Appendix A-3: Souris River Plan of Study ResSim Model Stochastic Setup

June 17, 2020

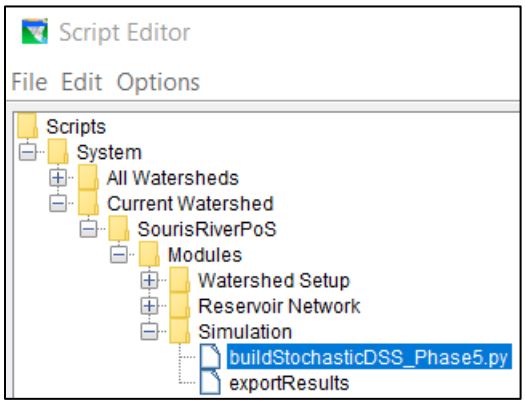
This document outlines how to import output from the stochastic USGS model into a DSS file and setup the ResSim model to run the stochastic dataset.

1. Importing Stochastic Traces into DSS

The buildStochasticDSS.py Jython script will import a directory of stochastic flow, precipitation, potential evapotranspiration (PET), and standard precipitation-evapotranspiration index data into HEC-DSS format.

Location and environment of script

The script must be run with ResSim while in the simulation module with an active simulation (i.e. simulation name is bolded, highlighted). This allows it to place the dss file in the "shared/stochasticInputs.dss" file.

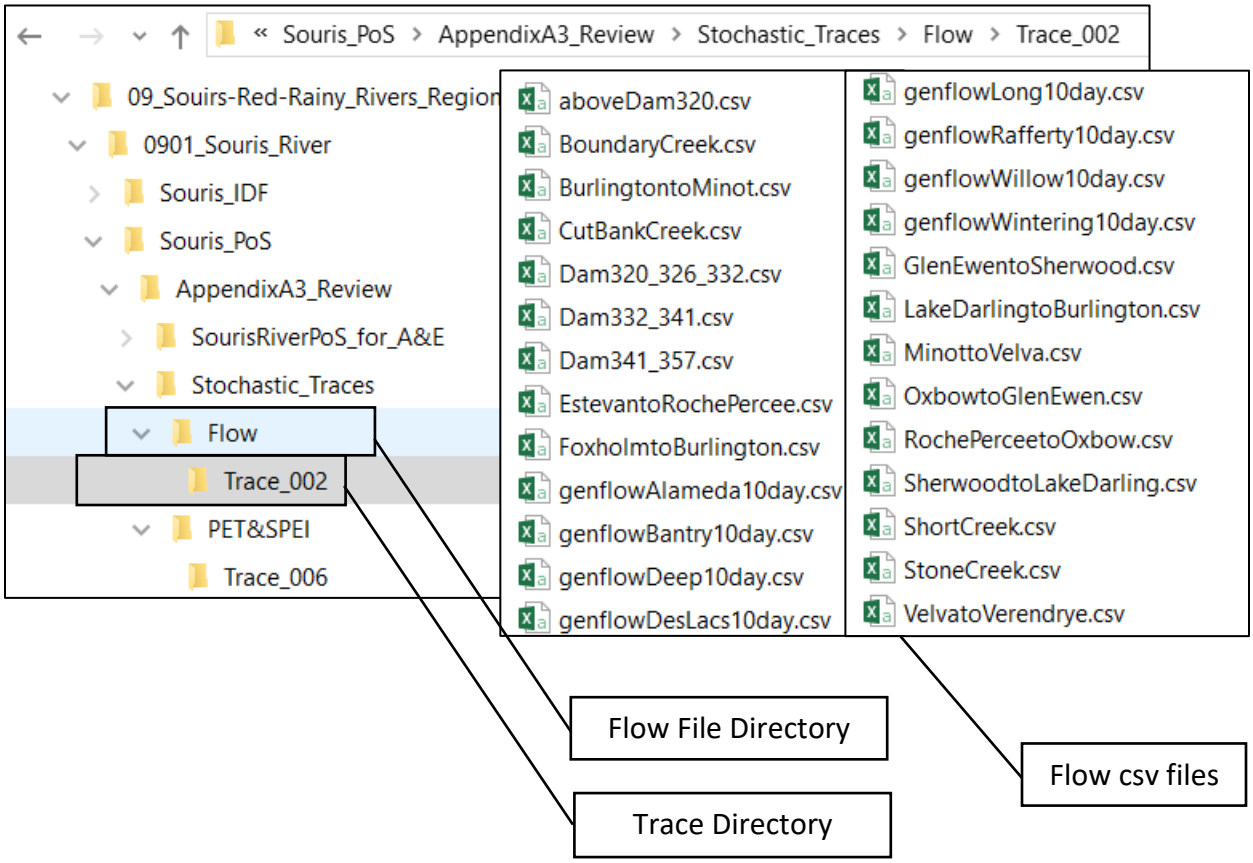


Flow file location

The USGS stochastic csv flow files must be in the following format:

