|----|------|
| IDEN | | | | | | | | | | | 127 |
| 2REL | MONTH | RFLAG | ID | NUM | | TAR | | | | | 128 |
| 2FRE | ID | MONTH | NUM | METH | MAT | TIME | | XF | | | 130 |
| 2FRQ | ID | MONTH | NM | | IDEN | | QF(1) | | QF(2) | | 132 |
| 2RES | TABLE | MONTH | NUM | | IDEN | | IDEN | | IDEN | | 133 |
| 2SCP | MNAN | NUM | | IDEN | | IDEN | | IDEN | | IDEN | 135 |
| 2SWR | MNAN | NUM | | | | IDEN | | | | IDEN | 135 |
| 2SGP | MNAN | NUM | IDEN | | IDEN | | IDEN | | IDEN | | 136 |
| 2SRE | MNAN | NUM | IDEN | | IDEN | | IDEN | | IDEN | | 136 |
| 2SBA | MNAN | | | | | | | | | | 136 |
| 2BUD | | | | | | | | | | | 137 |
| 2NAT | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2REG | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2UNA | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2DEP | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2TAR | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2DIV | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2SHT | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2RFL | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2IFT | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2IFS | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2CLO | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2CLC | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |
| 2STO | TA | PT | MORE | ID | NUM | DP | MAV | XF | | | 124 |

Job Type 4 Records – Tables from SIM Output HRR File Data

| 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | page |
|---|---|----|----|----|----|----|----|----|----|----|------|
| 4SWR | MNAN | NUM | | IDEN | | IDEN | | IDEN | | IDEN | 140 |
| 4SGP | MNAN | NUM | IDEN | IDEN | IDEN | IDEN | IDEN | | | | 140 |
| 4ZZF | VAR | MON | TABLE | NUM | | | | | | | 141 |
| 4ZZZ | TA | PT | MORE | VAR | NUM | | | | | | 142 |
| 4 | 8 | 12 | 16 | 20 | 24 | 28 | 32 | 36 | 40 | 44 | page |

**CHAPTER 5**
**WRAP-HYD**

The purpose of the WRAP program *HYD* is to facilitate developing hydrology-related input data for *SIM*. The *HYD*rology data program provides a set of routines described in *Reference Manual* Chapter 3 that read, modify, and create sequences of naturalized or otherwise adjusted monthly stream flow volumes and net reservoir surface monthly evaporation less precipitation depths. *HYD* provides certain computational routines that are also available in *SIM* and others that are not. For the routines incorporated in both programs, the format of the computed output is different. The primary *HYD* output is the basic *SIM* FLO and EVA input files of *IN* and *EV* records or these *SIM* hydrology input data as a data storage system DSS file. *HYD* also includes options for reading and writing stream flow and evaporation-precipitation data as columns in a table, which facilitates transferring data from and to spreadsheet programs such as Microsoft Excel.

## HYD Input and Output

The primary output provided by the program *HYD* consists of one or both of the following two separate *SIM* hydrology input datasets.

- sequences of monthly naturalized or otherwise adjusted stream flow volumes which are input to *SIM* as a file with filename extension FLO or DSS
- sequences of monthly reservoir surface net evaporation minus precipitation depths which are input to *SIM* as a file with filename extension EVA or DSS

The monthly stream flow volumes and net evaporation-precipitation depths cover a specified hydrologic period-of-analysis and are located at specified control points. *HYD* provides options to organize the datasets in various alternative formats. *HYD* also tabulates various other related data read from *SIM* input and output files or other sources and/or computed within *HYD*.

In general, *HYD* adjusts input sequences of monthly stream flow volumes to represent specified conditions of water resources development/management/use and river basin hydrology for input to *SIM*. A typical application of this *HYD* capability is to adjust gaged monthly stream flows to obtain naturalized flows. Sequences of historical water supply diversions, return flows, reservoir net evaporation and storage changes, and other related data may be provided as monthly flow volume adjustment input to *HYD*. The program includes capabilities for computing reservoir evaporation volume adjustments based on the same reservoir volume/area input data used in *SIM*.

Program *HYD* also reads input sequences of monthly evaporation rates, precipitation rates, or net evaporation less precipitation rates as monthly depths. *HYD* manipulations of these data include combining operations and changing the organization of the datasets.

Control point *CP* input records are almost the same in either *HYD* or *SIM*. *CP* records from a *SIM* input DAT file can be copied to a *HYD* input HIN file and visa versa. Naturalized flows read as input for some control points (typically gaged sites) may be distributed to other control points (ungaged sites) using the same methods within either *HYD* or *SIM* based on control point *CP* record parameters and information from a flow distribution DIS file. The format and content of the flow distribution DIS file and its input records are the same for both *HYD* and *SIM*.

*HYD*

HYD can also read a *SIM* simulation results output *OUT* file to obtain *HYD* input. As discussed in Chapter 5 of the *Reference Manual*, the *SIM* OUT file contains control point, water right, and reservoir output records. Table 4.10 with accompanying variable definitions in the preceding Chapter 4 of this *Users Manual* lists all of the variables recorded on the OUT file output records. Those variables read by *HYD* are listed below in Table 5.1. The three-character identifier shown in parenthesis corresponds to the identifiers in Table 4.10 used for the *TABLES* time series records.

Table 5.1
Variables Read by *HYD* from *SIM* Output OUT File

_____

| *OUT file control point output records* | *OUT file water right output records* |
|---|---|
| control point identifier | water right identifier |
| naturalized stream flows (NAT) | water right group identifiers |
| regulated stream flows (REG) | stream flow depletions for water right (DEP) |
| unappropriated stream flows (UNA) | return flows for water right (RFL) |
| stream flow depletions at control point (DEP) | *WR* diversion or *IF* release target (TAR) |
| return flows returned at control point (RFR) | *WR* diversion or *IF* release shortage (SHT) |

*OUT file reservoir output records*
reservoir identifier
net evaporation-precipitation depths before runoff adjustments (EVR)
net evaporation-precipitation depths after runoff adjustments (EPD)

_____

Any of the variables listed in Table 5.1 may be written by *HYD* to a *HYD* output file in the same standard format as *IN* and *EV* records but with a user-specified record identifier. Naturalized flow volumes and net evaporation-precipitation depths read from a *SIM* output OUT file are treated by *HYD* in the same way as when these data are read from other *HYD* input files.

Any of the variables read from *SIM* OUT file control point and water right output records can be used with *HYD* stream flow adjustment specifications *AS* records to adjust stream flows. Thus, strategies may be adopted to develop *SIM* stream inflows (*IN* records) representing specified conditions of river basin development based on adjustments derived from *SIM* simulation results. Stream flow adjustment strategies using these *HYD* stream flow adjustment capabilities are discussed in Chapter 6 of the *Reference Manual*.

## Data Manipulation Capabilities Provided by HYD

*WRAP-HYD* is a set of computational and data organization options designed to provide assistance in developing datasets of naturalized or otherwise adjusted stream flows and net evaporation-precipitation rates. Data may be simply read from a *HYD* input file and written to a *HYD* output file with no adjustments other than changing the organization and/or format of the dataset. Alternatively, the data may undergo a variety of adjustments and manipulations employing the various computational options of *HYD* outlined in Tables 5.2 and 5.3.

Table 5.2
Capabilities Provided by HYD

---

- *Initial Manipulations of Stream Flows and Evaporation-Precipitation Depths*

  1. Multiplying the original data by constants specified on *XL* or *CP* records or multiplying or adding monthly-varying factors from *MF* records.

  2. Assigning flows or net evaporation-precipitation rates to a control point by either verbatim repeating data from another control point or by multiplying the repeated flows by the factors from the *CP* records.

- *Annual Set of Monthly Flow Volumes or Evaporation-Precipitation Depths*

  3. Sets of 12 monthly volumes or depths for control points may be determined by computing means or assigning a specified exceedance frequency.

- *Developing Sets of Net Evaporation-Precipitation Depths (EV Records)*

  4. Subtracting precipitation depths from evaporation depths to obtain net evaporation-precipitation depths.

  5. Developing net evaporation-precipitation depths for a particular control point as a weighted average of values from two, three, or four other data sets.

  6. Adjusting evaporation-precipitation depths (E) using the equation:   $E_{adjusted} = a\,E^b + c$

- *Developing Sets of Naturalized or Otherwise Adjusted Stream Flows (IN Records)*

  7. Adding or subtracting sets of adjustments to stream flows associated with historical water supply diversions and return flows, reservoir storage and evaporation, *SIM* simulation results, and other factors that may be pertinent.

  8. Developing adjustments for the historical effects of reservoir storage and net evaporation-precipitation.

  9. Applying the equations:   $Q_{adjusted} = a\,Q^b + c$   or   $\Delta Q_{adjustment} = (a\,Q^b + c) - Q$

  10. Distributing flows from gaged (known flow) to ungaged (unknown flow) locations.

  11. Adjusting stream flows to prevent incremental flows from being negative.

- *Changing the Organization and Format of the Datasets*

  12. Converting the format of the FLO and EVA files between records grouped by control points versus records grouped by year.

  13. Converting an HYD file in an old format to FLO and EVA files in standard format.

  14. Converting between FLO and EVA text files and DSS binary files.

  15. Converting flows and evaporation-precipitation depths to a columnar format, and vice versa, to interchange with Microsoft Excel or other programs.

  16. Converting *SIM* simulation results to *SIM/HYD* input record format.

---

Table 5.3
Activating HYD Capabilities

_____

| **Optional Capability** | **Activation Switch** |
|---|---|
| • *Initial Data Manipulations* | |
|   1.   Multiplying by factors on *XL*, *CP,* or *MF* records. or adding factors from *MF* records. | *CP* record fields 4 and 5 *MF* and *XL* records |
|   2.   Repeating data at multiple control points. | *CP* record fields 7 and 8 |
| • *Representative Annual Set of Monthly Data* | |
|   3.   Methods for assigning sets of 12 monthly values. | *AN* record |
| • *Developing Sets of Net Evaporation-Precipitation Rates (EV Records)* | |
|   4.   Subtracting precipitation from evaporation. | *EP* record |
|   5.   Averaging data sets. | *EP* record |
|   6.   Applying the equation: $E_{adjusted} = a\, E^{b} + c$ | *EQ* record |
| • *Developing Sets of Naturalized Stream Flows (IN Records)* | |
|   7.   Adding adjustments. | *JC* field 7, *AS* record |
|   8.   Reservoir adjustments. | *AS* followed by *RS* record |
|   9.   Applying the equation: $Q_{adjusted} = a\, Q^{b} + c$ | *EQ* record |
|   10.  Flow distribution. | *JC* field 11 and *CP* field 6 |
|   11.  Negative incremental flow adjustments. | *JC* record fields 16 & 17 |
| • *Changing the Organization and Format of the Datasets* | |
|   12.  Grouping by control points versus years. | *JC* record fields 5,6,12,13 |
|   13.  Converting from old HYD file format. | *JC* record fields 5,6,12,13 |
|   14.  Converting between text and DSS files. | *JC* record fields 5,6,12,13 |
|   15.  Converting between a table in columnar format. | *JC* record fields 5,6,12,13 |
|   16   *SIM* simulation results to input record format. | *OI* record |

_____

      The HYD capabilities outlined in Table 5.2 are described in Chapter 3 of the *Reference Manual*. The tasks are listed in Table 5.2 generally in the order in which they are performed within *HYD*. All tasks are optional. The model-user specifies any number of tasks to be performed in a particular execution of *HYD* through entries on the *JC, CP, AN, EP, OI, AS, RS* and *EQ* input records. Table 5.3 notes the records that are used to activate each of the *HYD* capabilities outlined in Table 5.2. These *HYD* options involve reading data from *HYD* input files or a *SIM* output OUT file and performing computations to create stream flow and/or evaporation-precipitation datasets stored in new files. *HYD* options also include developing several related tables as well as sets of *IN* and *EV* records or DSS records. A single execution of *HYD* may include any number of data adjustments. Alternatively, in order to sequence the adjustments certain ways, multiple runs may be made with the output file from one run being read as the input file for the next. Files may also be transported back and forth between *HYD* and spreadsheet programs or DSS.

## Input and Output Files

Program *HYD* input filenames (*root.extension*) all have the same root, denoted here as *root1*, and extensions indicating the type of data in each file. *HYD* output filenames have a common root, denoted here as *root2*, and extensions representing type of data. The root (*root2*) selected for the filenames for the output files will typically be different than the root (*root1*) of the input files to prevent existing files from being overwritten.

The user assigns the roots for the input (root1) and output (root2) filenames during the login procedure that is typically managed through the *WinWRAP* interface. If the user chooses to not enter root2, the default automatically adopted by *HYD* is to create root2 by appending the phrase *OUT* to root1. Thus, the default for root2 is root1OUT. For example, if the filename root *Example* is entered for input files but the filename root for output files is left blank, the FLO input file and FLO output file will have the filenames *Example.FLO* and *ExampleOUT.FLO*, respectively.

The basic *HYD* input HIN file is required. The message HMS file is always created automatically. The other input and output files are provided as needed depending upon the tasks being performed with *HYD*. The required job control *JC* record placed at the beginning of the HIN file contains parameters that select the other files to be activated (opened). The second column of Table 5.4 shows the *JC* record parameter or other input that activates each of the files.

Table 5.4
HYD Input and Output Files

| Filename | Activation | Contents |
|----------|-----------|----------|
| | *HYD* Input Files | |
| root1.HIN | always required | All input not contained in other input files |
| root1.FLO | JC(1) = 1, 2, 5 or JC(3)=2, 3, 4 | Inflow *IN* records with stream inflows |
| root1.EVA | JC(2) = 1, 2, or 5 | *EV* records with evaporation-precip depths |
| root1.HYD | JC(1) = 3, 4 or JC(2) = 3, 4 | *IN* and *EV* records in a single file |
| root1.DSS | JC(1) = 6 or JC(2) = 6 | Flows and evap-precip in DSS format |
| root1.DIS | JC(7) = 1 | Flow distribution *FD*, *FC*, and *WP* records |
| root1.OUT | JC(1)=7, JC(2)=7, or JC(6)=1,2 or one or more *OI* records | *SIM* simulation results output OUT file |
| | *HYD* Output Files | |
| root2.HMS | always opened automatically | Traces and error and warning messages |
| root2.FLO | JC(8) = 1, 2 | Inflow *IN* records with stream inflows |
| root2.EVA | JC(8) = 1, 2 | *EV* records with evaporation-precip depths |
| root2.DSS | JC(8) = 6 | Flows and evap-precip in DSS format |
| root2.HOT | JC(8) = 3, 4 or JC(9) = 3, 4 JC(1) = 1, 2, 3 or JC(1) = 1 NEGINC = 2, 3 on JC record One or more *OI* records | All output not contained in other output files |

*HYD*

The main *HYD* input file with filename extension HIN contains the records controlling the operations performed by *HYD*. With job control *JC* record JC(1) and JC(2) options 1 and 2, FLO and EVA input files have the same format in either *HYD* or *SIM*. Input file types DIS and DSS also have the same format in either *HYD* or *SIM*. The *HYD* root1.OUT input file is the *SIM* output OUT file without any modification. *JC* record parameter JC(6) indicates to *HYD* whether the OUT file was created by *SIM* in text format or as an unformatted binary file. The input file with filename extension HYD dates back to early versions of WRAP in which hydrology input was provided to *SIM* in a file with filename extension HYD. Program *HYD* includes capabilities to convert old *SIM* HYD input files to FLO and EVA files in now standard formats.

Output file types are also listed in Table 5.4. Root2.FLO, root2.EVA, and root2.DSS files are created by *HYD* to serve as input files for *SIM*. The river flow and evaporation-precipitation data may also be stored in columnar format in a root2.HOT file for transport to Microsoft Excel or other programs. Other information that may be stored in a HOT file include tables of:

- variables specified by *OI* records that are read by *HYD* from a OUT file
- watershed parameters from a DIS file as specified by JC(10)
- negative incremental flow adjustments as specified by NEGINC on the *JC* record.
- component parts of reservoir adjustments as specified by JC(11) on the *JC* record and parameter RS(6) on one or more individual *RS* records. JC(11) opens the HOT file if it is not already opened. RS(6) selects reservoirs for which to create tables.

The HYD message HMS file is similar to the *SIM* message MSS file. *HYD* contains a system of traces and error and warning messages written to the message HMS file that is similar to *SIM*. Features for detecting errors in data files are covered by Chapter 7 of the *Reference Manual*.

### Types of Input Records

Like all of the *WRAP* programs, *HYD* input files contain a set of records controlling various options and supplying the data to be used in the computations. The various types of records and the files in which they are stored are listed in Table 5.5. The record types are labeled by a two-character identifier placed at the beginning of each record. These record identifiers provide a mechanism for organizing and referencing the input by data type.

