FINAL MEMORANDUM

TO: Ray Alvarado September 26, 2002

FROM: Boyle Engineering Corporation

SUBJECT: **CDSS Daily Yampa Model – Task 6 Daily Model Documentation**

Introduction

The objective of Task 6 is to provide detailed documentation on the creation of a daily model from the monthly Yampa River data set provided by the State. The State provided Boyle Engineering Corporation (Boyle) with the command and time series files *(*.cmd* and *.stm*) necessary to create a monthly and daily Yampa River Model. These files consist of the Phase IIIb version files with modifications of Wyoming's uses on the Little Snake River (December 2001). Because Boyle received only the command and time series file, it was necessary to generate all the monthly StateMod input files, then run the model in baseflow mode to obtain the Monthly Baseflow file (*ym2001Fx.xbm)* needed for the daily modeling efforts.

The Daily Pattern approach was recommended for developing a daily model of the entire Yampa River Basin in the **CDSS Daily Yampa Model – Task 2 Pilot Study** memorandum (Task 2 Memorandum). Procedures for developing the daily model were detailed in **CDSS Daily Yampa Model - Task 4 Recommendation for Full Basin Model** memorandum (Task 4 Memorandum). Creation of the CDSS Daily Yampa Model is discussed and the calibration results presented in the **CDSS Daily Yampa Model – Task 5 Daily Yampa Model** memorandum (Task 5 memorandum).

Creation of the Daily Model Data Set

The files required to run the Daily Pattern Yampa Daily Model are listed in Table 1. All input files are listed; however, only those files that are new or have been revised for the daily modeling efforts are discussed in subsequent sections. The steps used to modify the input files are described in these sections. Common changes to DMI command files, such as renaming the input, output, and/or basename files, removing "-no_daily_data" commands, and changing data sources are not detailed. All the command files used to generate input files and the input files themselves can be found in the data set delivered with the Task 5 memorandum.

Response File (ym2001DC.rsp)

The response file contains the names of all other data files required to run the model. New file names have been used for the files that have been updated and files related to daily modeling have been added. See the list of files in Table 1. The file is changed by hand-editing.

Table 1
Daily Yampa Input Files

File Description	File Name	New or Revised for Daily Model
Response File	ym2001DC.rsp	✓
Control File	ym2001D.ctl	✓
River Network File	ym2001.rin	
Reservoir Station File	ym2001D.res	✓
Direct Diversion Station File	ym2001D.dds	✓
River Station File	ym2001D.ris	✓
Instream Flow Station File	ym2001D.ifs	✓
Instream Flow Rights File	ym2001.ifr	
Reservoir Rights File	ym2001.rer	
Direct Diversion Rights File	ym2001.ddr	
Operational Rights File	yampaFC.opr	
Precipitation – Annual	yampaF.dum	
Evaporation	yampaF.eva	
Baseflow Data - Monthly	ym2001Fx.xbm	
DD demand-Monthly	ym2001C.ddm	
DD demand overwrite - Monthly	yampaF.dum	
DD demand - Annual	yampaF.dum	
Instream flow demand - Annual	ym2001.ifa	
Delay Table	yampaF.dly	
Reservoir target	ym2001C.tar	
Reservoir End of month contents	ym2001.eom	
Baseflow Parameter	yampaF.dum	
Historical Streamflow - Monthly	ym2001.rih	
Historical Diversions - Monthly	ym2001.ddh	
GIS file	yampaF.gis	
Output Control	ym2001DC.out	
Daily Streamflow	ym2001.rid	✓
Daily Direct Flow Demand	YampaF.dum	
Daily Instream Flow Demand	YampaF.dum	
Daily Reservoir Target	yampaF.dum	
Daily Delay Table	ym2001.dld	✓
Daily Historical Streamflow	ym2001.riy	✓
Daily Historical Diversion	yampaF.dum	
Daily Historical EOD Content	yampaF.dum	

Control File (ym2001D.ctl)

The control file, which is created and maintained by editing manually, contains information that controls the model simulation. Ten new lines were added to the bottom of the file, one for each of ten additional control variables that were not required by the monthly model. Of these, only the *iday* switch is used in this analysis. This variable was set to "1" for daily analysis.