Parent directory

- ➔ Flow
  - ➔ Trace folder (e.g. Trace_002)
    - ➔ Flow csv files (e.g. StoneCreek.csv…must be named exactly as shown in screenshot below)

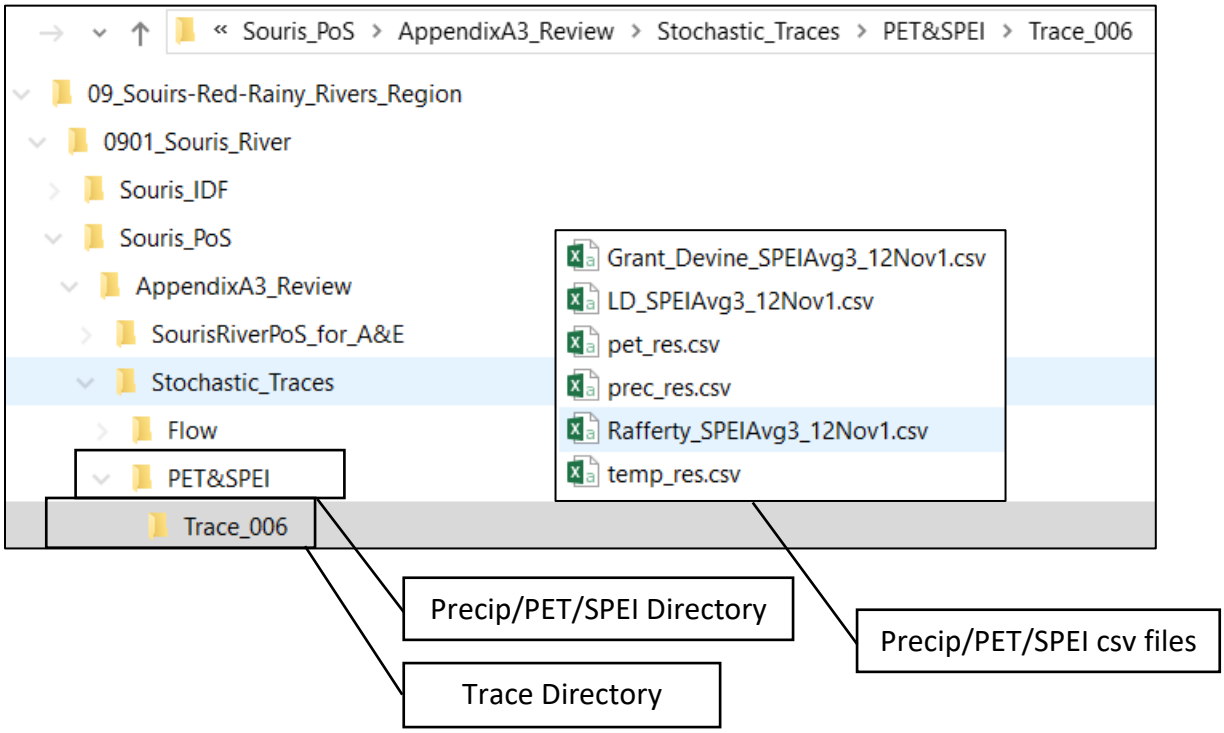


The parent and flow file directories is specified by the user in line 15 of the script.

```
14 #Change this path to where the stochastic flow files are...the directory should contain folders with each trace name that contain all the flow files named as they are in the fileMapper dictionary below
15 flowPath = r'C:\Users\b6ecpjd7\Desktop\Projects\09_Souirs-Red-Rainy_Rivers_Region\0901_Souris_River\Souris_PoS\AppendixA3_Review\Stochastic_Traces\Flow'
```

Precipitation, PET, and SPEI file location

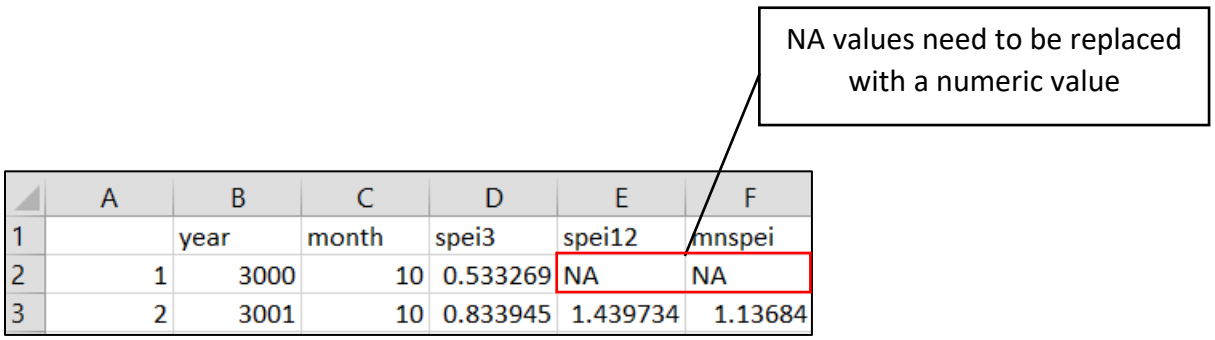
The precipitation and PET files must be located in the following format:



The Precip/PET/SPEI directory is specified by the user in line 17 of the script. The precip, PET, and SPEI filenames must have the same naming as shown.

```
16 #Change this paths to where the PET and Prec files are...the directory should contain folders with each trace name that contain a pet_res.csv file and a prec_res.csv
17 precipPETpath = r'C:\Users\b6ecpjd7\Desktop\Projects\09_Souirs-Red-Rainy_Rivers_Region\0901_Souris_River\Souris_PoS\AppendixA3_Review\Stochastic_Traces\PET&SPEI'
```

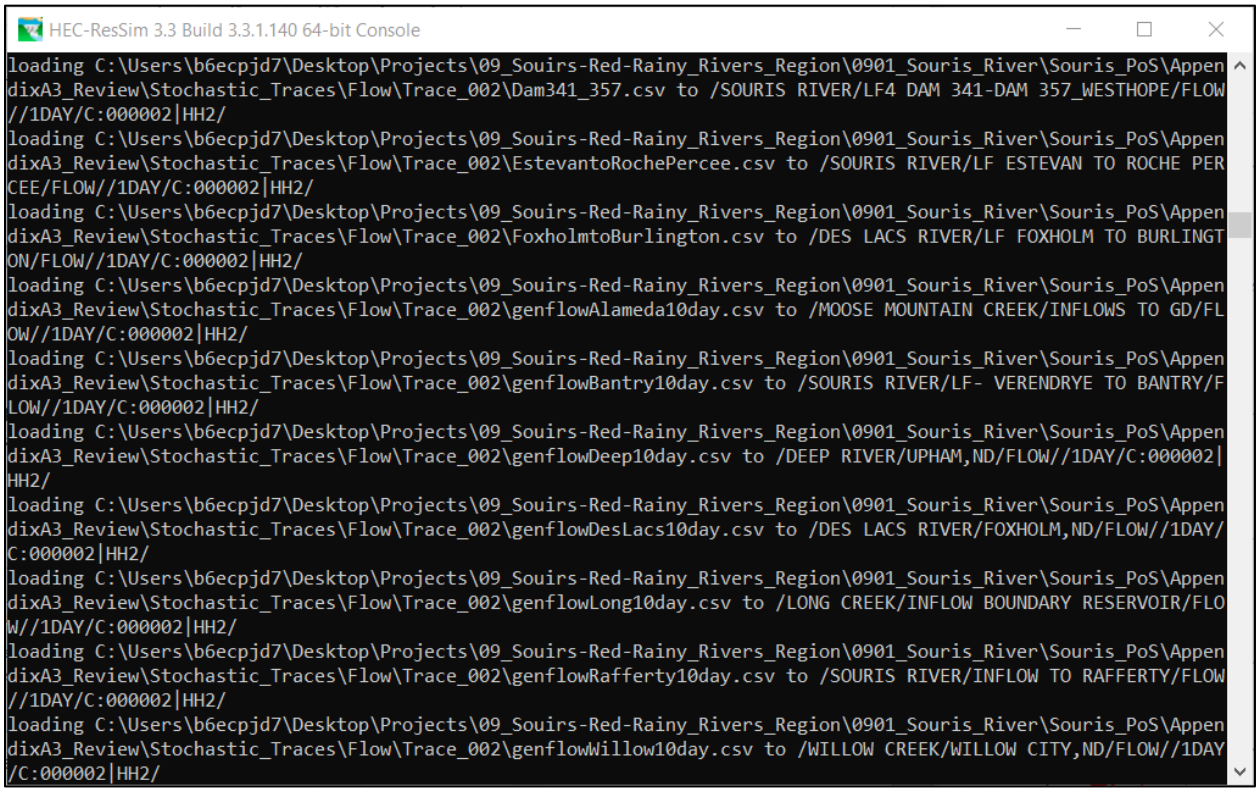
All “NA” values within the SPEI files, (Grant_Devine_SPEIAvg3_12Nov.csv, LD_SPEIAvg3_12Nov1.csv, and Rafferty_SPEIAvg3_12Nov1.csv), must be replaced by a numeric value, or else the files cannot be read by ResSim. These values are only found in cells E2 and F2 in the csv files, as shown below. It is recommended that these values are replaced with a “0” or the 3-month SPEI, “spei3”, as 12-month SPEI cannot be calculated for these cells, but this is at the user’s discretion.