Some of the same input record types are used in both *HYD* and *SIM*. Several *HYD* records are not used by *SIM*. Likewise, many record types associated with the main *SIM* input file are not pertinent to *HYD*. However, these records may be included in a *HYD* input HIN file and will be simply ignored by *HYD*.

The following record types are used by *HYD* as well as *SIM*. The format and content of these records, described in Chapter 3, are essentially the same with either program.

*\*\*, CP, CI, SV, SA, ED, IN, EV, FD, FC, WP*

The *JC*, *MF*, *OI*, *EP*, *AN*, *AS*, *FA*, *RS*, *SC*, and *EQ* records are unique to *HYD*. Table 5.5 lists all the *HYD* input records. Descriptions follow after Table 5.5 for the *WRAP-HYD* records that are different than the common *SIM* and *HYD* records which are already described in the *SIM* chapter.

Table 5.5
Types of HYD Input Records

Basic Input File  (filename root1.HIN)

*Records for organizing the data management and computational tasks*

| | |
|---|---|
| ** | comments or notes not read by the computer that may be inserted throughout |
| JC | *J*ob *C*ontrol data with basic input/output selections and other option switches |
| XL | multiplier factors designed primarily for use as unit conversions |
| OI | data from *SIM O*UT file is written to *HYD* HOT file in a standard format |
| EP | specification of *E*vaporation-*P*recipitation depth manipulations |
| AN | representative year of monthly flows or evaporation-precipitation rates |
| ED | *E*nd of *D*ata |

*Records for defining control point connectivity and providing data for control points*

| | |
|---|---|
| CP | *C*ontrol *P*oint connectivity and naturalized flow, evaporation, and channel loss data |
| MF | *M*onthly *F*actors for arithmetic manipulation of flows and evap-precip depths |
| CI | *C*onstant *I*nflows or outflows entering or leaving system at a control point |

*Records for describing storage-volume relationship for a reservoir*

| | |
|---|---|
| SV | *S*torage *V*olumes corresponding to areas on *SA* record |
| SA | *S*urface *A*rea corresponding to volumes on *SV* record |
| RS | coefficients for storage-area equation may be entered on *R*eservoir *S*pecification record |

Hydrology Input Files  (root1.FLO, root1.EVA, root1.HYD)

| | |
|---|---|
| IN | *IN*flows to the system (inflow stream flow volume/month) |
| EV | *EV*aporation (reservoir net evaporation-precipitation depth/month) |

Flow Distribution File  (filename root1.DIS)

| | |
|---|---|
| FD | *F*low *D*istribution specifications for transferring flows from gaged to ungaged sites |
| FC | *F*low distribution *C*oefficients for certain flow distribution options |
| WP | *W*atershed *P*arameters used in the flow distribution computations |

Either Basic Data File or Flow File  (root1.HIN or root1.FLO)

*Records for Adjusting Stream Flows*

| | |
|---|---|
| AS | *A*djustment *S*pecifications for adjusting stream flows |
| FA | *F*low *A*djustments |
| RS | *R*eservoir *S*pecifications for developing stream flow adjustments |
| SC | *S*torage *C*ontents of a reservoir |
| EQ | coefficients for regression *EQ*uations |

*Job Control JC Record*.-  The *JC* record is used to specify input and output options and various other job control parameters.

*Monthly Factor MF Record*.-  The *MF* record attached to the *CP* provides a set 12 monthly multiplication or addition factors for adjusting either flows or evaporation-precipitation rates.

*OUT Input File OI Record*.-  The *OI* record is used to write data read from the *SIM* output OUT file directly to the *HYD* output HOT file in a standard format as *SIM* or *HYD* input records.

*Evaporation-Precipitation EP Manipulation Record*.-  The *EP* record controls the combining of reservoir evaporation, precipitation, and net evaporation-precipitation datasets.

*Annual AN Record*.-  Representative flow volumes or evaporation-precipitation for each of the 12 months are determined by optional methods and assigned to extend the period-of-analysis.

*Adjustment Specifications AS Record*.-  The *AS* record activates stream flow adjustment computations and controls the selection of adjustment options.

*Flow Adjustments FA Record*.-  Stream flow adjustment amounts may be input on *FA* records.

*Reservoir Specifications RS Record*.-  A *RS* record activates routines for computing river flow adjustments modeling the effects of a reservoir.  Information needed for the computations are provided, and the selection of adjustment options is controlled.

*Storage Contents SC Record*.-  Historical storage contents for a reservoir are input on *SC* records for use in developing the stream flow adjustments specified on a *RS* record.

*Equation EQ Record*.-  Adjustment equation coefficients are provided on *EQ* records.

## Data Arrays

The program *HYD* consists of a set of routines for creating, adjusting, and writing data arrays.  Most *HYD* data management and computational operations work with the stream flow *FLOW* and evaporation-precipitation *EP* arrays.  The *FLOW* array contains monthly stream flow volumes (volume/month).  The *EP* array contains monthly evaporation rates, precipitation rates, or net evaporation − precipitation rates (depth/month).  The three dimensional arrays are indexed as follows.

*FLOW (control point, year, month)*
*EP (control point, year, month)*

The control points are sequenced in the order in which the *CP* records are placed in the HIN file. The total number of control points is the number of *CP* records in the HIN file.  The arrays hold data for all of the months in the hydrologic period-of-analysis specified in *JC* record fields 2 and 3.  The total number of years is defined by *JC* record field 2.  There are 12 months in each year.

All elements of the *FLOW(cp,yr,month)* and *EP(cp,yr,month)* arrays are set equal to zero at the beginning of a *HYD* execution.  The arrays are initially populated (partially or completely) filled) with data read by *HYD* from input files in accordance with specifications on the *JC* record.  *JC* record parameters also specify the format and organization of the output files to

which the arrays are written at the end of the *HYD* execution.  Adjustments to the *FLOW* and *EP* arrays during an execution of *HYD* are defined by *CP*, *CI*, *FD*, *EP*, *AN*, *AS*, *RS*, and *EQ* records.

Control point identifiers *CPID(cp,1)* and *CPID(cp,2)* entered in *CP* record fields 2 and 3 are defined as follows.

> *CPID(cp,1)* – six-character identifier of the control point
> *CPID(cp,2)* – identifier of the next downstream control point

Computations are performed and the *FLOW* and *EP* array data are written to *HYD* output files in the sequential control point order in which the *CP* records are entered in the HIN file.  Flow adjustment specification *AS* record cascading computations require the next downstream control points *CPID(cp,2)* entered on the *CP* records to define spatial connectivity.  Other entries on the *CP* record define various adjustments to the *FLOW* and *EP* array data.  With the exception of *CPID(cp,1)* in field 2, all *CP* record fields may be blank unless needed to define specific adjustments to the *FLOW* and *EP* arrays.  *CP* records are not needed at all if only *OI* record operations are being performed.

*HYD* will also read the variables listed in Table 5.1 from a *SIM* output OUT file.  If a OUT file is read, all of the control point, water right, and reservoir records contained in the OUT file are read.  Only the variables listed in Table 5.1 are read from these records.  *HYD* stores the data read from the OUT file (filename root1.OUT) in the following arrays.

> *OUTCP (control point, variable, year, month)*
> *OUTWR (water right, variable, year, month)*
> *OUTRES (reservoir, variable, year, month)*
>
> > *OUTCPID(control point)*
> > *OUTWRID(water right)*
> > *OUTRESID(reservoir)*

The numbers of control points, water rights, and reservoirs included in a OUT file are read from parameters recorded in the fifth record of the OUT file.  The total number of control points in the root1.OUT file is not necessarily the same as the total number of control points in the root1.HIN file.  The *OUTCP* array contains the five variables listed in Table 5.1.  The *OUTWR* and *OUTRES* arrays contain three and two variables, respectively, listed in Table 5.1.  *OUTCPID*, *OUTWRID*, and *OUTRESID* arrays contain the identifiers for the control points, water rights, and reservoirs.

The *OUTWR(water right, variable)* arrays contains three rather than four variables because diversions or releases (DIV) in the array replace targets (TAR) and shortages (SHT) read from the OUT file.  Water right *WR* record diversions and instream flow *IF* record reservoir releases (DIV) are determined by subtracting shortages (SHT) from targets (TAR).

The *OUTCP*, *OUTWR*, and *OUTRES* data arrays read from the root1.OUT file are used within *HYD* in three different alternative ways.

1. An *OI* record writes any of the variables from the root1.OUT input file directly to the root2.HOT output file as records in a specified format.

2. JC(1) and JC(2) option 7 entered on the *JC* record directs that the initial population of the *FLOW* and/or *EP* arrays be from the data in the *OUTCP* and/or *OUTRES* arrays which are accessible to the various routines including *AN* and *EP* record operations.

3. *AS* record fields 5 and 6 control use of the OUT file data for stream flow adjustments. JC(6) can be used to open the OUT file for use in *AS* record operations even if it has not already been opened by JC(1), JC(2), or *OI* records.

The *OI* record is designed to convert *SIM* simulation results to *SIM* or *HYD* input data records. Data from the OUT file arrays are written to the HOT file in a prescribed format. The *OI* record requires no other HIN file input records other than the *JC* record. *CP* records are not required. *CP* records and their control point identifiers are not referenced by the *OI* record operations even if *CP* records are present in the *HYD* input HIN file. The *OI* record outputs the OUTCP, OUTWR, and OUTRES array data in the same sequential order as the control point, water right, and reservoir records are found in the OUT file.

The *OUTCP* and *OUTRES* arrays can also be used to initially populate the *FLOW* and *EP* arrays by specifying JC(1) and/or JC(2) option 7 on the *JC* record. The *FLOW* array is then used by the other *HYD* operations identically the same as if populated from any other *HYD* input file. The *EP* array is also applied in essentially the same manner regardless of whether initially filled with precipitation-evaporation data from an OUT file or other type of input file. However, the OUT file precipitation-evaporation data are from *SIM* reservoir output records and are referenced by reservoir identifiers. The *AN* and *EP* records can be used with the OUT file precipitation-evaporation data as long as reservoir identifiers are entered on the *CP*, *AN*, and *EP* records rather than control point identifiers.

The arrays in the Fortran code are dimensioned to reserve memory space. The number of control points in the *FLOW* and *EP* arrays is determined automatically by *HYD* by counting the *CP* records. The size of the *SIM* output OUT file arrays is set by parameters read from the fifth line of the OUT file. The number of years is set by *JC* record field 3. The maximum number of reservoir storage/area tables (*SV/SA*) records is set internally at 50. The maximum number of upstream gages on *FD* records is set internally at 20. There are no limits on the number of *CP*, *FD/FC/WP*, *EP*, *OI*, *AN*, *AS*, *FA*, *RS*, *RC*, *CI*, and *EQ* records and associated data adjustments.

### Organization of HYD Operations

*WRAP-HYD* is designed for flexibility for use is a myriad of ways. A single execution of the program may include any number of data adjustments. Alternatively, in order to sequence the adjustments certain ways, multiple runs may be made with the output file from one run being read as the input file for the next. *HYD* both reads and creates *IN* and *EV* records or DSS records. Files may also be transported back and forth between *HYD* and spreadsheet or other programs.

All elements of the *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays are set equal to zero at the beginning of a *HYD* execution. The sequence of operations on the values in the *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays are outlined in Table 5.6. All operations are optional. The operations on the arrays are performed in the order listed in Table 5.6. They are also discussed below in the order in which they occur during an execution of *HYD*.

- Files are opened, the HIN file is read, and initial error and warning checks are performed. Optional additional ICHECK option 2 checks of *IN* and *EV* records may be performed. Other checks are performed later as the various operations are performed.

- Data are read as specified by *JC* record parameters from either *IN* and *EV* records in FLO and/or EVA files or a HYD file, records in a DSS file, *SIM* OUT file simulation results, or as columns in a table in FLO and/or EVA files. These monthly stream flow volumes and monthly evaporation, precipitation, or net evaporation less precipitation depths are assigned to the *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays. Any array elements not read-in are still zeros. The following operations are based on modifying and outputting the values stored in these two arrays.

- The *AN* record computes statistics for the 12 months of the year from the *FLOW* and/or *EP* arrays which can be used to extend the hydrology to cover additional years for which data are not available.

- Sets of monthly reservoir surface evaporation and/or precipitation depths or monthly net evaporation-precipitation depths are combined as specified by *EP* records to obtain new sets of depth/month values stored in the *EP(cp,yr,month)* array. Actually, the arrays combined by addition and subtraction operations to derive the *EP* array can be any sets of numbers.

- Stream flow adjustments outlined in *Reference Manual* Chapter 3 are performed as specified by adjustment specification *AS* and/or regression equation *EQ* records. Each *AS* or *EQ* record results in revised values in the *FLOW(cp,year,month)* array for the specified control point and optionally downstream control points. The *AS* and/or *EQ* record adjustments are performed in sequential order as each *AS* or *EQ* record is read from the input file. Thus, the order of the *AS* and *EQ* records set the order of the adjustment computations. Any number of *AS* and *EQ* records and resulting adjustments, in any order, may be included in an execution of *HYD*.

  Information required to perform *AS* record adjustments is provided by associated *FA*, *CI*, *RS*, and *SC* records or read from a root1.OUT file. A reservoir specification *RS* record defines the component parts computed within *HYD* of an adjustment for the effects of a reservoir. The computed component parts may be written to the root2.HOT file as a table for information. The total reservoir adjustment is treated just like any other adjustment of the *FLOW(cp,year,month)* array. Any number of reservoirs (*RS* records) may be included in a *HYD* run. All adjustments are performed sequentially in the order that the *AS* records are entered in the input file.

  The regression equations: $\qquad Q_{adjusted} = a\,Q^b + c$

  $$\Delta Q_{adjustment} = (a\,Q^b + c) - Q$$

  $$E_{adjusted} = a\,E^b + c$$

  are applied to the *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays as specified by *EQ* records with the coefficients *a*, *b*, and *c* read from the *EQ* records. Again, any number of *EQ* records may be included in the data set, with the adjustments being performed in the order that the *EQ* records are read. If both *EQ* and *AS* records are included, they may be intermixed in any order.

- River flows are distributed from gaged (known flow) to ungaged (unknown flow) control points using methods covered in Chapter 3 of the *Reference Manual* as specified by *FD*, *FC*, and *WP* records from the DIS file. Watershed parameter tables may be written to the HOT file for information. The synthesized stream flows are stored in the *FLOW(cp,year,month)* array.

- Negative incremental flow adjustments described in Chapter 3 of the *Reference Manual* are performed as specified by *ADJINC* on the *JC* record. The *FLOW(cp,year,month)* array is modified. The adjustments may also be written to the HYD output HOT file as specified by *NEGINC* on the *JC* record.

- The *FLOW(cp,year,month)* and *EP(cp,year,month)* arrays are written to output files as *IN* and *EV* records, DSS records, and/or as tables, as specified by parameters on the *JC* record.

Table 5.6
Sequential Order of HYD Operations

_____

1. FLOW and EP arrays are populated with initial data in accordance with JC(1) and JC(2) specifications from the *JC* record. *CP* record CPDT(cp,1) and CPDT(cp,2) factors and monthly *MF* record factors are applied and *CP* record CPIN(cp) and CPEV(cp) operations are performed as data are read from FLO, EVA, HYD, and/or DSS input files to populate the FLOW and EP arrays. These *CP* record operations are not applied if the FLOW and EP arrays are initially populated from the OUT file.

2. Table 5.1 data from OUT file is stored in memory if specified by JC(1)=7, JC(2)=7, or JC(6)=1,2. OUT file data is written to the HOT file as specified by *OI* records.

3. *AN* record operations using either FLOW or EP array data develop a representative dataset for a year for use in creating a new dataset or extending the period covered.

4. *EP* record combining operations using data from the EP array are performed if one or more *EP* records are included in HIN file. Results are stored in the EP array.

5. The FLOW array data are adjusted in accordance with *AS*, *FA*, *RS*, and *EQ* records if specified by the presence of *AS* and/or *EQ* records. Adjusted flows are stored back in the FLOW array.

6. Flow distribution operations are performed as specified by *CP* records using information from DIS file *FD*, *FC*, and *WP* records, with synthesized flows recorded in the FLOW array. Flow distribution methods are the same in both *HYD* and *SIM*.

7. Negative incremental flow adjustment operations are performed with flows in the FLOW array in accordance with *JC* record parameters NEGINC and EPADJ.

8. The final FLOW and EP arrays with accumulated adjustments are written to output files in formats specified by JC(8), JC(9), and JC(10) from the *JC* record.

_____

**Alternative Formats for Stream Flow and Evaporation-Precipitation Datasets**

Monthly stream flow volumes and evaporation-precipitation depths are processed by *HYD* in the following three phases.