Reservoir Station File (ym2001D.res)

A global "setres" command was added to the **watright** command file *rsvr.cmd* to set the daily flag variable (*cresidy)* equal to "5" for all reservoirs. This flag tells StateMod, while in simulation mode, to develop daily targets by linearly "connecting" monthly reservoir targets found in the *ym2001c.tar* file

Additionally, reservoir starting contents for each reservoir pool owner (*curown*) were revised using the **watright** "setrespool" command. The starting contents reflect historical contents as of September 30, 1974. This change was required because the State's monthly model command files created a data set for simulating 1909 through 1996, compared with the 1975-1996 simulation period for the daily model. Generally, if a daily model has the same simulation period as the monthly model from which it is being created, this detail is not required.

Execution of the **watright** command file *rsvr.cmd* created two files: the reservoir station file (*ym2001D.res*) and the reservoir right file (*ym2001D.rer*). The reservoir right file was discarded, as it is a duplicate of the *ym2001.rer* file.

Diversion Station File (ym2001D.dds)

A global "setdiv" command was added to the **watright** command file *dds.cmd* to set the daily flag variable (*cdividy)* equal to "4" for all diversion stations. This flag tells StateMod, while in simulation mode, to disaggregate the monthly diversion demands found in the *ym2001DC.ddm* file by connecting the midpoints of the monthly data. Execution of the **watright** command file *dds.cmd* created two files: the preliminary diversion station file (*ym2001DC.dds*) and the direct diversion right file (*ym2001DC.ddr*). The diversion right file was discarded, as it is a duplicate of the *ym2001.ddr* file.

The preliminary diversion station file was then input to the usual sequence of **demandts** runs to produce the final diversion station file. Only minor edits related to input, output and basename files were made to the **demandts** command files. The commands were then executed in the following order (see Section D.8 in Appendix D of the Phase IIIb documentation for the **demandts** process.)

1. *ph2ddh.cmd*
2. *ddh.cmd*
3. *ph2hddm.cmd*
4. *hddm.cmd*
5. *cddm.cmd*

The final diversion station file (*ym2001DC.dds*) was copied to the Daily Yampa directory and renamed *ym2001D.dds*. The final historical diversion (**.ddh*), historical demand (**H.ddm*), and calculated demand (**C.ddm*) files were identical to those created in the monthly model, and therefore, were discarded.

River Station File (ym2001D.ris)

Multiple "setris" commands were added to the **makenet** command file (*make.cmd*) to set the daily flag variable (*crunidy*) in the river station file to the gage specified in Table 2 and shown in Figure 1 (found at the end of this memo). The *crunidy* variable tells StateMod to calculate each day's baseflow by disaggregating the monthly baseflow (*ym2001FX.xbm*) using a pattern supplied by the corresponding daily gage flow in the daily gage flow file (*ym2001DC.rid*). Selection of the appropriate "pattern gage" is discussed in the Task 4 memorandum.

Table 2
Daily Pattern Gages for Yampa River Sub-basins

Basin subdivision	Pattern Gage
Yampa basin above Stagecoach Reservoir	09239500 Yampa River at Steamboat Springs
Yampa basin from USGS 09244410 Yampa River near Hayden to Stagecoach Reservoir, excluding Fish Creek and Elk River basins	09239500 Yampa River at Steamboat Springs
Fish Creek basin	09238900 Fish Creek at Upper Station
Elk River basin	09241000 Elk River at Clark
Mainstem Yampa River below USGS 09244410 Yampa River near Hayden	09251000 Yampa River near Maybell
Elkhead Creek	09245000 Elkhead Creek near Elkhead
Fortification Creek	09245000 Elkhead Creek near Elkhead
East Fork Williams Fork	09253000 Little Snake River near Slater
Williams Fork basin excluding East Fork Williams Fork	09251000 Yampa River near Maybell
Upper Mainstem Little Snake River	09253000 Little Snake River near Slater
Slater Creek	09255000 Slater Fork near Slater
Willow Creek	09258000 Willow Creek near Dixon
Lower Mainstem Little Snake River	09260000 Little Snake River near Lily

Execution of the **makenet** command file *make.cmd* created multiple files, of which only the river station file (*ym2001D.ris*) file is different from the monthly model files. All other **makenet** generated files are discarded.

Instream Flow Station File (ym2001D.ifs)

A global "setisf" command was added to the **watright** command file *isf.cmd* to set the daily flag variable (*cifridy*) equal to "0" for all instream flow stations. This flag tells StateMod to disaggregate the monthly instream flow demand found in the *ym2001.ifa* file to daily values by setting them to the average daily value. Execution of the **watright** command file *isf.cmd* created three files: the instream flow station file (*ym2001D.ifs*), the instream flow right file (*ym2001D.ifr*), and the instream flow annual demand file (*ym2001D.ifa*). The instream flow right (**.ifr*) and annual demand (**.ifa*) files were discarded, as they are duplicates of the corresponding monthly dataset files.