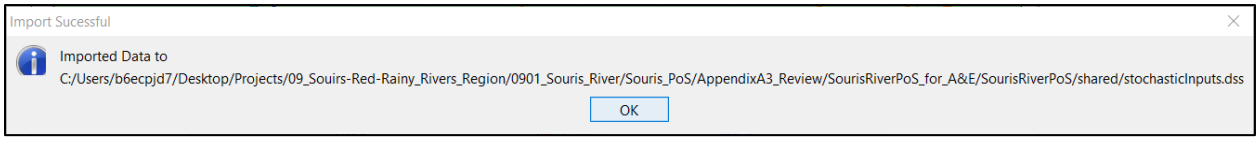
	A	B	C	D	E	F
1		year	month	spei3	spei12	mnspei
2	1	3000	10	0.533269	NA	NA
3	2	3001	10	0.833945	1.439734	1.13684

Running the script

When the script is run messages will be output in the console updating you on progress.



If it completed successfully, you should see the following message box:



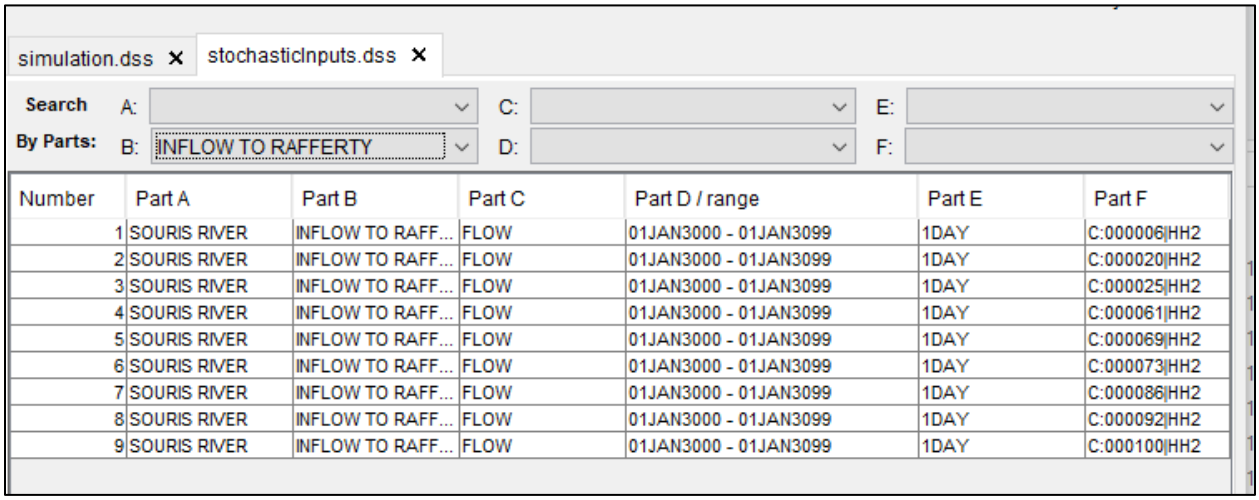
The data has been imported into DSS and stored in metric units, (except for SPEI values which are unitless).

Gross evaporation is calculated within the script by using the linear relationship estimated by WSA in a document titled *Relations between Gross Evaporation and Potential Evapotranspiration in Rafferty, Boundary, Grant Devine, and Lake Darling Reservoir* received on July 8, 2019 for Rafferty Reservoir, Boundary Reservoir, Grant Devine Lake, and Lake Darling.

Net evaporation is calculated within the script by subtracting precipitation from gross evaporation.