1. The monthly stream flow volumes and evaporation-precipitation depths are read from FLO, EVA, DSS, OUT, and/or HYD input files near the beginning of an execution of program *HYD* and stored in the FLOW and EP arrays. The data undergoes certain manipulations during the process of being read and stored in computer memory in the FLOW and EP arrays.

2. The data in the FLOW and EP arrays may be modified by the various *HYD* operations controlled by *JC*, *CP*, *CI*, *AN*, *EP*, *AS*, *RS*, and *EQ* input records from the HIN file.

3. The data in the FLOW and EP arrays are recorded in FLO, EVA, DSS, and/or HOT output files near the end of the program execution.

*HYD* reads input files near the beginning of the data handling and computational tasks and writes to output files near the end. The format for the output files may be different than that of the input files. Using *HYD* to convert flow and evaporation-precipitation data files between formats consists simply of reading input files in any particular format and writing to output files in any selected different format. Input and output options are controlled by the job control variables on the *JC* record.

The format of *IN* and *EV* records in FLO and EVA files are the same for program *HYD* input and output datasets and program *SIM* input datasets. *IN* and *EV* records in FLO and EVA files may be grouped by year or grouped by control point. Each *IN* or *EV* record corresponds to both a year and a control point. The records may be grouped by year, with the group for each year consisting of records for all control points. Alternatively, records may be grouped by control point with records for all of the years grouped together for a control point followed by records for all years for the next control point.

In the standard format, each *IN* and *EV* record has 12 values for the 12 months of the year. Early versions of *WRAP* used a hydrology input file with filename extension HYD containing *IN* and *EV* records in a format with two records per year with six months on each record. Program *HYD* can read data in this *SIM* input HYD file format, store the data in the FLOW and EP arrays, with or without subsequent adjustments, and then write the data in any of the output format options.

Input and output datasets may be converted between text files and binary Data Storage System DSS files. DSS files are the same for either *SIM* or *HYD*. Datasets may also be converted between *IN* and *EV* record or DSS file formats and columnar formats useful in transporting to Microsoft Excel spreadsheets. *SIM* does not read the columnar format created and/or read by *HYD*.

Stream flow volumes and evaporation-precipitation depths may be read from a *SIM* OUT file and stored in the FLOW and EP arrays for later output in any of the alternative formats. Stream flow volumes and evaporation-precipitation depths along with other variables read from an OUT file may also be written directly to a HOT file with *OI* records without being stored in the FLOW and EP arrays. The *OI* record is unique in writing a variety of variables directly to the HOT file without going through the FLOW and EP arrays which are subject to various data manipulations.

*HYD*

*Alternative Data Formats*

Stream flow volumes and evaporation-precipitation depths are stored in input and output files in the following optional alternative formats.

- *IN* and *EV* records arranged in alternative sequences grouped either by year or by control point and stored in text files typically with extensions FLO and EVA though programs *SIM* and *HYD* also optionally read an input file with extension HYD.

- binary records in a Hydrologic Engineering Center (HEC) Data Storage System (DSS) file with filename extension DSS.

- columns in a text file stored in *HYD* input files with filename extensions FLO and EVA or in a *HYD* output file with filename extension HOT.

The format of *IN* and *EV* records and DSS records is the same in program *SIM* input files and program *HYD* input and output files.  *IN* and *EV* records are described earlier in Chapter 3 (pages 96-99) dealing with *SIM* and later in this chapter (pages 182-185).  DSS records are described below.  The columnar format also described below is applicable only to *HYD*.

*DSS Files*

Hydrologic Engineering Center (HEC) Data Storage System (DSS) files are in a direct access binary format that can be read only by software with HEC-DSS capabilities.  The WRAP programs are linked at compilation with a HECDSS library of routines allowing them to read input data and store simulation results as HEC-DSS files.  As discussed in Chapter 1 of both this *Users Manual* and the *Reference Manual*, DSS files facilitate the application HEC-DSSVue with *WRAP-HYD* and *WRAP-SIM*.

DSS files always have the filename extension DSS.  HEC-DSS references data records by their pathnames, which consist of six parts in the format /A/B/C/D/E/F/.  The pathnames for input and output are assigned automatically by the WRAP programs.  The DSS pathnames for the data records stored in DSS files of *HYD* and *SIM* hydrology data are in the following standard format.

 A  –  filename root of input or output file
 B  –  control point identifier
 C  –  FLOW or EVAP indicating stream flow or evaporation-precipitation
 D  –  date of the beginning of the time series such as 01JAN1940
 E  –  MON for monthly time interval
 F  –  CP for control point

*Columnar Format*

Spreadsheet programs such as Microsoft Excel are useful for plotting, regression analyses, and other manipulations of river flow and evaporation/precipitation data.  For example, naturalized flows at multiple control points may be developed by adjusting gaged stream flows at gaging

stations with different record lengths and with gaps of missing data. Naturalized flows covering different time periods may be transported from *HYD* to Microsoft Excel to apply regression analyses to fill in missing months and extend coverage to a common simulation period for all control points and then back to *HYD* to convert to standard *IN* record format.

   *HYD* will write and read monthly stream flow or evaporation/precipitation data in a text file, with the data sequence for each selected control point being in a single column. Working with monthly time series data in columns, of length 12 months times number of years in hydrologic simulation period, is often more convenient than two dimensional arrays with 12 columns for January-December and a row for each year. With the columnar text file format, each column contains all stream flows (or evaporation/precipitation depths) for a particular control point. For example, 1940-1999 monthly naturalized flows at 125 selected control points may be represented by 125 columns with each containing 600 monthly flows. The columns may have different lengths and gaps with missing data.

   *HYD* writes the tables in the following format.

| Year | Mon | CP-1 | CP-2 | CP-3 | CP-4 | CP-5 | CP-6 |
|------|-----|------|------|------|------|------|------|
| 1991 | 1 | 778.1 | 239.8 | 827.5 | 452.6 | 49.2 | 1723.0 |
| 1991 | 2 | 3215.4 | 319.5 | 4513.2 | 299.2 | 64.6 | 6293.8 |
| 1991 | 3 | 2185.4 | 399.4 | 3149.5 | 354.1 | 53.8 | 5298.1 |

The year and month columns are each four-characters wide, and the monthly flow volume or monthly evaporation-precipitation depth columns are 10-characters wide with the data right-justified. In reading the table, the first eight characters (year and month columns) are not read by *HYD* and thus may be blank or contain notes or other information. Lines starting with ** or 40 blank characters are skipped over. Thus, ** may be used to insert notes. The table is written with the control points (columns) in the same order as the *CP* records. However, the columns may be in any order in reading a table. Any number of control points ranging from one to the total number of *CP* records may be included in a table. The control point identifiers in the first row must correspond to the identifiers in field 2 of the *CP* records. Every year of the period-of-analysis (with 12 monthly rows per year) must be included in chronological sequence.

*Input Data Format Options*

   Program *HYD* will read monthly stream flow volumes and evaporation-precipitation depths in the file and record formats described in Table 5.7. The options for reading the river flow and evaporation-precipitation data are selected by entries for JC(1) and JC(2) in fields 5 and 6 of the *JC* record. For options 1, 2, 3, and 4, the monthly river inflow volumes and evaporation, precipitation, or net evaporation-precipitation depths are read as sets of *IN* and *EV* records. For option 5, these data are read as a table with each column containing the data for a particular control point. With option 6, the data are read from a data storage system DSS file with a fixed standard binary format, with no format options to be selected. With option 7, the data are read from a *SIM* simulation output OUT file, which may be in a text file format or an unformatted binary file. JC(6) flags whether the OUT file was created by *SIM* in text format or as an unformatted binary file.

Table 5.7
Options for *HYD* Stream Flow and Evaporation-Precipitation Input Data Organization

| JC(1), JC(2) Option | Filename Extension | Format Description |
|---|---|---|
| 1 | FLO and EVA | Records are grouped by year. Records for all control points for a year are followed by a complete set of records for the next year. Each record contains 12 values for the 12 months of the year. |
| 2 | FLO and EVA | Records are grouped by control point. Records for all years for a control point are followed by a complete set of annual records for the next control point. Otherwise, option 2 is the same as option 1. |
| 3 | HYD | *IN* records for all control points for a year are followed by *EV* records for all control points for the year with pairs of records with each record covering six months. The set of all *IN* records for one year is followed by the set of *EV* records for that year. |
| 4 | HYD | Same sequencing as option 3 but each record covers 12 months. |
| 5 | FLO&EVA | The data are in columns of a table rather than *IN* and *EV* records. |
| 6 | DSS | Data are read from a DSS file which has a standard binary format. |
| 7 | OUT | The data are read from a *SIM* output OUT file. JC(6) flags whether the OUT file is in a text file format or an unformatted binary file. |

Optional input formats for *SIM* are defined by INEV in *JO* record field 2. The *HYD JC* record JC(1) and JC(2) options are compared with the *SIM JO* record INEV options as follows.

- JC(1)/JC(2) options 1, 2, and 6 are the same as INEV options 1, 2, and 6.
- JC(1)/JC(2) option 3 is the same as INEV option 5.
- JC(1)/JC(2) option 4 is the same as INEV option 3.
- JC(1)/JC(2) option 2 can be used to replicate INEV option 4.
- JC(1)/JC(2) options 5 and 7 have no *SIM* INEV counterpart.

In the JC(1) and JC(2) option 1 format which is equivalent to INEV option 1 for *SIM*, records for all control points are grouped together for each year. The set of all records for a year is followed by the set of all records for the next year. The option 1 format is designed to allow program *SIM* to store one year of data at a time. Thus, computer memory requirements are greatly reduced for *SIM* relative to storing all the data in memory with option 2. However, compiling data by control point is usually more convenient. Option 2 listed in Table 5.7 allows the records for all years for a particular control point to be grouped together.

The *IN* and *EV* record format and file organization have been restructured in recent versions of *WRAP* compared to its early predecessor *WRAP2/WRAP3* versions. However, *HYD*

and *SIM* include options for reading *IN* and *EV* records in either the old or new record and file formats. With the current standard approach, the *IN* and *EV* records are in a 12-months-per-record format and are separated into two files, with filename extensions FLO and EVA. In the old *WRAP2/WRAP3* method (option 3 in the Table 5.7), each record covers six-months (two records per year), and the *IN* and *EV* records are combined and stored as a hydrology root.HYD file. Program *HYD* has an option that reads an old-format file with extension HYD and converts to the new format FLO and EVA files.

*SIM* can also read *IN/EV* records from a DAT file. Option 4 allows the *IN/EV* records in *SIM* DAT file format to be read by program *HYD* from a HYD file and written to FLO and EVA files in the format required for a *SIM* DAT file. The *IN/EV* records can be transferred between a *SIM* DAT file and *HYD* HYD and FLO/EVA files.

Option 5 facilitates transporting data between a spreadsheet program such as Microsoft Excel and *WRAP-HYD*. With the fifth option, the data are read as columns from a spreadsheet table rather than as rows of *IN/EV* records. *HYD* writes stream flow and evaporation-precipitation data in this same format if specified by JC(8) and JC(9) on the *JC* record.

With input option 6 specified by JC(1) or JC(2), a data storage system DSS file with filename root1.DSS is opened and read. With output option 6 specified by JC(8), a DSS file with filename root2.DSS is opened, and the flows and evaporation-precipitation depths are written to the DSS file. The DSS hydrology file follows a standard organizational format common to both *SIM* and *HYD* which is described in Chapter 3 of this *Users Manual*.

With JC(1) and JC(2) input option 7, monthly stream flow volumes and/or evaporation-precipitation depths are read from a *SIM* output OUT file. Variables read by program *HYD* from the *SIM* output OUT file are listed in Table 5.1. JC(1) and JC(2) input option 7 results in the *FLOW*(cp,year,month) and/or *EP*(res,year,month) arrays being initially filled with the data read from the OUT file. Parameters JC(4) and JC(5) are used to select the variable to be adopted.

As previously discussed, data read from the OUT input file are stored in their own arrays which are used by *HYD* for multiple purposes. The data may populate the *FLOW(cp,yr,month)* and/or *EP(res,yr,month)* arrays at the beginning of the *HYD* execution or be used in other ways. The OUT file input data can be used as later adjustments to the *FLOW(cp,yr,month)* array as controlled by *AS* and *AN* records. OUT file input transferred to the *EP(cp,yr,month)* array can be used in *AN* and *EP* record operations. The OUT input file data can also be printed directly to the *HYD* output HOT file in a specified format as controlled by *OI* records. The *OI* record feature is designed to convert *SIM* output to *SIM* or *HYD* input data records.

*Output Data Format Options*

*HYD* records monthly stream flow volumes and evaporation-precipitation depths in files organized in the alternative formats listed in Table 5.8. The options for writing the flow and evaporation-precipitation data are selected by entries for JC(8) and JC(9) in fields 12 and 13 of the *JC* record.

Table 5.8
Options for *HYD* Stream Flow and Evaporation-Precipitation Output Data Organization

| JC(8), JC(9) Option | Filename Extension | Format Description |
|---|---|---|
| 1 | FLO and EVA | Records are grouped by year. Records for all control points for a year are followed by a complete set of records for the next year. Each record contains 12 values for the 12 months of the year. Same as JC(1) and JC(2) option 1. |
| 2 | FLO and EVA | Records are grouped by control point. Records for all years for a control point are followed by a complete set of records for the next control point. Otherwise, option 2 is the same as option 1. Same as JC(1) and JC(2) option 2. |
| 3 | HOT | Records are grouped by year. The set of *IN* records for a year are followed by the set of *EV* records for that year. |
| 4 | HOT | Records are grouped by control point. The set of all *IN* records is followed by the set of all *EV* records. |
| 5 | FLO&EVA | The data are written as columns of a table rather than *IN* and *EV* records. Same as JC(1) and JC(2) option 5. |
| 6 | DSS | Data are written to a DSS file which has a standard binary format. Same as JC(1) and JC(2) option 6. |

**Miscellaneous HYD Output Information**

The central focus of *HYD* is working with time sequences of monthly stream flow volumes and evaporation-precipitation depths which are stored in input and output files as outlined in the preceding section. Like all the WRAP programs, *HYD* also writes trace messages and warning and error messages to its message HMS file. *HYD* also creates in its HOT file the optional miscellaneous tabulations listed that may be useful to model users for various purposes.

- *OI* records allow any of the variables from a *SIM* output OUT file listed in Table 5.1 to be written by *HYD* directly to the HOT file in the format of *SIM* input records.

- JC(10) on the *JC* record creates a table of watershed parameters developed from the data read from a flow distribution DIS file.

- The parameter NEGINC on the *JC* record creates a listing of negative incremental flow adjustments computed as described in *Reference Manual* Chapter 3.

- RS(6) on one or more reservoir specifications *RS* records creates a table showing the component parts of reservoir adjustments. *JC* record JC(11) opens the HOT file if it is not already opened. RS(6) selects individual reservoirs for which to create tables.

**Sequential Order of Input Records**

The input records are organized in the files in the sequential order outlined in Table 5.9. Other records from a *SIM* DAT file may be included in their normal sequence even though they are not used by *HYD*. The unused *SIM* records will simply be passed over when read by *HYD*.

The job control *JC* and *ED* records are the only required *HYD* input records. The *JC* record is placed at the beginning of the HIN file preceded only by optional comment records. The ED file is placed at the end of the HIN and DIS file. A ED record is also place at the end of a FLO file if the FLO file contains *AS*, *FA*, *RS*, *SC* and *EQ* records.

The *XL, CP, CI, SV,* and *SA* records are applicable to both programs *HYD* and *SIM*. The format of the *CI, SV,* and *SA* records are identical in both *HYD* and *SIM*. The *XL* and *CP* records are almost the same in *HYD* and *SIM*, with relatively minor differences.

The *HYD CP* record has the parameter INEV(cp) in field 6 that is not included on the *SIM CP* record. The *MF* record attached to the *CP* record is unique to *HYD*. The optional *MF* record follows immediately after its *CP* record.

The *XL, CP, CI, SV,* and *SA* records are placed in the same order in both the *HYD* input HIN file and *SIM* input DAT file. The single optional *XL* record follows the single required *JC* record. The set of all *CP* records is next in the sequence, followed by the set of all *CI* records. The set of pairs of *SV/SA* records follow next. The set of *XL, CP/MF, CI,* and *SV/SA* records are followed in the *HYD* input HIN file by a group of optional *OI, EP,* and *AN* records.

*OI, EP,* and *AN* records are unique to *HYD*, not used with *SIM*. Any number of *OI, EP,* and *AN* records are grouped together in any order. The *OI, EP,* and *AN* records must be grouped together in one set, but individual records can be placed in any order within the set. All of the *OI, EP,* and *AN* records are read and their contents stored in memory before any computational operations controlled by them are performed.