Daily Streamflow File (ym2001.rid)

A new **TSTool** command file (*rid.cmd*) was created to generate a file containing the daily streamflow values to be used in disaggregating the monthly baseflow values (see DMI Utilities – **makenet** for a discussion of the *crunidy* variable in the river station file (*ym2001D.ris*)). While the Historical Daily Streamflow file, described below, contains missing data flags, this file must have actual or estimated values for every gage, for every day. As described in the Task 5 Memorandum, it was necessary to fill daily values for USGS 09238900 – Fish Creek at Upper Station, USGS 09241000 – Elk River at Clark and USGS 09258000 – Willow Creek near Dixon so that these gages could be used to dissagregate baseflows for their specified sub-basin. Because of this, the *rid.cmd* file incorporates two important **TSTool** commands:

- fillRegression()
- fillDayTSFrom2MonthTSAnd1DayTS()

The "fillRegression()" command was used to fill missing monthly data for Fish Creek, Elk River and Willow Creek. The "fillDayTSFrom2MonthTSAnd1DayTS()" command was then used to fill the missing daily data for the gages. The same independent gage was used for both the monthly filling and the daily filling. The command file required two "setOutputPeriod()" commands. The first was placed at the beginning of the file and specified 1890-2000 as the period from which to develop regression relationships and fill data; the second specified 1975-1996 as the period for which the daily time series was output to the **.rid* file. The second "setOutputPeriod()" command was at the end of the file, prior to writing out the results. The **TSTool** command file *rid.cmd* is included on the data set delivered with the Task 5 memorandum.

Daily Delay File (ym2001.dld)

The daily delay table file contains coefficients to lag return flows. Estimation of the lag terms is discussed in detail in the **CRDSS Daily Yampa Model Subtask 1 – Equivalent daily return flow factors** memorandum. The file is created using an editor.

Daily Historical Streamflow (ym2001.riy)

A new **TSTool** command file (*riy.cmd*) was created to generate a file containing all the historical daily streamflow available for the Yampa River Basin for the study period. This command file reads the available daily streamflow records from HydroBase and writes them in StateMod format.

Comments

TSTool

Quite a bit of time was spent evaluating the results of the daily filling using the **TSTool** commands "fillRegression()" and "fillDayTSFrom2MonthTSAnd1DayTS()" in conjunction with the "setOutputPeriod()" command. The problems encountered were two-fold. First, setting the output period to 1975-1996 at the beginning of the command file confined the regression analysis to that period. In other words, the regression analysis did not avail itself of the common period of record between dependent and independent gages prior to 1975. **TSTool** documentation states that "setOutputPeriod()" sets "the query and output period for time series", which does imply that the command impacts the data available for developing the regression. However, it would be helpful if the documentation explicitly mentioned the impact of the specified output period on subsequent analysis. The term "output period" may be misleading to the end user, because he thinks of "output" as his final product rather than output from the query process. A second solution would be to enhance **TSTool** with a separate option to define the time period for the regression.

Second, placing the command after data retrieval and filling, but before the WriteStatemod command, resulted in monthly regression models that were based on all the common gage period available in the database. However, when this change was made, then "fillDayTSFrom2MonthTSAnd1DayTS()" did not work correctly for one out of three gages for which this instruction was used. The resulting daily time series file had missing data flags in it, which was not the case previously. Specifically, daily filling worked for Fish Creek at Upper Station near Steamboat Springs (09238900), based on Yampa River at Steamboat Springs (09239500), and for Elk River at Clark (09241000), based on Little Snake River near Slater (09253000). It did not work correctly for Willow Creek near Dixon (09258000) based on Slater Fork near Slater (09255000).

As far as Boyle is aware, this second issue has not been resolved in the software. By experimenting, we discovered that we could create the desired **.rid* file by placing two "setOutputPeriod()" commands in the command file. The first specified 1890-2000 and was placed at the beginning of the file; the second specified 1975-1996 and was placed at the end of the file, prior to writing out the results. It is our understanding that when "setOutputPeriod()" is not invoked, all relevant data in the database is retrieved by default, so one would expect there would be no difference between results with and without "setOutputPeriod(10/01/1890,09/30/2000)" at the beginning of the command file.