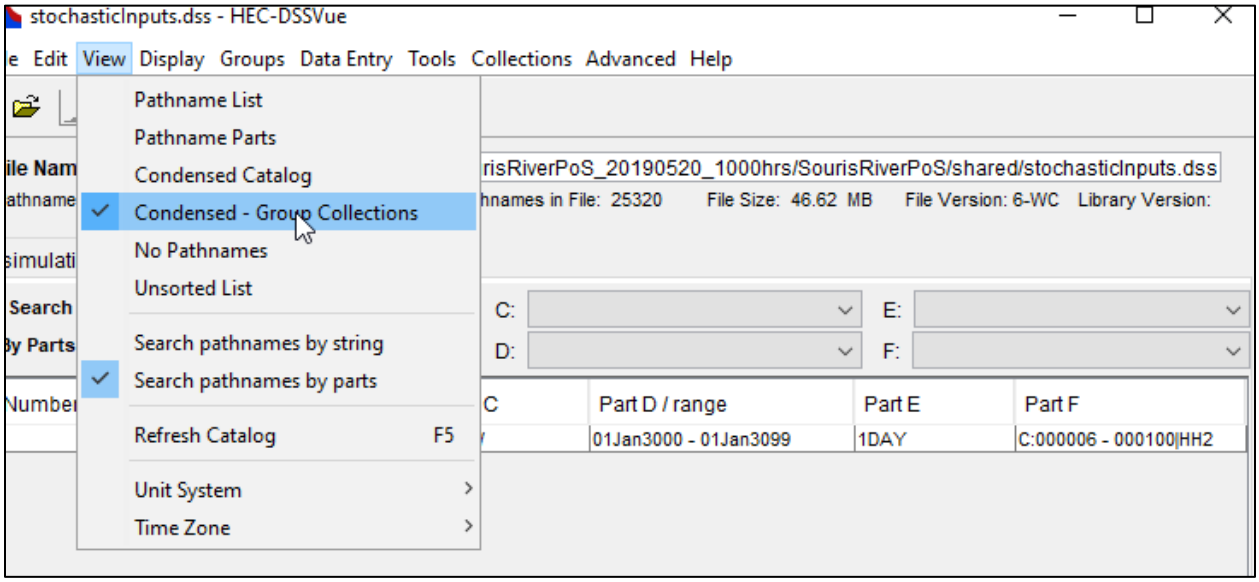
2. HEC-DSS Collections

DSS can store multiple variants of timeseries data in a “collection” format. For example, multiple inflow traces for Rafferty Reservoir can be associated with each other. The “collection” becomes available when the fPart is named with C:XXXXX|Description format where the “XXXXXX” is a six digit integer containing the trace number and the “Description” field contains text. See the example naming convention in the screenshot below:



Number	Part A	Part B	Part C	Part D / range	Part E	Part F
1	SOURIS RIVER	INFLOW TO RAFF...	FLOW	01JAN3000 - 01JAN3099	1DAY	C:000006|HH2
2	SOURIS RIVER	INFLOW TO RAFF...	FLOW	01JAN3000 - 01JAN3099	1DAY	C:000020|HH2
3	SOURIS RIVER	INFLOW TO RAFF...	FLOW	01JAN3000 - 01JAN3099	1DAY	C:000025|HH2
4	SOURIS RIVER	INFLOW TO RAFF...	FLOW	01JAN3000 - 01JAN3099	1DAY	C:000061|HH2
5	SOURIS RIVER	INFLOW TO RAFF...	FLOW	01JAN3000 - 01JAN3099	1DAY	C:000069|HH2
6	SOURIS RIVER	INFLOW TO RAFF...	FLOW	01JAN3000 - 01JAN3099	1DAY	C:000073|HH2
7	SOURIS RIVER	INFLOW TO RAFF...	FLOW	01JAN3000 - 01JAN3099	1DAY	C:000086|HH2
8	SOURIS RIVER	INFLOW TO RAFF...	FLOW	01JAN3000 - 01JAN3099	1DAY	C:000092|HH2
9	SOURIS RIVER	INFLOW TO RAFF...	FLOW	01JAN3000 - 01JAN3099	1DAY	C:000100|HH2

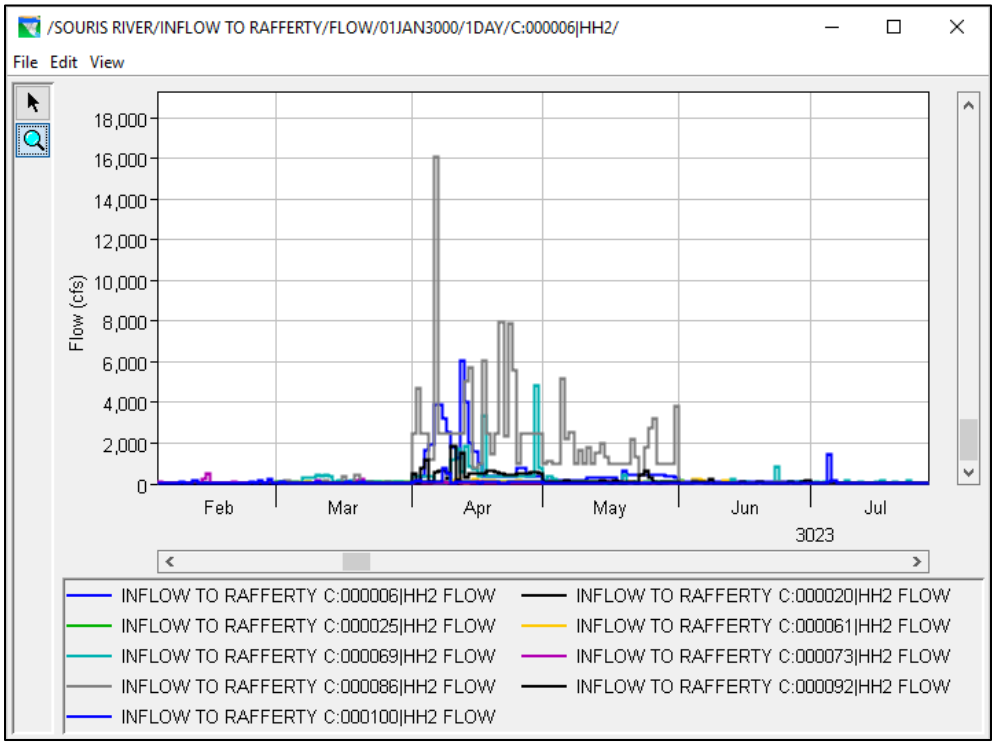
The collection can be viewed together by selecting View → Condensed-Group Catalogs in DSS-VUE (see screenshot below). This option is only available if DSS recognizes dataset stored in the collection format.