The *EQ, AS, FA, RS,* and *SC* records comprise another group of *HYD* input records that are unique to *HYD*. This group of records may be placed either at the end of the HIN file or at the end of the FLO file, as specified by JC(3) on the *JC* record. Computations controlled by each *EQ* or *AS* record are performed prior to reading the next *AS* or *EQ* record.

An *AS* record precedes each set of *FA* records and each set of *RS/SC* records. *FA* records are grouped by control point. A *RS* record precedes each group of *SC* records. *SC* records for a control point are grouped together. *EQ* records may be before, after, or between sets of *AS/FA* records and *AS/RS/SC* records.

The hydrology *IN* and *EV* records and flow distribution *FD, FC,* and *WP* records are the same in either programs *HYD* or *SIM*. *IN* and *EV* records are stored in *FLO* and *EVA* files, a *HYD* file, or a *DSS* file. The organization of the *IN* and *EV* records in these input files is controlled by JC(1) and JC(2) on the *JC* record. *FD, FC,* and *WP* records are stored in a DIS file with the same sequencing when read by either *HYD* or *SIM*.

Table 5.9
Sequential Order of Input Records

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| ** | Comments | Comments may be inserted throughout the files. |

*Basic Input File  (filename root1.HIN)*

| JC | Job Control Data | *JC* record is preceded only by optional comment ** records. |

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| XL | Multiplier Factors | Optional *XL* record follows the *JC* record. |
| CP/MF | Control Point | Set of *CP/MF* records follows the *JC*, *DC*, and *XL* records. |
| CI | Constant Inflows | Set of optional *CI* records follows set of all *CP* records. |
| SV | Storage Volumes | Set of all *SV-SA* record tables grouped together in any order with |
| SA | Surface Area | each *SA* record immediately following corresponding *SV* record. |

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| OI | OUT input file | *OI*, *EP*, and *AN* records are grouped together in any order |
| EP | Evap-Precip | following the above records.  Any number of *OI*, *EP*, and |
| AN | Representative Year | *AN* records in any order may be included in the group. |

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| EQ, AS, FA, RS, SC | | Set of stream flow adjustment records listed below. |

*EQ, AS, FA, RS, SC records are placed at*
*the end of either the HIN File or FLO File*

| AS | Adjustment Specifications | An *AS* record precedes each set of *FA* records and each |
| FA | Flow Adjustments | set of *RS/SC* records.  *FA* records for a CP are grouped. |
| RS | Reservoir Specifications | A *RS* record precedes each group of *SC* records. |
| SC | Storage Content | *SC* records for a control point are grouped together. |
| EQ | Regression Equation | *EQ* records may be before, after, or between *AS* records. |
| ED | End of Data | *ED* is last record in HIN file or after adjustment records. |

*Stream Flow File  (filename root1.FLO)*

| IN | Inflows | *IN* records are grouped together by year and control point. |

*Evaporation-Precipitation Depth File  (filename root1.EVA)*

| EV | Evaporation | *EV* records are organized the same as *IN* records. |

*Hydrology File (filename root1.HYD)  [alternative to standard FLO and EVA files]*

| IN | Inflows | *IN/EV* records are grouped by year.  Set of *EV* records for all control |
| EV | Evaporation | points for year follow set of all *IN* records for the preceding year. |

*Flow Distribution File  (root1.DIS)*

| FD | Flow Distribution | Each *FC* record follows the corresponding *FD* |
| FC | Flow Distribution Coefficients | record.  The set of all *WP* records follows the set |
| WP | Watershed Parameters | of all *FD/FC* records. |
| ED | End of Data | |

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**Content and Format of Each Type of Input Record**

The remainder of this chapter consists of a set of tables outlining the information to be entered in each field of each type of *WRAP-HYD* input record. The record identifier is entered as the first two characters of each record. Comment records are not read by the program, except for the ** record identifier. The other records begin with a two-character identifier, followed by a 6-character wide field and several four-character and eight-character fields. This manual describes input format in terms of fixed-width fields. However, optionally as discussed in Chapter 1, fields with integer *I* and real *F* numerical data formats may be delimited with commas.

The Fortran format specifications found in the fourth column of the following tables describing each record type are the same for all the WRAP programs and are illustrated as follows.

A6     alphanumeric (AN) label right justified in a field that is 6 characters wide

2x     two blank spaces (Fields with the spacing descriptor x are skipped over and not read.)

F8.0     real number in field of 8 characters with any number of digits to the right of the decimal (Either include decimal or right justify the number.)

12F8.0     twelve real numbers with each in a field with a width of 8 characters

I8     integer number right justified in field of 8 characters (Decimal is not allowed.)

3I8     three integer numbers with each right justified in field of 8 characters

Instructions regarding the content and format of each of the record types follow in essentially the sequential order in which the records are listed in Tables 5.5 and 5.9 and sequenced in the input files.

**\*\* Record** – Comments

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | ** | Record identifier |
| 2 | 3-no limit | | | AN | Comments which are not read by the program |

Comment (**) records are not read by the program, except for the ** identifier. They are used to insert notes in the input dataset. The two asterisks ** may also be used to temporarily deactivate records. Any number of comment records may be placed at the following locations.

- almost any place in the HIN file
- before the first *IN* and *EV* records for each year in the FLO and EVA files
- before each set of flow adjustment *AS* records in the HIN and FLO files
- before each set of reservoir adjustment *RS* and *SC* records in the HIN and FLO files
- before the *FD* records and between the *FD* and *WP* records in the DIS file

**ED** Record − End of Data

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | ED | Record identifier |

An *ED* record is required at the end of the HIN and DIS files.  The *ED* record is also required at the end of a FLO file if the FLO file contains *AS*, *FA*, *RS*, *SC* and *EQ* records.  The *JC* and *ED* are the only required *HYD* records.  The HIN file begins with a *JC* and ends with an *ED* record.

**JC** Record − Job Control

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | JC | Record identifier |
| 2 | 3-8 | YRST | I6 | + | First year of hydrologic period-of-analysis. |
| 3 | 9-12 | NYRS | I4 | + | Number of years in period-of-analysis. |
| | | | | | *Level of Error Checks* |
| 4 | 16 | ICHECK | I4 | blank,0 | Normal trace and reduced error checks. |
| | | | | 1 | Normal error checks and input trace. |
| | | | | 2 | *IN/EV* record check. |
| | | | | 3 | *CP* records are copied to HMS file. |
| | | | | 4 | *AS* and *EQ* records are copied to HMS file. |
| | | | | 5 | *SV/SA* records are copied to HMS file. |
| | | | | 6 | *IN/EV* records are copied to HMS file. |
| | | | | 7 | *FD/FC/WP* records are copied to HMS file. |
| | | | | | *Stream Flow Input Options* |
| 5 | 20 | JC(1) | I4 | blank,0 | Stream flows are not read as input. |
| | | | | 1 | *IN* records read from FLO file grouped by years. |
| | | | | 2 | *IN* records from FLO file grouped by control points. |
| | | | | 3 | *IN* records from HYD file with 6 flows per record. |
| | | | | 4 | *IN* records from HYD file with 12 flows per record. |
| | | | | 5 | Flows read from FLO file in columnar format. |
| | | | | 6 | Stream flows read from DSS file. |
| | | | | 7 | Stream flows read from OUT file. |
| | | | | | *Evaporation-Precipitation Input Options* |
| 6 | 24 | JC(2) | I4 | blank,0 | Evaporation-precipitation depths are not read. |
| | | | | 1 | *EV* records from EVA file grouped by years. |
| | | | | 2 | *EV* records from EVA file grouped by control point. |
| | | | | 3 | *EV* records from HYD file with 6 flows per record. |
| | | | | 4 | *EV* records from HYD file with 12 values per record |
| | | | | 5 | Evaporation-precip from FLO file in column format. |
| | | | | 6 | Evaporation-precipitation depths read from DSS file. |
| | | | | 7 | Evaporation-precipitation depths read from OUT file. |

**JC** Record – Job Control  (Continued)

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| | | | | | *Flow Adjustment Input Options* |
| 7 | 28 | JC(3) | I4 | blank,0 | No flow adjustments from HIN and FLO files. |
| | | | | 1 | Flow adjustment data read from HIN file. |
| | | | | 2 | Flow adjustment data read from FLO file. |
| | | | | 3 | Flow adjustment from HIN ($1^{st}$) and FLO ($2^{nd}$) files. |
| | | | | 4 | Flow adjustment from FLO ($1^{st}$) and HIN ($2^{nd}$) files. |
| | | | | | *SIM Output OUT File Input Flow Variable Options* |
| 8 | 32 | JC(4) | I4 | blank,0 | Initial flows are not obtained from the OUT file. |
| | | | | 1 | Initial flows are naturalized flows (NAT). |
| | | | | 2 | Initial flows are regulated flows (REG). |
| | | | | 3 | Initial flows are unappropriated flows (UNA). |
| | | | | 4 | Initial flows are stream flow depletions (DEP). |
| | | | | 5 | Initial flows are return flows (RFR). |
| | | | | | *OUT File Input Evap-Precip Variable Options* |
| 9 | 36 | JC(5) | I4 | blank,0 | Evap-precip depths are not obtained from OUT file. |
| | | | | 1 | Evap-precip depths before runoff adjustments (EVR). |
| | | | | 2 | Evap-precip depths after runoff adjustments (EPD). |
| | | | | | *OUT Input File Format* |
| 10 | 40 | JC(6) | I4 | Blank,0,1 | OUT file is opened as a text file. |
| | | | | 2 | OUT file is opened as an unformatted binary file. |
| | | | | | *Flow Distribution DIS File Activation* |
| 11 | 44 | JC(7) | I4 | blank,0 | DIS file is not activated. |
| | | | | 1 | DIS file is activated. |
| | | | | | *Stream Flow Output Options* |
| 12 | 48 | JC(8) | I4 | 1 | FLO output file grouped by years. |
| | | | | 2 | FLO output file grouped by control points. |
| | | | | 3 | HOT output file grouped by years. |
| | | | | 4 | HOT output file grouped by control points. |
| | | | | 5 | Flows tabulated as columns in the FLO file. |
| | | | | 6 | DSS output file. |
| | | | | | *Evaporation-Precipitation Output Options* |
| 13 | 52 | JC(9) | I4 | 1 | EVA output file grouped by years. |
| | | | | 2 | EVA output file grouped by control points. |
| | | | | 3 | HOT output file with 6 flows per record. |
| | | | | 4 | HOT output file with 12 flows per record. |
| | | | | 5 | Evap-precip tabulated as columns in the EVA file. |
| | | | | 6 | DSS output file. |

*JC* record is continued on the next page.

**JC** Record – Job Control  (Continued)

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| | | | | | *Watershed Parameter Tables* |
| 14 | 56 | JC(10) | I4 | 1 | Incremental watershed parameter table in HOT file. |
| | | | | 2 | Table of parameters from *WP* records in HOT file. |
| | | | | 3 | Both watershed parameter tables created. |
| | | | | | *Reservoir Adjustment Tables* |
| 15 | 60 | JC(11) | I4 | 1 | HOT file opened if not already opened. |
| | | | | | *Negative Incremental Flow Options* |
| 16 | 64 | ADJINC | I4 | blank,0,1 | Negative incremental flows are not considered. |
| | | | | 2 | Downstream flow adjustments are performed. |
| | | | | 3 | Upstream flow adjustments are performed. |
| | | | | −3 | Option 3 with secondary control points excluded. |
| 17 | 68 | NEGINC | I4 | blank,0,1 | No incremental flow adjustments written. |
| | | | | 2 | Downstream flow adjustments written to HOT file. |
| | | | | 3 | Upstream flow adjustments written to HOT file. |
| | | | | | *Set Default for Evap-Precip Adjustment* |
| 18 | 72 | EPADJ | I4 | blank,0 | No adjustment unless specified on *CP* record. |
| | | | | −1 | Adjustments based on ungaged CP (*FD* field 2). |
| | | | | −2 | Adjustments based on gaged CP (*FD* record field 3). |
| | | | | | *DSS Message File Options* |
| 19 | 76 | JC(12) | I4 | −1 | Messages are written only if HYD is aborted due to some DSS related problem. |
| | | | | 1 | Messages that DSS file has been opened or closed. |
| | | | | blank, 2 | Error or warning messages if DSS problems occur. |
| | | | | 3 | Trace of all DSS records written to DSS files. |
| | | | | 4 | Trace of all DSS records read from DSS files. |
| | | | | 5 and 6 | Not used.  Same as option 4. |
| | | | | 7 | Beginning level of debugging messages. |
| | | | | 8 | Intermediate level of debugging messages. |
| | | | | 9 | Maximum level of debugging messages. |
| | | | | | *Label of First Month in DSS File* |
| 20 | 77-80 | DSSMONTH | 1x,A3 | blank | Default is for first month to be January. |
| | | | | AN | First month in DSS file (JAN, FEB, MAR, ... ,DEC) |

The *JC* record is required as the first record in the *HYD* input HIN file, preceded only by optional comment ** records.

**Explanation of JC Record Fields**

*Fields 2 and 3*:  The time period covered is defined by the starting year and length in years.

*Field 4*:  The various levels of error checks and messages and trace information are described in Chapter 7 of the *Reference Manual*.  ICHECK option 1 should normally be selected unless needs arise for other options.

*Field 5*:  JC(1) specifies the source file and format of the river flows that are read to initially fill the FLOW(cp,year,month) array.  The FLOW(cp,year,month) array assigned these original flow amounts read at the beginning of an execution of *HYD* is subject to various adjustments as program execution proceeds.  The dataset of flows to be read by *HYD* at the beginning of program execution may be organized in the alternative formats outlined in Table 5.7.

*Field 6*:  JC(2) specifies the file source and format outlined in Table 5.7 of the evaporation, precipitation, or net evaporation-precipitation depths that are read to initially populate the EP(cp,year,month) array.

*Field 7*:  Adjustments to the FLOW(cp,year,month) array are performed as directed by adjustment specification *AS* records using information provided on *FA*, *RS*, and *SC* records and/or as specified by adjustment equation *EQ* records.  The *EQ*, *AS*, *FA*, *RS*, and *SC* records are input in either the HIN and/or FLO file as specified by JC(3) in *JC* record field 7.

*Fields 8 and 9*:  With JC(1) and JC(2) option 7, the FLOW and EP arrays are initially filled with data read from the *SIM* output OUT file (*HYD* input file with filename root1.OUT file).  Variables read by *HYD* from the OUT file are listed in Table 5.1.  JC(4) and JC(5) in *JC* record fields 8 and 9 control the choice of which variables are selected to initially populate the FLOW and EP arrays.

*Field 10*:  *SIM* options allow the OUT file to be written as a formatted text file or unformatted binary file, with the default being a text file.  JC(6) tells *HYD* which type of OUT input file it is opening.  JC(6) also serves to open the OUT input file for *AS* record applications even when it is not already being opened for JC(1) or JC(2) option 7 or *OI* records.  The root1.OUT file is opened by either JC(1) or JC(2) option 7, one or more *OI* records, or a non-zero entry for JC(6) in *JC* record field 10.  Any time the root1.OUT file is opened, all of the variables listed in Table 5.1 are read and stored.  The file is opened only once with all *JC*, *OI*, and *AS* record applications of its data having access.

*Field 11*:  Methods for distributing flows from gaged (known flow) to ungaged (unknown flow) control points are identical in *SIM* and *HYD* and are described in *Reference Manual* Chapter 3.  The choice of flow distribution method is controlled by INMETHOD in *CP* record field 6.  INMETHOD options 3 through 8 require data from a DIS file.  If INMETHOD in *CP* record field 6 is greater than 2 for one or more control points, a DIS file must be opened by parameter JC(7) in *JC* record field 11.  The Fortran subroutines that perform the flow distribution computations are essentially identical in *HYD* and *SIM*.

***Fields 12 and 13***:   Options defining the format of the output files in which stream flows and evaporation-precipitation depths are recorded are controlled by JC(8) and JC(9) and described in Table 5.8.  JC(8) and JC(9) specify the use of either FLO and/or EVA, DSS, or HOT files to store the final values in the FLOW(cp,year,month) and EP(cp,year,month) arrays.

***Field 14***:   Assuming a DIS file is activated by JC(7) in field 11, JC(10) in field 14 allows two types of optional tables of watershed parameters to be created in the root2.HOT file.  The flow distribution computations can be accomplished without summarizing the watershed parameters in these tables.  The tables provide general information that may be of interest to the model user.

***Field 15:***   RS(6) on the *RS* record creates a table in the HOT file summarizing the adjustments associated with a reservoir.  The RS(6) parameter must be activated on the *RS* record of each individual reservoir for which a table is to be created.  JC(11) in *JC* record field 15 opens the HOT file for this purpose.  If the HOT file is opened anyway by other parameters, JC(11) is unnecessary.