We have found **TSTool**, as a whole, to be a very powerful tool. The user who overcomes its steep learning curve is rewarded with the ability to easily manipulate large amounts of data in a wide variety of useful ways.

Other

We have found the enhancements to StateMod that allow operation on a daily time step to be highly flexible. The model allows several different approaches to daily operation, including both disaggregation and permitting the user to supply daily input for some or all variables. This allows the

user to choose from several means of generating a daily model using a combination of methods most suited to the basin in question.

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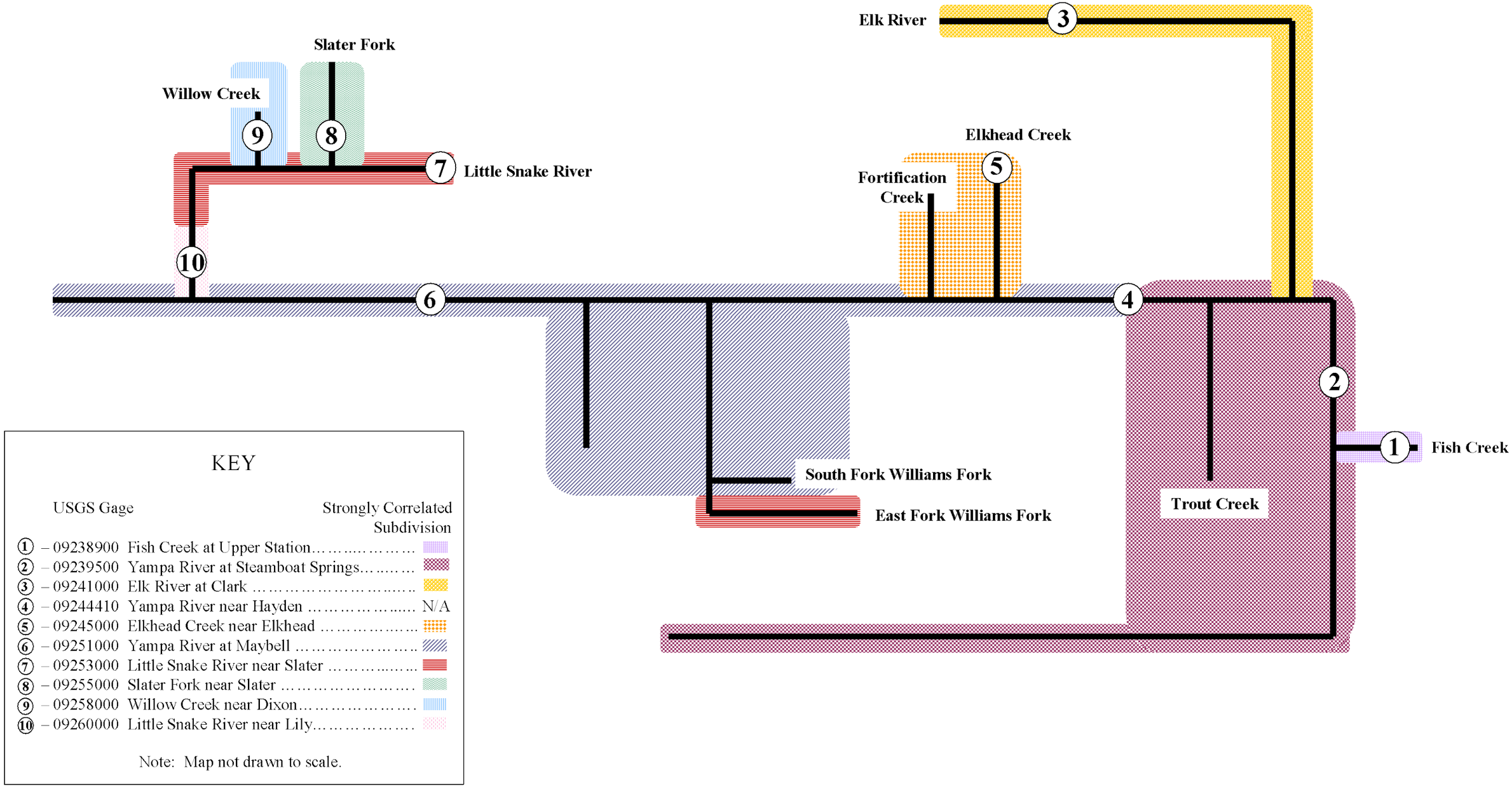

Figure 1 –Final Application of Daily Pattern Gages