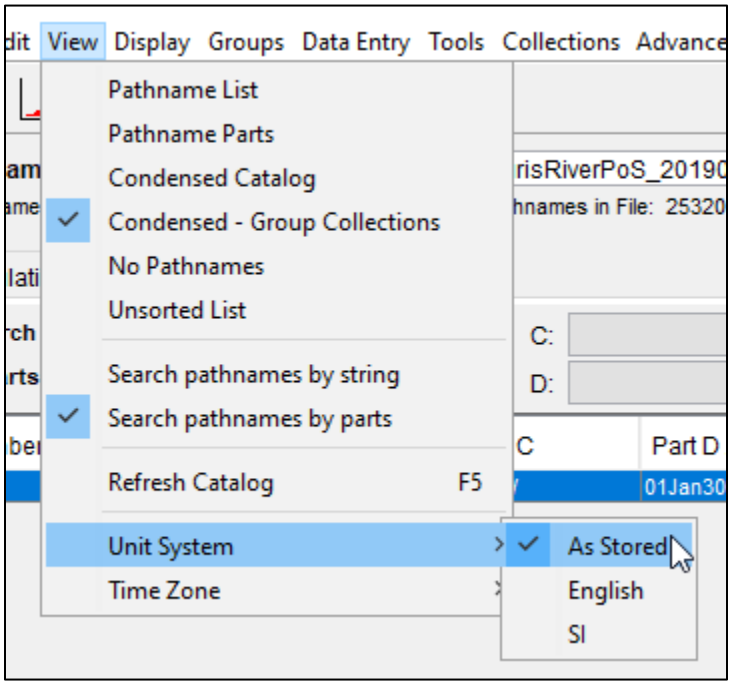
Once the condensed group catalog is selected only one record for each set of traces appears.

Number	Part A	Part B	Part C	Part D / range	Part E	Part F
1	SOURIS RIVER	INFLOW TO RAF...	FLOW	01Jan3000 - 01Jan3099	1DAY	C:000006 - 000100|HH2

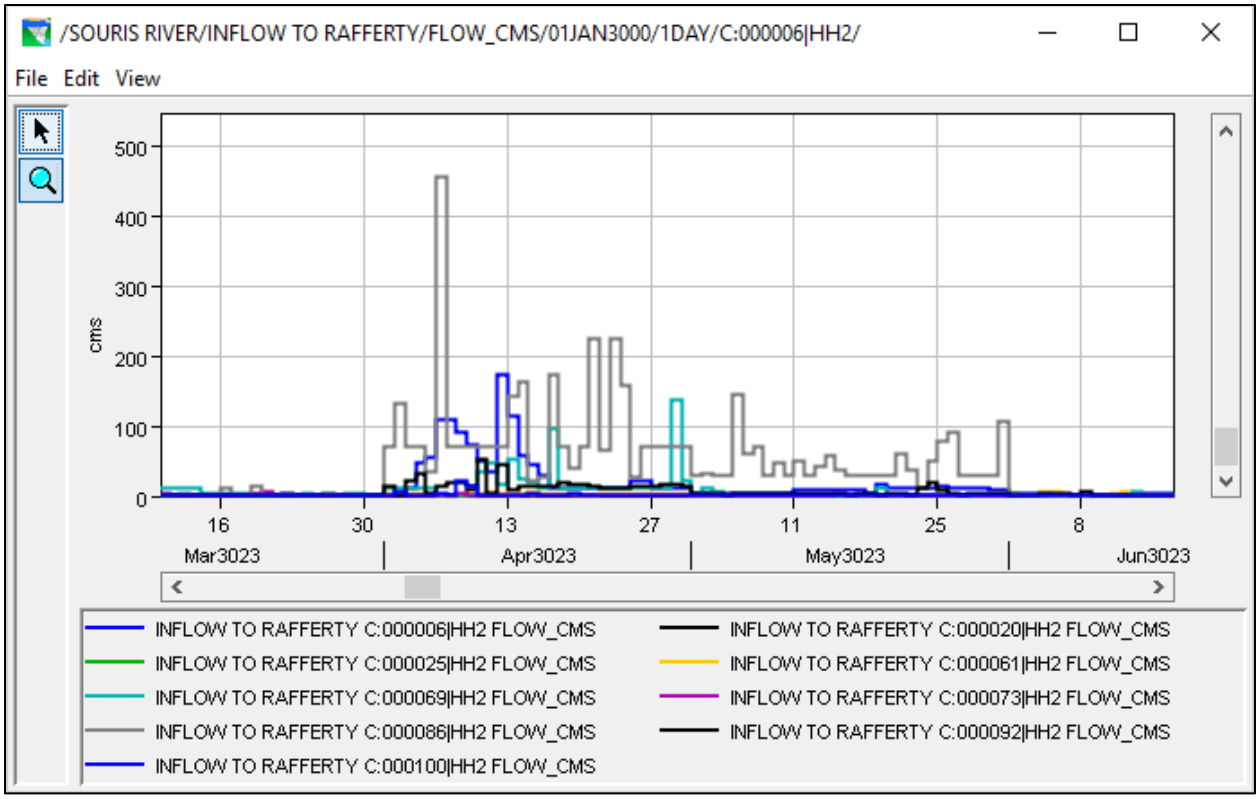
One can easily view the traces together by plotting or tabulating.