***Fields 16 and 17***:   *JC* record fields 15 and 16 are the same as *SIM JD* record fields 8 and 9 except ADJINC options 4 and 5 performed within the *SIM* simulation are not relevant in *HYD*. The subroutine that computes the incremental flow adjustments is identical in *HYD* and *SIM*. Negative incremental flow options are described in Chapter 3 of the *Reference Manual*.

***Field 18***:   Options for adjusting evaporation-precipitation depths for runoff at the reservoir site are the same in *HYD* and *SIM* and are described in Chapter 3 of the *Reference Manual*.  Options are specified by *CP* record field 9 with the EPADJ default set by *JD* record field 10 in *SIM* and *JC* record field 17 in *HYD*.

***Fields 19 and 20***:   The Hydrologic Engineering Center (HEC) Data Storage System (DSS) is described in Chapters 1 and 6 of the *Reference Manual*.  Routines from a HEC-DSS library are incorporated into the *SIM*, *TABLES*, and *HYD* programs allowing creation of and access to DSS files.  The same type of DSS information provided in *JC* record fields 19 and 20 for *HYD* is entered on the *OF* record for *SIM* and the FILE record for *TABLES*.  JC(1), JC(2), JC(3), and JC(4) record options control the use of DSS files with *HYD* to store stream flow and evaporation-precipitation data.

***Field 19***:   The HEC-DSS library routines incorporated into the WRAP programs create a variety of different types of trace and error messages.  A parameter sets the level of messages to be written to the message file as outlined in Reference Manual Chapter 7.  JC(12) sets the level of DSS trace and error messages written to the HMS file.

***Field 20***:   Dates are included in the pathnames that label DSS time series data records.  Field 20 provides a label for the first month of the time series data in the DSS file.  If field 20 is blank, JAN for January is adopted by default.

**XL** Record  –  Multiplication Factors and Parameter Limits

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | XL | Record identifier |
| | | | | | *Multiplication Factors Applied to Input Data* |
| 2 | 3-8 | STX | F6.0 | + | Multiplier of reservoir storage volumes on *WS*, *OR*, *SV*, *PV*, *MS*, and *IS* records. |
| | | | | Blank, 0 | Default = 1.0 |
| 3 | 9-16 | INX | F8.0 | + | Multiplier of flows on *IN* records, subject to being superseded by non-blank *CP* record field 4. |
| | | | | Blank, 0 | Default = 1.0 |
| 4 | 17-24 | EVX | F8.0 | + | Multiplier of E-P rates on *EV* records, subject to being superseded by non-blank *CP* record field 5. |
| | | | | Blank, 0 | Default = 1.0 |
| 5 | 25-32 | CIX | F8.0 | + | Multiplier of flows on *CI* records. |
| | | | | Blank, 0 | Default = 1.0 |
| 6 | 33-40 | SAX | F8.0 | + | Multiplier of reservoir surface areas on *SA* records. |
| | | | | Blank, 0 | Default = 1.0 |
| | | | | | *Multiplication Factors Used in Computations* |
| 7 | 41-48 | | 8x | not read by HYD | Multiplier factor for hydropower computations used in *SIM* but not used in *HYD*. |
| 8 | 49-56 | DEPTHX | F8.0 | + | Multiplier factor for runoff depth in NRCS CN method flow distribution computations. |
| | | | | Blank, 0 | Default = 0.01875  (Reference Manual Chapter 3) |
| | | | | | *Limits on CN and Mean Precipitation* |
| 9 | 57-64 | CNLB | F8.0 | + | Lower limit on CN  (Reference Manual Chapter 3) |
| | | | | Blank, 0 | Default = 0.0 |
| 10 | 65-72 | CNUB | F8.0 | + | Upper limit on CN |
| | | | | Blank, 0 | Default = 100.0 |
| 11 | 73-80 | MPLB | F8.0 | + | Lower limit on MP |
| | | | | Blank, 0 | Default = 0.0 |
| 12 | 81-88 | MPUB | F8.0 | + | Upper limit on MP |
| | | | | Blank, 0 | Default = 100 inches or other rainfall unit in effect |
| | | | | | *Warning Limit on Runoff EP-Adjustment* |
| 13 | 89-96 | EPWL | F8.0 | + | Limit for warning message (Reference Manual Ch 3) |
| | | | | Blank, 0 | Default = 2.0 feet or other depth unit in effect |

The *XL* record is identical in *HYD* and *SIM* with the exception of the *SIM* hydropower factor in field 7 which serves no purpose in *HYD*.

**CP** Record  –  Control Point Information

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | CP | Record identifier |
| 2 | 3-8 | CPID(cp,1) | A6 | AN | Control point identifier   [cp = 1,NCPTS] |
| 3 | 11-16 | CPID(cp,2) | 2x,A6 | AN | Identifier of next downstream control point. |
|   |       |            |       | Blank,OUT | Basin outlet. There is no control point downstream. |
|   |       |            |       | | *Multiplier Factors* |
| 4 | 17-24 | CPDT(cp,1) | F8.0 | blank,0 | Default factor = 1.0 |
|   |       |            |       | + | Factor by which inflows on *IN* records are multiplied. |
|   |       |            |       | − | Monthly factors on following MF record are applied. |
| 5 | 25-32 | CPDT(cp,2) | F8.0 | blank,0 | Default factor = 1.0 |
|   |       |            |       | + | Factor by which net evaporation rates are multiplied. |
|   |       |            |       | − | Monthly factors on following MF record are applied. |
|   |       |            |       | | *Do Not Include IN/EV Records in Output* |
| 6 | 36 | INEV(cp) | I4 | 1 | Omit the *IN* records for this CP in the output file. |
|   | This optional *HYD* parameter |  |  | 2 | Omit the *EV* records for this CP in the output file. |
|   | is not used on *SIM CP* record. |  |  | 3 | Omit both the *IN* and *EV* records in the output file. |
|   |       |            |       | 4 | Omit both for this CP and all previous control points. |
|   |       |            |       | 5 | Omit for this CP and all subsequent control points. |
|   |       |            |       | | *Method for Obtaining Naturalized Flows* |
| 7 | 40 | INMETHOD | I4 | 0,1 | *IN* records are input for this control point. |
|   |    | (cp) |  | 2 | Specifications are provided by *CPIN(cp)* in field 7. |
|   |    |      |  | 3 | Flow distribution equation is used. |
|   |    |      |  | 4 | NRCS CN method with synthesized flows limited to |
|   |    |      |  |   | not exceed source control point flows. |
|   |    |      |  | 5 | NRCS CN method without above noted flow limit. |
|   |    |      |  | 6 | Channel loss coefficient with DAR method. |
|   |    |      |  | 7 | Drainage area ratio method (areas from WP records). |
|   |    |      |  | 8 | NRCS method with channel losses. |
| 8 | 43-48 | CPIN(cp) | 2x,A6 | blank | INMETHOD in field 6 is not 2. |
|   |       |          |       | AN | Another CP from which *IN* records are repeated. |
|   |       |          |       | NONE | The words *none, zero, NONE, or ZERO* indicate |
|   |       |          |       | ZERO | zero stream flows at this control point. |
|   |       |          |       | | *Method for Obtaining Net Evaporation-Precipitation* |
| 9 | 51-56 | CPEV(cp) | 2x,A6 | blank | *EV* records are read as input. |
|   |       |          |       | AN | Another CP from which *EV* records are repeated. |
|   |       |          |       | NONE | The words *none, zero, NONE, or ZERO* in this field |
|   |       |          |       | ZERO | indicate zero net evaporation at this control point. |
|   |       |          |       | | *EP Adjustment for Runoff from Reservoir Site* |
| 10 | 57-64 | EWA(cp) | F8.0 | blank,0 | Default set by JC record field 16 is used. |
|   |       |         |      | −1.0 | Ungaged CP from *FD* record field 3 is used. |
|   |       |         |      | −2.0 | Gaged CP from *FD* record field 3 is used. |
|   |       |         |      | −3.0, <−3.0 | No adjustment. Overrides blank *JC* field 16. |
|   |       |         |      | + | Watershed area in acres for runoff adjustment. |

**CP** Record – Control Point Information (Continued)

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| | | | | | *Channel Loss Factor* |
| 11 | 65-72 | CL(cp) | F8.0 | + | Channel loss factor for stream reach below CP. |
| | | | | blank | The default channel loss factor value is 0.0. |
| | | | | | *Watershed Areas on WP Records* |
| 12 | 80 | INWS(cp) | I8 | blank,0 | Parameters on *WP* record are for the total watershed. |
| | | | | + | *WP* record parameters for incremental watersheds. |

The set of all *CP* records follows the *JC* and *XL* records in the HIN file. The *CP* record has the same format for either *HYD* or *SIM* except the *HYD CP* record has the parameter INEV(cp) added as *CP* record field 6 and the addition of a *MF* record as an extension of the *CP* record.

*CP* records control some of the *HYD* computations and provide information required for other *HYD* computations. *CP* records for all control points are required to support essentially all *HYD* operations except those activated by *OI* records. The *OI* record needs no information from *CP* records and does not reference *CP* records. The other input records use the ordering provided by CPID(cp,1) in *CP* record field 1. Computations are performed and output written in the control point sequence in which *CP* records are read from the HIN file. *AS* record cascading operations require CPID(cp,2) provided in *CP* record field 3. All fields of the *CP* record except fields 1 and 2 (CD and CPID(cp,1)) may be left blank unless specifically needed.

The FLOW(cp,year,month) and EP(cp,year,month) arrays are multiplied by CPDT(cp,1) and CPDT(cp,2) from *CP* record fields 4 and 5 which have defaults of 1.0 as the stream flow and evaporation-precipitation data are initially read from FLO, EVA, HYD, or DSS files.

Flows are distributed from gaged (known flow) to ungaged (unknown flow) control points based either on CPDT(cp,1) and/or CPIN(cp) specified in *CP* record fields 4 and 8 or INMETHOD from *CP* record field 7. If INMETHOD is greater than 2 for one or more control points, a flow distribution file must be activated (opened) with JC(7) in *JC* record field 11.

Flow adjustments controlled by *AS* records require the next downstream control point identifier entered in *CP* record field 3 for each control point to define system connectivity for the cascading computations. The channel loss factors used in cascading flow adjustments downstream are provided in field 10 of the *CP* records.

*CP* records are used for *EP* and *AN* record operations to sequence the control points. Each control point (or reservoir) identifier referenced by *EP* and *AN* records must be found in field 2 of one of the *CP* records. The EP(cp or reservoir,year,month) array upon which the *EP* and *AN* records operate may be populated from the OUTRES*(reservoir,year,month)* array from the OUT file in which data are referenced by reservoir rather than control point. With only *JC*, *EP*, *AN*, and *CP* records in the HIN file, the identifiers in *CP* record field 2 may be reservoir identifiers.

**MF** Record  –  Monthly Factors

| field | columns | variable | format | Value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | MF | Record identifier. |
| 2 | 3-8 | MF | F6.0 | + | Factors for each of 12 months. |
| 3-13 | 9-96 | MF | F8.0 | + | |

Control point *CP* record fields 4 and 5 are multiplier factors for all stream flows and all evaporation-precipitation depths FLOW(cp,year,month) and EP(cp,year,month) for that control point. The MF record expands this capability. A negative number for *CPDT(cp,1)* or *CPDT(cp,2)* indicates that the *CP* record will be followed by a *MF* record with a set of 12 numbers. The 12 monthly factors on the *MF* record are applied as specified in *CP* record fields 4 and 5 as follows.

> For *CPDT(cp,1)* or *CPDT(cp,2)* of −2.0, flows or evaporation depths are multiplied by the *MF* record factors.

> For *CPDT(cp,1)* or *CPDT(cp,2)* of −3.0, *MF* record factors are added to flows or evaporation depths.

> For *CPDT(cp,1)* or *CPDT(cp,2)* of −4.0, the operation and factors specified for the preceding control point are repeated for this control point.


### *Sequencing of Records in HIN File*

The HIN file record sequencing is based on dividing record types into the following groups.

- The HIN file begins with a required *JC* record followed by optional *XL* record.

- The JC and XL records are followed by the set of all *CP/MF* records, followed by the set of all *CI* records, followed by the set of all pairs of *SV/SA* records. The *CP*, *CI*, *SV*, and *SA* records are essentially the same in *HYD* and *SIM* and are sequenced the same in the *HYD* HIN file and *SIM* DAT file.

- Any number of *OI*, *EP*, and *AN* records are grouped together in any order in the HIN file. The *OI*, *EP*, and *AN* records must be grouped together in one group, but individual records can be placed in any order within the group. The set of all *OI*, *EP*, and *AN* records follows after the *CP/MF*, *CI*, and *SV/SA* records.

- The *EQ*, *AS*, *FA*, *RS*, and *SC* records comprise a group of sets of input records that are placed as the last records in either the HIN file and/or FLO file as specified by JC(3) from the *JC* record. The HIN file always ends with an *ED* record. The set of *EQ*, *AS*, *FA*, *RS*, and *SC* records ends with an *ED* record in either the HIN or FLO files.

**CI** Record  –  Constant Inflows and/or Outflows (12 monthly flows per record)

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | CI | Record identifier. |
| 2 | 3-8 | CIID | A6 | AN | Control point identifier. |
| 3-14 | 9-104 | CI(M=1,12) | 12F8.0 | +,– | Flow added to naturalized flow at control point CIID for month M. |

The set of all *CI* records follows the set of all *CP* records in *HYD* just like in *SIM*. The *CI* record format is identical in both *HYD* and *SIM*. *F*lows on *CI* records are added to the stream flows at the specified control point and, with adjustments for channel losses, at all downstream control points. Addition and cascading of the 12 monthly flows is repeated in each year.

Any number of optional *CI* records may be entered for any control point in any order. Two alternative *CI* record formats include 12 monthly flows on either one record or two records.

**CI** Records  –  Constant Inflows and/or Outflows (two records with six monthly flows each)

*First **CI** Record*  –  Constant Inflows and/or Outflows for Months 1-6

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | UC | Record identifier. |
| 2 | 3-8 | CIID | A6 | AN | Control point identifier. |
| 3-8 | 9-56 | CI(M=1,6) | 6F8.0 | + | Monthly flows for months 1-6. Six flows are entered on each of two CI records. |

*Second **CI** Record*  –  Constant Inflows and/or Outflows for Months 7 through 12

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | UC | Record identifier. |
| 2 | 3-8 | | 6x | | Field 2 of second record is not used. |
| 3-8 | 9-56 | CI(M=7,12) | 6F8.0 | + | Monthly flows for months 7-12. Six flows are entered on each of two CI records. |

**SV** Record  –  Storage Volumes for Reservoir Storage versus Area Table

| Field | columns | variable | format | value | Description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | SV | Record identifier. |
| 2 | 3-8 | RES | A6 | AN | Reservoir identifier. |
| 3-27 | 9-208 | TARA(I) I=1,25 | 12F8.0 | + | Reservoir storage volumes corresponding to surface areas in same fields of the following *SA* record. |

**SA** Record  –  Surface Areas for Reservoir Storage versus Area Table

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | SA | Record identifier. |
| 2 | 3-8 | RES | 6x | | Field not used. |
| 3-27 | 9-208 | TARB(I) I=1,25 | 12F8.0 | + | Reservoir surface areas corresponding to storage volumes in same fields of the preceding *SV* record. |

The set of all pairs of *SV* and *SA* records follows the set of all *CI* records which follows the set of all *CP* records in the HIN file.  *SV* and *SA* records are the same in both *HYD* and *SIM*.  A reservoir storage-area relationship may be defined optionally with a pair of *SV-SA* records or by equation coefficients provided on the *AS* record in *HYD* or *WS* record in *SIM*.

The reservoir surface area versus storage volume relationships are used solely for computing net evaporation-precipitation volumes.   Within  the  *HYD*  computational  routines,  for  given beginning-of-month and end-of-month storage volumes, the water surface area determined by linear interpolation of the storage volume (*SV* record) versus surface area (*SA* record) table is combined with a net evaporation-precipitation to obtain a monthly volume.

The *SV* and *SA* records have the same format.  The *SV-SA* tables are allowed a maximum of 25 pairs of values.  A *SV* record must be followed by the corresponding *SA* record.  A complete set of all *SV-SA* records are grouped together in the HIN file.