Note that even though it is selected to view the data in the format stored, it is displayed in English units for some data series because of the cPart name is “Flow” or “Precip”.



To plot the data in CMS units, the cPart must be changed to something else like Flow_CMS. This allows DSS to display the data in the stored format.



3. Running a Stochastic Dataset in ResSim

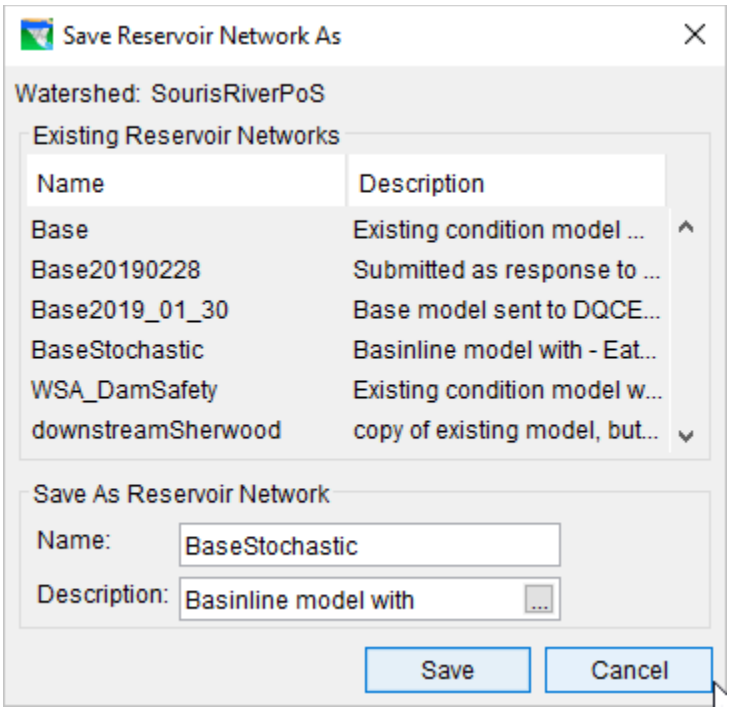
A few changes must be made to the model network and alternative to run a stochastic dataset. A network and alternative already setup to run the stochastic dataset is has been included in a model along with this document.

The guide curves for J. Clark Salyer have been changed to calculate within the state variable. This is because there is a dependency on whether the year is classified as a flood year. If results downstream of Bantry are not important, a static pool guide curve can be assumed.