**OI** Record – *SIM* Output OUT File Data Written to *HYD* Output HOT File

| field | columns | variable | format | value | Description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | OI | Record identifier. |
| | | | | | *Variable Read from OUT File* |
| 2 | 8 | OVAR(I) | I6 | 1 | Naturalized flows from control point output (NAT). |
| | I = 1 to total | | | 2 | Regulated flows from control point output (REG). |
| | number of *OI* records | | | 3 | Unappropriated flows from control point (UNA). |
| | | | | 4 | Stream flow depletions from control point (DEP). |
| | | | | 5 | Return flows from control point output (RFR). |
| | | | | 6 | Stream flow depletions for water right (DEP). |
| | | | | 7 | Return flows for water right output records (RFL). |
| | | | | −7 | *HYD* shifts return flows (RFL) forward one month. |
| | | | | 8 | Diversions for WR or releases for IF right (DIV). |
| | | | | 9 | Evap-precip depths before runoff adjustments (EVR). |
| | | | | 10 | Evap-precip depths after runoff adjustments (EPD). |
| | | | | | *Specifications for Records Written to HOT File* |
| 3 | 12 | OG(I) | I4 | blank,0,1 | Output records are grouped with all cps for each year. |
| | | | | 2 | Output grouped with all years for each control point. |
| 4 | 15-16 | OCD(I) | 2x,A2 | blank | First two characters blank with no record identifier. |
| | | | | AN | Record identifier written as the first two characters. |
| 5 | 20 | OCP(I) | I4 | blank, 0 | Control point or reservoir identifier or first 6 characters of water right identifier from OUT file is adopted. |
| | | | | 1 | Identifier specified in field 6 below is adopted for the output record written to the HOT file records. |
| 6 | 23-28 | OUID(I) | 2x,A6 | AN | Identifier included in output record written to HOT file which may be blank or contain up to six characters. |
| | | | | | *Selection of Control Points, Reservoirs, or Rights* |
| 7 | 29-36 | OID(I) | 2x,A6 | Blank, 0 | All control points or reservoirs in OUT file. |
| | | | | AN | Control point identifier for VAR = 1, 2, 3, 4, or 5. Reservoir identifier for VAR = 9 or 10. |
| 8 | 37-52 | OWRID (I) | A16 | Blank, 0 | Records are created for all water rights in OUT file. |
| | | | | AN | Water right identifier for VAR = 6, 7, or 8. |

The *OI* record is designed for converting *SIM* simulation results to records in a *SIM* or *HYD* input file. *OI* records allow data read from a *SIM* output OUT file (*HYD* root1.OUT input file) to be written directly to the *HYD* output HOT file (root2.HOT). No computations are performed to modify the data, and no other *HYD* input records other than the *JC* record are needed. The data are written to the root2.HOT file in the same standard format as *IN* and *EV* records, but the identifiers are for either control points, reservoirs, or water rights depending on the variable, and the optional record identifier in the first two fields of each record is specified in *OI* field 4.

## Explanation of OI Record Fields

*Field 2*:   The variable (VAR in field 2) to be written as records in the *HYD* output file with filename root2.HOT is selected from the list outlined in Table 5.1.

VAR option 7 refers to return flows (RFL) associated with a water right.  *SIM* includes a next-month return flow option in which the return flows reenter the river system in the month after the diversion.  VAR option −7 consists of shifting the return flows to the next month.

Water right *WR* record diversions and instream flow *IF* record reservoir releases (DIV) selected with VAR option 8 are determined by subtracting shortages (SHT) from targets (TAR).

*Field 3*:   With the default OG option 1, the records written to the file with filename root2.HOT file are grouped by year.  Records for all control points for a year are followed by a complete set of records for all control points for the next year, and so forth.  With option 2, records all years for a particular control point are followed by the set of records for all years for the next control point.  With either option, each record contains 12 values for the 12 months of the year.

*Field 4*:   OCD is a two-character record identifier such as IN, EV, FA, TS, or any other two characters.  With field 4 left blank, no record identifier is assigned and the first two characters of the record are blank.

*Fields 5 and 6*:   A six-character identifier is written in the second field containing columns 3-8 of the output records written to the HOT file.  The identifier will typically identify a control point, reservoir, or water right.  If field 5 is blank, the control point (VAR = 1, 2, 3, 4, or 5) or reservoir (VAR = 9 or 10) identifier or first six characters of the water right (VAR = 6, 7, 8) identifier from the OUT file is recorded in the records written to the HOT file.  An integer 1 in field 5 indicates that an identifier entered in field 6 is to be written in the output records.  A 1 in field 5 and blank field 6 results in the identifier field being blank in the output records written to the HOT file.

*Fields 7 and 8*:   Depending on the variable selected in field 2, the data is for either control points (VAR = 1, 2, 3, 4, or 5), water rights (VAR = 6, 7, 8), or reservoirs (VAR = 9 or 10).  Parameter OID in field 5 or OWRID in field 6 allows reading of either one control point, one reservoir, or one water right or all control points, all reservoirs, or all water rights found in the OUT input file.  A blank field 7 or 8 defaults to all.

**EP** Record  –  Evaporation-Precipitation Combining Specifications

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | EP | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point or reservoir identifier |
| 3 | 11-16 | EPID(I,1) | 2x,A6 | AN | Control point or reservoir identifier |
| 4 | 17-24 | EPM(I,1) | F8.0 | + | Multiplier |
| 5 | 27-32 | EPID(I,2) | 2x,A6 | AN | Control point or reservoir identifier |
| 6 | 33-40 | EPM(I,2) | F8.0 | + | Multiplier |
| 7 | 43-48 | EPID(I,3) | 2x,A6 | AN | Control point or reservoir identifier |
| 8 | 49-56 | EPM(I,3) | F8.0 | + | Multiplier |
| 9 | 59-64 | EPID(I,4) | 2x,A6 | AN | Control point or reservoir identifier |
| 10 | 75-72 | EPM(I,4) | F8.0 | + | Multiplier |

I = 1 to total number of *EP* records

The monthly evaporation depths, precipitation depths, or net evaporation-precipitation depths for the control point or reservoir identified in *EP* record field 2 are computed as a weighted average of the values read for the control points identified in *EP* record fields 3, 5, 7, and 9 using the multipliers from fields 4, 6, 8, and 10.  This averaging operation is performed on the relevant values in the EP(cp or res, year, month) array.  The resulting computed depths are recorded back into the EP(cp or res, year, month) array.  Thus, known depths at some control points or reservoirs are used to compute depths at other control points or reservoirs.  Depths may also be changed at the same control point or reservoir.

*EP* and *AN* record operations reference the identifiers in *CP* record field 2 for sequencing purposes.  The EP(cp or res,year,month) array upon which the *EP* and *AN* records operate may be populated from the OUTRES(res,year,month) array read from the OUT file in which data are referenced by reservoir rather than control point.  With only *JC*, *EP*, *AN*, and *CP* record operations activated in the HIN file, the identifiers in *CP* record field 2 may be reservoir identifiers.  However, the *EP* record can not be used with OUT file data referenced to reservoirs with *CP* records referenced to control points.  All fields other than fields 1 and 2 (CD and CPID(cp,1)) on the CP record may be left blank if not needed.

**AN** Record  –  Year of Monthly Stream Flow Volumes or Evaporation-Precipitation Depths

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | AN | Record identifier |
| 2 | 3-8 | ID | 2x,A6 | blank | All control points (or all reservoirs). |
|   |     |    |       | AN | Control point identifier (or reservoir identifier). |
| 3 | 12 | AN(I,1) | I4 | blank,0,1 | Monthly stream flow volumes. |
|   |    |         |    | 2 | Monthly evaporation-precipitation depths. |
| 4 | 16 | AN(I,2) | I4 | blank,0,1 | Compute means for each of the 12 months of year. |
|   |    |         |    | 2 | Adopt exceedance frequency from field 5 below. |
|   |    |         |    | 3 | Adopt the 12 amounts from the following *AN* record. |
| 5 | 17-24 | ANF(I) | F8.0 | + | Exceedance frequency as percent for option 2 above. |
|   |       |        |      |   | *Output or Results* |
| 6 | 28 | AN(I,3) | I4 | blank,0,1 | *IN* or *EV* records to HOT file (with replacement). |
|   |    |         |    | 2 | *IN* or *EV* records to HOT file (without replacement). |
|   |    |         |    | 3 | Stored in *FLOW* or *EP* array. |
|   |    |         |    |   | *Time Span Covered by New Data* |
| 7 | 29-36 | AN(I,4) | I8 | blank, + | First year of data created.  Default = YRST from *JC* |
| 8 | 37-44 | AN(I,5) | I8 | blank, + | Last year of data created.  Default=YRST+NYRS−1 |
|   |       |         |    |   | *Time Span for Mean or Frequency Computations* |
| 9 | 45-52 | AN(I,6) | I8 | blank, + | First year.  Default is YRST in *JC* record field 2. |
| 10 | 53-60 | AN(I,7) | I8 | blank, + | Last year.  Default = YRST + NYRS − 1 |

I = 1 to total number of *AN* records

**AN** Record  –  Supplemental Second *AN* Record for *AN* Record Field 4 AN(I,2) Option 3

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | AN | Record identifier |
| 2 | 3-8 | ID | 6x | blank | Field is not read. |
| 3 | 9-16 | ANA(I,1) | F8.0 | + | Flow volume or evap-precip depth for month 1 (Jan) |
| 4 | 17-24 | ANA(I,2) | F8.0 | + | Flow volume or evap-precip depth for month 2 (Feb) |
| 5 | 25-32 | ANA(I,3) | F8.0 | + | Flow volume or evap-precip depth for month 3 (Mar) |
| 6 | 33-40 | ANA(I,4) | F8.0 | + | Flow volume or evap-precip depth for month 4 (Apr) |
| 7 | 41-48 | ANA(I,5) | F8.0 | + | Flow volume or evap-precip depth for month 5 (May) |
| 8 | 49-56 | ANA(I,6) | F8.0 | + | Flow volume or evap-precip depth for month 6 (Jun) |
| 9 | 57-64 | ANA(I,7) | F8.0 | + | Flow volume or evap-precip depth for month 7 (Jul) |
| 10 | 65-72 | ANA(I,8) | F8.0 | + | Flow volume or evap-precip depth for month 8 (Aug) |
| 11 | 73-80 | ANA(I,9) | F8.0 | + | Flow volume or evap-precip depth for month 9 (Sep) |
| 12 | 81-88 | ANA(I,10) | F8.0 | + | Flow volume or evap-precip depth in month 10 (Oct) |
| 13 | 80-96 | ANA(I,11) | F8.0 | + | Flow volume or evap-precip depth in month 11 (Nov) |
| 14 | 97-104 | ANA(I,12) | F8.0 | + | Flow volume or evap-precip depth in month 12 (Dec) |

### Explanation of AN Record Fields

*AN* records are designed to create sets of 12 stream flow volumes or evaporation-precipitation depths at each pertinent control point. These sets of 12 monthly values can be repeated without change for multiple years to either create a new set of *IN* and/or *EV* records or to extend the number of years covered by a dataset. For example, using AN(I,2) option 1 in *AN* record field 4, a set of mean evaporation-precipitation rates may be computed from period-of-record data in the *EP* array to cover years not included in the record. Using AN(I,2) option 2, a flow dataset may be developed based on computing flows for each of the 12 months of the years that are equaled or exceeded during a specified percentage of the years in the FLOW array.

*Field 2*: The computations are repeated by control point for all the control points included in the FLOW or EP array (as defined by *CP* records) if *AN* record field 2 is blank. Entering a control point identifier in field 2 results in the computations being limited to just that control point. Reservoir identifiers may be substituted for *CP* identifiers. However, the *AN* record field 2 ID must match an identifier in field 2 of a *CP* record, since the *CP* record identifiers control referencing in the FLOW(cp,year,month) and EP(cp or reservoir,year,month) arrays.

*Field 3*: The operations may be performed with either FLOW(cp,year,month) array monthly stream flow volumes or EP(cp or reservoir,year,month) array evaporation-precipitation rates.

*Fields 4, 9, 10*: Three alternative options are available for creating the sets of 12 monthly values. The first two options use 12 data sets, one set for each of the months January through December, for the years defined by AN(I,6) and AN(I,7) in *AN* fields 9-10 with defaults from *JC* fields 2-3. Option 1 consists of computing the means for each month. Option 2 consists of determining the monthly volume or depth amount that is equaled or exceeded during ANF(I) percentage of years specified in field 5. Option 3 consists of entering a set of 12 values on an extra *AN* record placed behind this record. The second auxiliary *AN* record is entered only for AN(I,3) option 3.

*Field 5*: The exceedance frequency ANF(I) is used only if AN(I,3) option 2 is selected in field 4. The frequency is expressed as a percentage. With 25.0 entered for ANF(I), a January flow amount is determined that is equaled or exceeded during 25.0 percent of the years of data taken from the FLOW array for the period from AN(I,6) through AN(I,7). Flows are sorted. If no number of years corresponds to exactly 25.0 percent of the total number of years, linear interpolation is applied to the two January flow volumes that bracket the 25.0 percent value.

*Fields 6, 7, 8*: Field 6 controls the placement of the results of the *AN* record computations. Fields 7 and 8 define the span of years over which the one year of computed monthly flows or depths is repeated in the output. Field 6 options 1 and 2 consist of writing the final dataset developed by the *AN* record to the HOT file as a set of *IN* or *EV* records. The difference between options 1 versus 2 is relevant only if the period defined by *AN* fields 7 and 8 overlaps the period covered by the FLOW and EP arrays as defined by *JC* fields 2 and 3. With *AN* field 6 option 1, the new data is repeated for all years defined by the *AN* record fields 7 and 8, even though this may result in existing FLOW or EP array data being replaced. With option 2, the original data from the FLOW or EP array is adopted for the period of years defined by *JC* record fields 2 and 3, and the new synthesized data is repeated for all other years spanning the period defined by *AN* record fields 7 and 8. *JC* field 6 option 3 consists of storing the computed data in the FLOW or EP array. All *AN* fields 7 and 8 years falling within the *JC* fields 2 and 3 period are covered.

### IN and EV Records in Standard Default Format

**IN** Record – Inflows or Naturalized Stream Flows at a Control Point

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | IN | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| 3 | 9-12 | NYR | I4 | + | First year for an *IN* record repeated for multiple years |
|  |  |  |  | blank,0 | *IN* record is for one year only; it is not repeated |
| 4 | 13-16 | PYR | I4 | + | Year (last year to repeat if field 3 is not zero or blank) |
| 5 | 17-24 | INFLOW(cp,1) | F8.0 | + | Naturalized stream flow for month 1 |
| 6 | 25-32 | INFLOW(cp,2) | F8.0 | + | Naturalized stream flow for month 2 |
| 7 | 33-40 | INFLOW(cp,3) | F8.0 | + | Naturalized stream flow for month 3 |
| 8 | 41-48 | INFLOW(cp,1) | F8.0 | + | Naturalized stream flow for month 4 |
| 9 | 49-56 | INFLOW(cp,5) | F8.0 | + | Naturalized stream flow for month 5 |
| 10 | 57-64 | INFLOW(cp,6) | F8.0 | + | Naturalized stream flow for month 6 |
| 11 | 65-72 | INFLOW(cp,7) | F8.0 | + | Naturalized stream flow for month 7 |
| 12 | 73-80 | INFLOW(cp,8) | F8.0 | + | Naturalized stream flow for month 8 |
| 13 | 81-88 | INFLOW(cp,9) | F8.0 | + | Naturalized stream flow for month 9 |
| 14 | 89-96 | INFLOW(c,10) | F8.0 | + | Naturalized stream flow for month 10 |
| 15 | 97-104 | INFLOW(c,11) | F8.0 | + | Naturalized stream flow for month 11 |
| 16 | 105-112 | INFLOW(c,12) | F8.0 | + | Naturalized stream flow for month 12 |

**EV** Record – Evaporation, Precipitation, or Net Evaporation-Precipitation Rates

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | IN | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| 3 | 9-12 | NYR | I4 | + | First year for an *EV* repeated for multiple years |
|  |  |  |  | blank,0 | *EV* record is for one year only; it is not repeated |
| 4 | 13-16 | PYR | I4 | + | Year (last year to repeat if field 3 is not zero or blank) |
| 5 | 17-24 | EVAPR(cp,1) | F8.0 | + | Net evaporation-precipitation for month 1 |
| 6 | 25-32 | EVAPR(cp,2) | F8.0 | + | Net evaporation-precipitation for month 2 |
| 7 | 33-40 | EVAPR(cp,3) | F8.0 | + | Net evaporation-precipitation for month 3 |
| 8 | 41-48 | EVAPR(cp,1) | F8.0 | + | Net evaporation-precipitation for month 4 |
| 9 | 49-56 | EVAPR(cp,5) | F8.0 | + | Net evaporation-precipitation for month 5 |
| 10 | 57-64 | EVAPR(cp,6) | F8.0 | + | Net evaporation-precipitation for month 6 |
| 11 | 65-72 | EVAPR(cp,7) | F8.0 | + | Net evaporation-precipitation for month 7 |
| 12 | 73-80 | EVAPR(cp,8) | F8.0 | + | Net evaporation-precipitation for month 8 |
| 13 | 81-88 | EVAPR(cp,9) | F8.0 | + | Net evaporation-precipitation for month 9 |
| 14 | 89-96 | EVAPR(c,10) | F8.0 | + | Net evaporation-precipitation for month 10 |
| 15 | 97-104 | EVAPR(c,11) | F8.0 | + | Net evaporation-precipitation for month 11 |
| 16 | 105-112 | EVAPR(c,12) | F8.0 | + | Net evaporation-precipitation for month 12 |

**IN and EV Records in HYD File Format**

Earlier *WRAP2/WRAP3* versions of WRAP used a format, now specified as Option 3 in *JC* record fields 5 and 6, with *IN* and *EV* records with six months per record stored in a HYD file (filename extension HYD). *IN* records for all control points for a year are followed by a corresponding set of *EV* records. *IN/EV* records for all control points are grouped together by year. All the records for a year are followed by a complete set of records for the next year.

First IN Record for Each Year − Inflows

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | IN | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| 3 | 9-16 | PYR | I8 | + | Year |
| 4 | 17-24 | Q(1) | F8.0 | + | Naturalized stream flow for month 1 |
| 5 | 25-32 | Q(2) | F8.0 | + | Naturalized stream flow for month 2 |
| 6 | 33-40 | Q(3) | F8.0 | + | Naturalized stream flow for month 3 |
| 7 | 41-48 | Q(4) | F8.0 | + | Naturalized stream flow for month 4 |
| 8 | 49-56 | Q(5) | F8.0 | + | Naturalized stream flow for month 5 |
| 9 | 57-64 | Q(6) | F8.0 | + | Naturalized stream flow for month 6 |

Second IN Record for Each Year − Inflows

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | IN | Record identifier |
| 2 | 3-8 | | 6X | | not used |
| 3 | 9-16 | | 8X | | not used |
| 4 | 17-24 | Q(7) | F8.0 | + | Naturalized stream flow for month 7 |
| 5 | 25-32 | Q(8) | F8.0 | + | Naturalized stream flow for month 8 |
| 6 | 33-40 | Q(9) | F8.0 | + | Naturalized stream flow for month 9 |
| 7 | 41-48 | Q(10) | F8.0 | + | Naturalized stream flow for month 10 |
| 8 | 49-56 | Q(11) | F8.0 | + | Naturalized stream flow for month 11 |
| 9 | 57-64 | Q(12) | F8.0 | + | Naturalized stream flow for month 12 |

First EV Record for Each Year − Reservoir Evaporation-Precipitation Rates

| field | columns | variable | format | Value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | EV | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| 3 | 9-16 | PYR | I8 | + | Year |
| 4 | 17-24 | EV(1) | F8.0 | + | Reservoir evaporation-precipitation rate for month 1 |
| 5 | 25-32 | EV(2) | F8.0 | + | Reservoir evaporation-precipitation rate for month 2 |
| 6 | 33-40 | EV(3) | F8.0 | + | Reservoir evaporation-precipitation rate for month 3 |
| 7 | 41-48 | EV(4) | F8.0 | + | Reservoir evaporation-precipitation rate for month 4 |
| 8 | 49-56 | EV(5) | F8.0 | + | Reservoir evaporation-precipitation rate for month 5 |
| 9 | 57-64 | EV(6) | F8.0 | + | Reservoir evaporation-precipitation rate for month 6 |

Second EV Record for Each Year − Same format as indicated above.

### Alternative Formats for IN and EV Records

The content and organization of *IN* and *EV* records are the same in both programs *HYD* and *SIM*. Sequences of monthly stream flow volumes representing inflows to the river/reservoir system are entered on inflow *IN* records. The stream flows are typically naturalized flows but may represent other specified conditions of river basin development. Sequences of monthly reservoir surface net evaporation less precipitation depths are entered on evaporation *EV* records. The *IN* and *EV* records are organized by year and control point. The ordering of control points must be consistent for all of the years of *IN* records and *EV* records but is otherwise arbitrary. The years must be in chronological order starting with the earliest year and ending with the last.

Field 3 of the *IN* and *EV* records contains the variable *NYR* (first year) which signals the program to repeat the 12 monthly values on the record from the year *NYR* (field 3) through the year *PYR* (field 4). If field 3 is blank or zero, the *IN* or *EV* record represents only one year. If records are not repeated for multiple years, field 4 (*PYR*) may also be left blank after the first year since the records must be in chronological sequence. An error check confirms that any years entered are in the correct chronological sequence, but zeros (blanks) are ignored.

Parameters on the *JC* record specify the manner in which the *IN* and *EV* records are organized. The standard default set of input files include a FLO file for storing *IN* records and a EVA file for storing *EV* records. Optionally, program *HYD* will also read *EV* and *IN* records in a file with filename extension HYD in a format adopted in early versions of WRAP. The default record format and file organization are described first followed by a description of the old approach still maintained as an option.

There are two *IN* and *EV* record grouping options, by year and by control point. Grouping by control point requires more active computer memory in *SIM* than grouping by year but may be more convenient. With the option of grouping *IN* and *EV* records by year, *SIM* reads the *IN* and *EV* records for only one year in an iterative annual loop. With the option of grouping the *IN* and *EV* records by control point, all of the *IN* and *EV* records are read at the beginning of the simulation, requiring much more memory. In typical applications for large river basins, *SIM* simulations may involve numerous ungaged secondary control points that are not addressed in *HYD*. Thus, the reduction in computer memory requirements associated with grouping by year can be quite significant for *SIM*.

| Grouping by Year | | | | Grouping by Control Point | | |
|---|---|---|---|---|---|---|
| IN | CP-1 | 2001 | | IN | CP-1 | 2001 |
| IN | CP-2 | 2001 | | IN | CP-1 | 2002 |
| IN | CP-3 | 2001 | | IN | CP-1 | 2003 |
| IN | CP-1 | 2002 | | IN | CP-1 | 2004 |
| IN | CP-2 | 2002 | | IN | CP-2 | 2001 |
| IN | CP-3 | 2002 | | IN | CP-2 | 2002 |
| IN | CP-1 | 2003 | | IN | CP-2 | 2003 |
| IN | CP-2 | 2003 | | IN | CP-2 | 2004 |
| IN | CP-3 | 2003 | | IN | CP-3 | 2001 |
| IN | CP-1 | 2004 | | IN | CP-3 | 2002 |
| IN | CP-2 | 2004 | | IN | CP-3 | 2003 |
| IN | CP-3 | 2004 | | IN | CP-3 | 2004 |

**Alternative Organizational Formats for Flows and Evaporation-Precipitation Depths**

The options for organizing input datasets of monthly stream flow volumes (gaged, naturalized, or otherwise) and reservoir surface evaporation-precipitation rates are specified by the parameters JC(1) and JC(2) in *JC* record fields 5 and 6. The options are as follows.

*Option 1 for JC(1) and JC(2) on JC Record*

*IN* and *EV* records are stored in separate files, with filename extensions FLO and EVA, respectively. The records are in the standard default format shown on page 182. In the FLO and EVA files, the *IN* and *EV* records for all control points are grouped together by year. All of the records for a year are followed by a complete set of records for the next year.

With the option 1 grouping of *IN* and *EV* records by year, *SIM* reads the *IN* and *EV* records for only one year in an iterative annual loop requiring significantly less computer memory than option 2. The choice of option 1 versus option 2 does not affect *HYD* memory requirements since the FLOW(cp,year,month) and EP(cp,year,month) arrays are handled the same with either option.

*Option 2 for JC(1) and JC(2) on JC Record*

Option 2 is identical to option 1 except the *IN* and *EV* records are grouped by control point. All records for all years for the first control are grouped together before the records for the second control point.

*Option 3 for JC(1) and JC(2) on JC Record*

*IN* and *EV* records are stored in a single file with the filename extension root1.HYD. Pairs of records with six months on each are in the format shown on page 183. The records for all control points are grouped together a particular year. All the records for a year are followed by a complete set of records for the next year. The set of all *IN* records for all control points for a particular year is followed by the set of all *EV* records for that year.

*Option 4 for JC(1) and JC(2) on JC Record*

Option 4 is identical to Option 3 except each record contains 12 stream flows or evaporation-precipitation depths rather than six.

*Option 5 for JC(1) and JC(2) on JC Record*

The stream flow and evaporation data are tabulated in columns in FLO and EVA files.

*Option 6 for JC(1) and JC(2) on JC Record*

The monthly river flow volumes and evaporation-precipitation depths are read from a binary Hydrologic Engineering Center Data Storage System file with filename extension DSS.

*Option 7 for JC(1) and JC(2) on JC Record*

Flow volumes and evaporation-precipitation depths are read from a *SIM* output OUT file

**FD** Record  −  Flow Distribution

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | FD | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier for ungaged CP |
| 3 | 11-16 | DSG | 2x,A6 | AN | Source gaged control point |
| 4 | 17-24 | NG | I8 | + | Number of gaged cp's above ungaged site (blank = 0) |
|   |       |    |    | −1 | Ungaged CP is downstream of source CP |
| 5-no limit | 25-no limit | UGID(I) I=1,MAXGAG | 2x,A6 | AN | Identifiers of upstream gaged control points. No limit on the maximum number of identifiers. |

**FC** Record  −  Coefficients for Flow Distribution Equation

| field | columns | Variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | FC | Record identifier |
| 2 | 3-8 | COEF1 | F6.0 | + | Coefficient $a$  (may be drainage area ratio) |
| 3 | 9-16 | COEF2 | F8.0 | + or − | Coefficient $b$ (default = 1.0) |
| 4 | 17-24 | COEF3 | F8.0 | + or − | Coefficient $c$ (default = 0.0) |

$$Q_{ungaged} = a\, Q_{gaged}{}^{b} + c$$

**WP** Record  −  Watershed Parameters

| field | column | Variable | format | value | description |
|-------|--------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | WP | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| 3 | 9-16 | DA | F8.0 | + | Drainage area |
| 4 | 17-24 | CN | F8.0 | + | Curve number |
| 5 | 25-32 | MP | F8.0 | + | Mean precipitation |
| 6 | 33-40 | DAF | F8.0 | + | Multiplier to convert drainage area to square miles |

*FD*, *FC*, and *WP* records are stored in a flow distribution file with filename root.DIS.  The DIS file ends with an end-of-file *ED* record.  The DIS file *FD*, *FC*, and *WP* records have the same format, organization, and content with either *HYD* or *SIM*.  The explanatory notes provided with the *FD*, *FC*, and *WP* records in Chapter 3 of this *Users Manual* are pertinent here as well. Chapter 3 of the *Reference Manual* covers the alternative flow distribution methods for computed naturalized flows at ungaged control points based on flows at gaged control points.

A *FC* record must follow directly behind its *FD* record.  Otherwise, the *FD/FC* and *WP* records may be in any order in the DIS file.  The records are stored in a DIS file that ends with an *ED* record.  The end-of-file *ED* record is required.

**AS** Record – Stream Flow Adjustment Specifications

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | AS | Record identifier. |
| 2 | 3-8 | ID | A6 | AN | Control point identifier. |
| | | | | | *Beginning and Ending Years of Adjustments* |
| 3 | 13-16 | AS(1) | I8 | blank, 0 | First year of adjustments = first year of analysis. |
| | | | | + | First year of adjustments. |
| 4 | 21-24 | AS(2) | I8 | blank, 0 | Last year of adjustments = last year of analysis. |
| | | | | + | Last year of adjustments. |
| | | | | | *Source of Adjustments* |
| 5 | 28 | AS(3) | I4 | blank,0,1 | Following *FA* records. |
| | | | | −1 | Following *FA* records in format that includes the year and control point. |
| | | | | 2 | Following *RS* and *SC* records. |
| | | | | −2 | Following *RS* and *SC* records with *SC* records in format that includes year and control point. |
| | | | | 3 | *CI* records previously read from root1.DAT file. |
| | | | | 4 | Constant adjustment from field 11 below. |
| | | | | 5 | *SIM* OUT file data specified in field 6 below. |
| | | | | | *Data from SIM Output OUT File* |
| 6 | 32 | AS(4) | I4 | blank, 0 | No flow adjustment data from *SIM* output OUT file. |
| | | | | 1 | Naturalized flows from control point output (NAT). |
| | | | | 2 | Regulated flows from control point output (REG). |
| | | | | 3 | Unappropriated flows from cp output (UNA). |
| | | | | 4 | Stream flow depletions from cp output (DEP). |
| | | | | 5 | Return flows from control point output (RFR). |
| | | | | 6 | Flow depletions from water right output (DEP). |
| | | | | 7 | Return flows from water right output (RFL). |
| | | | | −7 | *HYD* shifts return flows (RFL) forward one month. |
| | | | | 8 | Diversions for WR or releases for IF right (DIV). |
| | | | | | *Negative Values for Flow Adjustments* |
| 7 | 36 | AS(5) | I4 | blank, 0 | Apply adjustments regardless of sign (+ or −). |
| | | | | 1 | Set negative adjustments equal to zero. |
| | | | | 2 | Set positive adjustments equal to zero. |
| | | | | | *Cascade Downstream?  Yes or No?* |
| 8 | 40 | AS(6) | I4 | blank, 0 | Adjustments apply to all downstream control points. |
| | | | | 1 | Adjustments apply to only this control point. |
| | | | | | *Negative Flow Options* |
| 9 | 44 | AS(7) | I4 | blank, 0 | Allow negative stream flows. |
| | | | | 1 | Change negative stream flows to zero. |
| | | | | 2 | Change to zero and subtract next month. |
| | | | | 3 | Modify adjustments to prevent negative stream flows |
| | | | | 4 | Modify adjustments and subtract negative next month |

**AS** Record  –  Stream Flow Adjustment Specifications (Continued)

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| | | | | | *Multiplier Factor* |
| 10 | 45-52 | AS8 | F8.0 | + | Factor to multiply flow adjustments (default=1.0). |
| | | | | | *Constant Flow Adjustment* |
| 11 | 53-60 | AS9 | F8.0 | + | Constant flow adjustment applied in all months. |
| | | | | | *CP or WR Identifier for Field 6 Data from OUT File* |
| 12 | 61-68 | AS10 | 2x,A6 | blank | Data at field 2 control point is used for adjustment. |
| | | | | AN | Control point identifier for field 6 data. |
| 13 | 69-84 | AS11 | A16 | blank | Options 6, 7, or −7 are not selected in field 6. |
| | | | | AN | Water right identifier for field 6 data. |

Any number of sets of *AS* records and accompanying *FA*, *RS*, and *SC* records can be used to specify adjustments to the monthly stream flow volumes in the FLOW(cp,year,month) array. Adjustments are volumes to be added to the flow volumes currently stored in the FLOW array. Each *AS* record defines a particular set of monthly flow adjustments to be added to flows at a selected control point and optionally at control points located downstream of that control point. The flow volume adjustments may be either positive or negative amounts. The different types of stream flow adjustments are outlined in Chapter 3 of the *Reference Manual*.

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**Explanation of AS Record Fields**

</div>

***Field 2***:  The identifier of the control point at which the adjustments are introduced is entered in field 2.  Depending on AS(6) in field 8, the adjustments may be limited to only flows at this control point or alternatively may be cascaded downstream affecting flows at downstream control points as well.

***Fields 3 and 4***:  AS(1) and AS(2) define the period of years for which the flow adjustments are applied.  The default is to cover the period-of-analysis defined by *JC* record fields 2 and 3. However, AS(1) and AS(2) can be used to define a sub-period consisting of an integer number of years falling within the overall period-of-analysis defined in *JC* record fields 2 and 3.

***Field 5***:  The parameter AS(3) specifies the type of flow adjustment and data source.  The following alternative adjustments to the monthly flow volumes in the FLOW(cp,year,month) array may be selected for application with this particular *AS* record.

1.  The monthly stream flow volumes may be adjusted by adding amounts read from a set of flow adjustment *FA* records that follow immediately behind the *AS* record.

2.  Adjustments for reservoirs may be computed based on information provided by *RS* and *SC* records that follow after the *AS* record.  The computed reservoir adjustments are added to the flows in the FLOW array just like any other type of adjustment.

3. A set of 12 adjustments read from a *CI* record for this control point may be added each year to the flows for the 12 months of the year. *CI* records are stored in the HIN file following the *CP* records.

4. A constant adjustment AS9 entered in *AS* record field 11 may be added to flows in all months.

5. The adjustments to be added to the flows in the FLOW(cp,year,month) array may be the variable defined by AS(4) read from the *SIM* simulation output OUT file.

For options 1, −1, 2, and −2, the format of the *FA* and *SC* records vary depending on *AS(3)* in *AS* record field 5. The only difference in the alternative format of the *FA* and *SC* records is whether or not fields for the control point identifier and year are included. With options −1 and −2, the control point identifier and year are included on the *FA* and *SC* records. With options 1 and 2, these fields are omitted.

___*Field 6*___: AS(4) in field 6 is relevant only if option 5 is selected for AS(3) in field 5. AS(4) selects the variable from the array of variables read from the OUT file to use for the adjustments.

___*Field 7*___: The adjustments defined by the parameters in fields 5 and 6 above may be either positive or negative amounts. With AS(5) of zero (blank field 7), the default is to add the adjustment amount to the flow in the FLOW array regardless of whether a negative or positive number is being added. With a 1 for the AS(5) switch, negative adjustment amounts are set equal to zero. With AS(5) option 2, positive adjustments are set equal to zero.

___*Field 8*___: The adjustment amounts are added to the flows in the FLOW(cp,year,month) array at the control point specified as ID in *AS* record field 2. If a 1 is entered for switch AS(6) in field 8, only the flows at that control point are adjusted. However, the default (zero or blank field 8) is to also cascade the adjustments to all control points located downstream of the control point defined in field 2. Channel losses defined by channel loss factors from the *CP* records are incorporated in the translation of the adjustments to downstream control points. The identifiers of next downstream control points on the *CP* records also define the spatial connectivity of the river system required to cascade to adjustments downstream.

___*Field 9*___: The results of adding adjustment amounts, which may be either positive or negative, to the flow volumes in the FLOW(cp,year,month) array may result in negative flow volumes in some months. Stream flow volumes normally should not be negative. AS(7) provides the following options for dealing with negative stream flows.

1. Negative flows may be allowed.

2. Negative flow values may be replaced with zeros with no further action.

3. Negative flow values may be replaced with zeros and the amount of the negative amount remaining subtracted from the flow in the next month. If that results in a negative flow in the next month, that flow is set to zero with the negative amount again forwarded to the following month.

4. The adjustment may be modified as necessary to prevent the control point flow in the FLOW array from being negative. The modified adjustment is incorporated in the

cascading computations meaning a different adjustment is now being added to flows at downstream control points.

5. Option 4 is the same as option 3 except the remaining negative amount of the adjustment associated with setting the adjustment equal to zero is subtracted from the next month flow similarly as option 2.

Negative flow options AS(7) in *AS* record field 9 may be applied with each individual *AS* record set of adjustments. Alternatively, the negative flow options may be applied to the final stream flows after all cumulative adjustments by inserting a final *AS* record with AS(3) of 4 in field 5 and AS9 of 0.0 in field 11.

**_Field 10_**: AS8 is an optional factor by which the flow adjustments are multiplied prior to being added to the flows in the FLOW array. AS8 can be a unit conversion factor or serve other purposes.

**_Field 11_**: AS9 is a constant adjustment amount that is added to the FLOW(cp,year,month) flow volumes in all months if AS(3) option 4 is specified in field 5.

**_Fields 12 and 13_**: Fields 12 and 13 are relevant only if AS(3) option 5 is specified in field 5 indicating that adjustments are amounts read from a *SIM* simulation results OUT file. The variables defined by field 5 AS(4) options 1, 2, 3, 4, and 5 are associated with control points. The variables defined by AS(4) options 6, 7, and 8 are associated with water rights.

AS10 in *AS* record field 12 is a control point identifier specifying the control point for which data from the OUT file are adopted as adjustments for *AS* record field 5 AS(4) options 1, 2, 3, 4, and 5. The default (blank field 12) is the control point identifier ID entered in field 2.

AS11 in *AS* record field 13 is a water right identifier specifying the water right for which data from the OUT file are adopted as adjustments for *AS* record AS(4) options 6, 7, −7, and 8. There is no default. If AS(4) option 6, 7, −7, or 8 is selected in field 6, a water right identifier must be specified for AS11 in field 13. This water right identifier must be found in the *SIM* OUT file.

### Sequencing of AS, FA, RS, SC and EQ Records in HIN or FLO Files

The set of all *EQ, AS, FA, RS*, and *SC* records may be placed as the last records in either the HIN and/or FLO files as specified by *JC(3)* entered in field 7 of the *JC* record. The *ED* record is always the last record in HIN file. An *ED* record is also placed at the end of a FLO file if the FLO file contains *EQ, AS, FA, RS*, or *SC* records. Thus, the set of all *EQ, AS, FA, RS*, and *SC* records are always immediately followed by an end-of-data *ED* record ending a HIN or FLO file.

- An *AS* record precedes each set of *FA* records and each set of *RS/SC* records.
- All *FA* records for a particular control point are grouped together as a set following their *AS* record.
- A *RS* record precedes each group of *SC* records and is preceded by an *AS* record.
- *SC* records for a control point are grouped together following their *AS/RS* records.
- *EQ* records may be before, after, or between sets of *AS/FA* and *AS/RS/SC* records.

**FA** Record – Stream Flow Adjustments

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | FA | Record identifier (optional after first record) |
| 2 | 3-8 | FA(1) | F6.0 | + | Stream flow adjustment for month 1 |
| 3 | 9-16 | FA(2) | F8.0 | + | Stream flow adjustment for month 2 |
| 4 | 17-24 | FA(3) | F8.0 | + | Stream flow adjustment for month 3 |
| 5 | 25-32 | FA(4) | F8.0 | + | Stream flow adjustment for month 4 |
| 6 | 33-40 | FA(5) | F8.0 | + | Stream flow adjustment for month 5 |
| 7 | 41-48 | FA(6) | F8.0 | + | Stream flow adjustment for month 6 |
| 8 | 49-56 | FA(7) | F8.0 | + | Stream flow adjustment for month 7 |
| 9 | 57-64 | FA(8) | F8.0 | + | Stream flow adjustment for month 8 |
| 10 | 65-72 | FA(9) | F8.0 | + | Stream flow adjustment for month 9 |
| 11 | 73-80 | FA(10) | F8.0 | + | Stream flow adjustment for month 10 |
| 12 | 81-88 | FA(11) | F8.0 | + | Stream flow adjustment for month 11 |
| 13 | 89-96 | FA(12) | F8.0 | + | Stream flow adjustment for month 12 |

**FA** Record – Stream Flow Adjustments (Alternative format with control point ID and year)

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | FA | Record identifier (optional) |
| 2 | 3-8 | ID | A6 | AN | Control point identifier (optional) |
| 3 | 13-16 | PYR | I8 | + | Year (optional) |
| 4 | 17-24 | FA(1) | F8.0 | + | Stream flow adjustment for month 1 |
| 5 | 25-32 | FA(2) | F8.0 | + | Stream flow adjustment for month 2 |
| 6 | 33-40 | FA(3) | F8.0 | + | Stream flow adjustment for month 3 |
| 7 | 41-48 | FA(4) | F8.0 | + | Stream flow adjustment for month 4 |
| 8 | 49-56 | FA(5) | F8.0 | + | Stream flow adjustment for month 5 |
| 9 | 57-64 | FA(6) | F8.0 | + | Stream flow adjustment for month 6 |
| 10 | 65-72 | FA(7) | F8.0 | + | Stream flow adjustment for month 7 |
| 11 | 73-80 | FA(8) | F8.0 | + | Stream flow adjustment for month 8 |
| 12 | 81-88 | FA(9) | F8.0 | + | Stream flow adjustment for month 9 |
| 13 | 89-96 | FA(10) | F8.0 | + | Stream flow adjustment for month 10 |
| 14 | 97-104 | FA(11) | F8.0 | + | Stream flow adjustment for month 11 |
| 15 | 105-112 | FA(12) | F8.0 | + | Stream flow adjustment for month 12 |

A set of *FA* records is preceded an *AS* record with AS(3) option 1 or −1 specified in *AS* record field 5. The choice of format for both the *FA* and *SC* records is specified by AS(3) in field 5 of the *AS* record. The only difference between the two format options is whether to include optional fields for the control point ID and year PYR as fields 2 and 3. These records, like all others, may also be in comma delimited format.

*Chapter 5 HYD*

**RS** Record – Reservoir Specifications for Stream Flow Adjustments

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | RS | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Reservoir identifier |
| | | | | | *Adjustment Components* |
| 3 | 16 | RS(1) | I8 | blank,0 | Add storage increase (default) |
| | | | | 1 | Add storage increase |
| | | | | −1 | Subtract storage increase |
| | | | | −9 | Do not consider storage increase |
| 4 | 24 | RS(2) | I8 | blank,0 | Subtract conservation storage decrease (default) |
| | | | | 1 | Add conservation storage decrease |
| | | | | −1 | Subtract conservation storage decrease |
| | | | | −9 | Do not consider conservation storage decrease |
| 5 | 32 | RS(3) | I8 | blank,0 | Subtract flood storage decrease (spill) (default) |
| | | | | 1 | Add flood storage decrease (spill) |
| | | | | −1 | Subtract flood storage decrease (spill) |
| | | | | −9 | Do not consider flood storage decrease (spill) |
| 6 | 48 | RS(4) | I8 | blank,0 | Add net evaporation-precipitation (default) |
| | | | | 1 | Add net evaporation-precipitation |
| | | | | −1 | Subtract net evaporation-precipitation |
| | | | | −9 | Do not consider net evaporation-precipitation |
| 7 | 48 | RS(5) | I8 | blank,0 | Add watershed runoff from reservoir site (default) |
| | | | | 1 | Add watershed runoff from reservoir site |
| | | | | −1 | Subtract watershed runoff from reservoir site |
| | | | | −9 | Do not consider runoff from reservoir site |
| | | | | | *Reservoir Adjustments Table* |
| 8 | 56 | RS(6) | I8 | blank,0 | Option not used |
| | | | | 1 | Adjustments table written to HOT file |
| | | | | | *Reservoir Information* |
| 9 | 57-64 | CAP | F8.0 | + | Reservoir storage capacity |
| 10 | 65-72 | EVCFA | F8.0 | + | Multiplier *A* for storage-area equation shown below. |
| 11 | 73-80 | EVCFB | F8.0 | + | Exponent *B* for storage-area equation shown below. |
| 12 | 81-88 | EVCFC | F8.0 | + | Constant *C* for storage-area equation shown below. |
| | | | | | surface area $= A \,(\text{storage})^B + C$ |
| 13 | 88-96 | RS7 | F8.0 | + | Beginning storage (beginning of first month) |
| | | | | blank,0 | Beginning storage content is zero |
| 14 | 97-104 | RS8 | F8.0 | + | Factor to multiply storage contents |
| | | | | blank, 0 | Default RS7 = 1.0 |

The *RS* record controls computation of adjustment amounts reflecting the impacts of reservoir storage to be added to the FLOW(cp,year,month) array flows in accordance with specifications on the preceding *AS* record. The component reservoir adjustments are outlined in Chapter 3 of the *Reference Manual*. A *RS* record is preceded by an *AS* record and followed by *SC* records.

**SC** Record  –  Storage Contents

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | SC | Record identifier (optional) |
| 2 | 3-8 | SC(1) | F6.0 | + | Storage contents for month 1 |
| 3 | 9-16 | SC(2) | F8.0 | + | Storage contents for month 2 |
| 4 | 17-24 | SC(3) | F8.0 | + | Storage contents for month 3 |
| 5 | 25-32 | SC(4) | F8.0 | + | Storage contents for month 4 |
| 6 | 33-40 | SC(5) | F8.0 | + | Storage contents for month 5 |
| 7 | 41-48 | SC(6) | F8.0 | + | Storage contents for month 6 |
| 8 | 49-56 | SC(7) | F8.0 | + | Storage contents for month 7 |
| 9 | 57-64 | SC(8) | F8.0 | + | Storage contents for month 8 |
| 10 | 65-72 | SC(9) | F8.0 | + | Storage contents for month 9 |
| 11 | 73-80 | SC(10) | F8.0 | + | Storage contents for month 10 |
| 12 | 81-88 | SC(11) | F8.0 | + | Storage contents for month 11 |
| 13 | 89-96 | SC(12) | F8.0 | + | Storage contents for month 12 |

**SC** Record  –  Storage Contents (Alternative format with control point ID and year PYR)

| field | columns | variable | format | value | description |
|---|---|---|---|---|---|
| 1 | 1-2 | CD | A2 | SC | Record identifier (optional after first record) |
| 2 | 3-8 | ID | A6 | AN | Reservoir (optional) |
| 3 | 13-16 | PYR | I8 | + | Year (optional) |
| 4 | 17-24 | SC(1) | F8.0 | + | Storage contents for month 1 |
| 5 | 25-32 | SC(2) | F8.0 | + | Storage contents for month 2 |
| 6 | 33-40 | SC(3) | F8.0 | + | Storage contents for month 3 |
| 7 | 41-48 | SC(4) | F8.0 | + | Storage contents for month 4 |
| 8 | 49-56 | SC(5) | F8.0 | + | Storage contents for month 5 |
| 9 | 57-64 | SC(6) | F8.0 | + | Storage contents for month 6 |
| 10 | 65-72 | SC(7) | F8.0 | + | Storage contents for month 7 |
| 11 | 73-80 | SC(8) | F8.0 | + | Storage contents for month 8 |
| 12 | 81-88 | SC(9) | F8.0 | + | Storage contents for month 9 |
| 13 | 89-96 | SC(10) | F8.0 | + | Storage contents for month 10 |
| 14 | 97-104 | SC(11) | F8.0 | + | Storage contents for month 11 |
| 15 | 105-112 | SC(12) | F8.0 | + | Storage contents for month 12 |

*SC* records contain end-of-month reservoir storage volumes used in conjunction with *RS* record computations.  The choice of format for both the *FA* and *SC* records is specified by AS(3) in field 3 of the *AS* record.  The only difference between the two options is whether to include optional fields for the control point ID and year PYR as fields 2 and 3.  With the AS(3) option 2, the ID and PYR fields are omitted.  With the AS(3) option −2, the ID and PYR fields are included.  These records, like all others, may also be in comma delimited format.

Each set of *SC* records in the HIN or FLO file is preceded by a *RS* record.  The *RS* record is preceded by an *AS* record.  Each set of *RS/SC* records is associated with a specified control point.

**EQ** Record  –  Regression Equation

| field | columns | variable | format | value | description |
|-------|---------|----------|--------|-------|-------------|
| 1 | 1-2 | CD | A2 | AS | Record identifier |
| 2 | 3-8 | ID | A6 | AN | Control point identifier |
| | | | | | *Regression Equation Coefficients* |
| 3 | 9-16 | A | F8.0 | + | Coefficient A |
| 4 | 17-24 | B | F8.0 | + | Coefficient B |
| 5 | 25-32 | C | F8.0 | + | Coefficient C |
| | | | | | *Beginning and Ending Years of Adjustments* |
| 6 | 37-40 | AS(1) | I8 | blank,0 | First year adjustments = first year of analysis period |
| | | | | + | First year of adjustments |
| 7 | 45-48 | AS(2) | I8 | blank,0 | Last year adjustments = Last year of analysis period |
| | | | | + | Last year of adjustments |
| | | | | | *Type of Adjustments* |
| 8 | 56 | QE | I8 | blank,0,1 | Flow $\quad\quad\quad\quad Q_{adjusted} = A\ Q^B + C$ |
| | | | | 2 | Flow Change $\quad \Delta Q_{adjustment} = (A\ Q^B + C) - Q$ |
| | | | | 3 | Evap-Precip $\quad E_{adjusted} = A\ E^B + C$ |
| | | | | | *Cascade Downstream if QE=2   (Yes or No?)* |
| 9 | 64 | AS(6) | I8 | 0 | QE=2 adjustments apply to all downstream cp's |
| | | | | 1 | *QE=2 adjustments apply to only this control point* |
| | | | | | *Negative Flow Options* |
| 10 | 72 | AS(7) | I8 | 0 | Allow negative stream flows |
| | | | | 1 | Change negative stream flows to zero |
| | | | | 2 | Change to zero and subtract next month |
| | | | | 3 | Modify adjustments to prevent negative stream flows |
| | | | | 4 | Modify adjustments and subtract negative next month |

*EQ* records are grouped with *AS*/*FA*/*RS*/*SC* records and may be placed before, after, or interdispersed with the *AS*/*FA*/*RS*/*SC* records.  These records are the last records in either the DAT and/or FLO files as specified by JC(3) entered in *JC* record field 7.

Fields 6, 7, 9, and 10 of the *EQ* record are identical to fields 3, 4, 8, and 9 of the *AS* record.

Only $\Delta Q_{adjustment}$ may be applied to downstream control points.  Therefore, *EQ* record field 9 is blank unless option 2 is selected for QE in field 8.

Field 8 specifies the manner in which a regression equation is applied.  Stream flows (QE=1) or evaporation-precipitation depths (QE=3) are adjusted by direct substitution into the equation.

$$Q_{adjusted} = A\ Q^B + C \quad \text{or} \quad E_{adjusted} = A\ E^B + C$$

Alternatively, for stream flows (QE=2), a change in flow $\Delta Q_{adjustment}$ may be computed that is then handled identically as adjustments read from *FA* records or computed in accordance with *RS* records.

$$\Delta Q_{adjustment} = (A\ Q^B + C) - Q$$

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