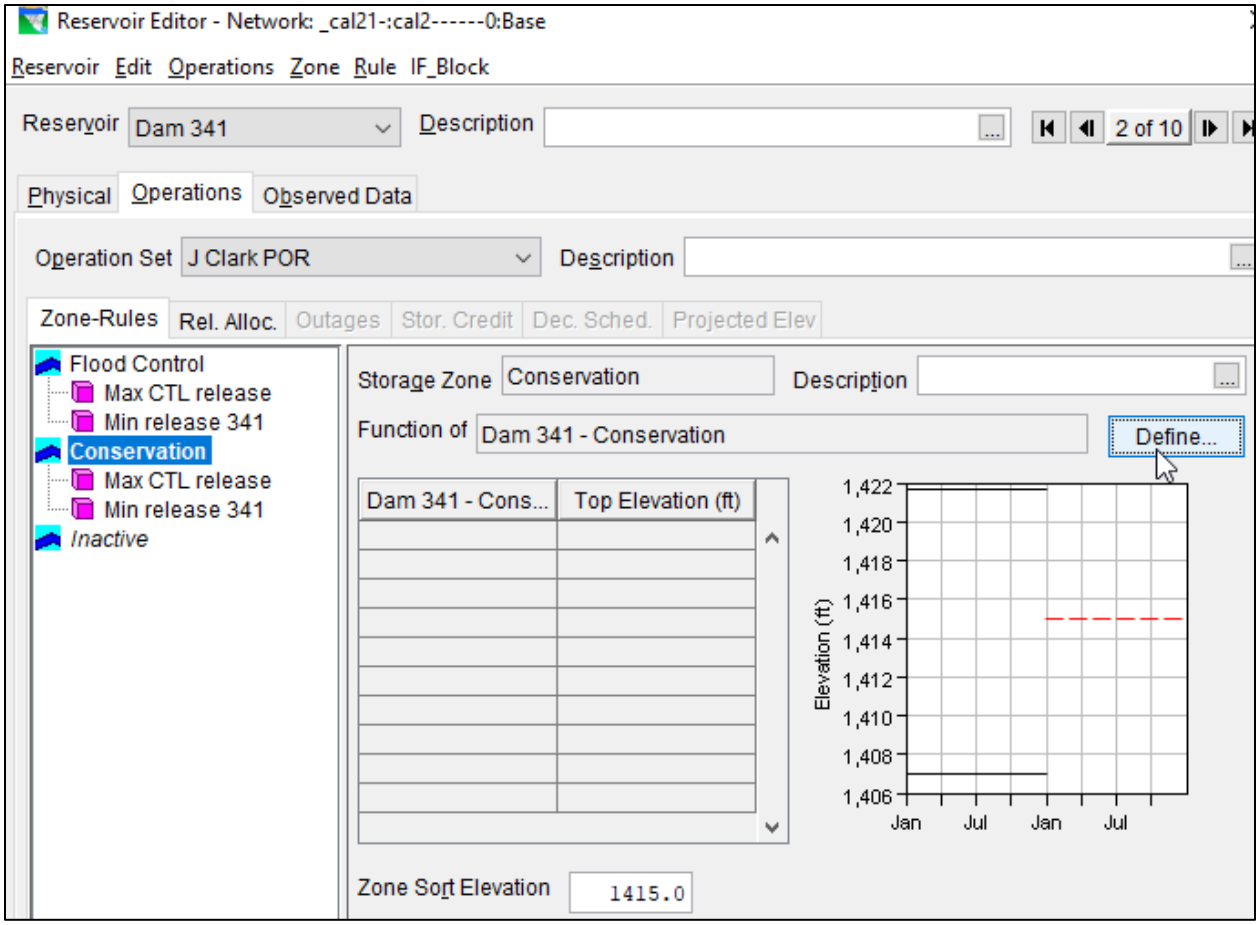
Water use time series at Boundary for the City of Estevan and SaskPower have been developed for the stochastic time frame (3000-3100).

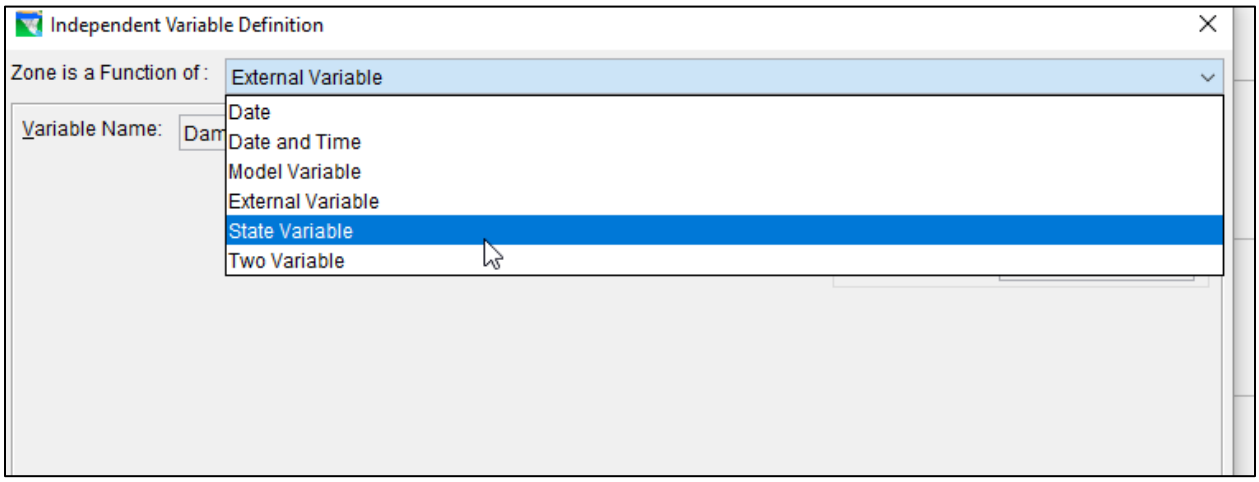
Create New Network for New J. Clark Salyer Pool GCs

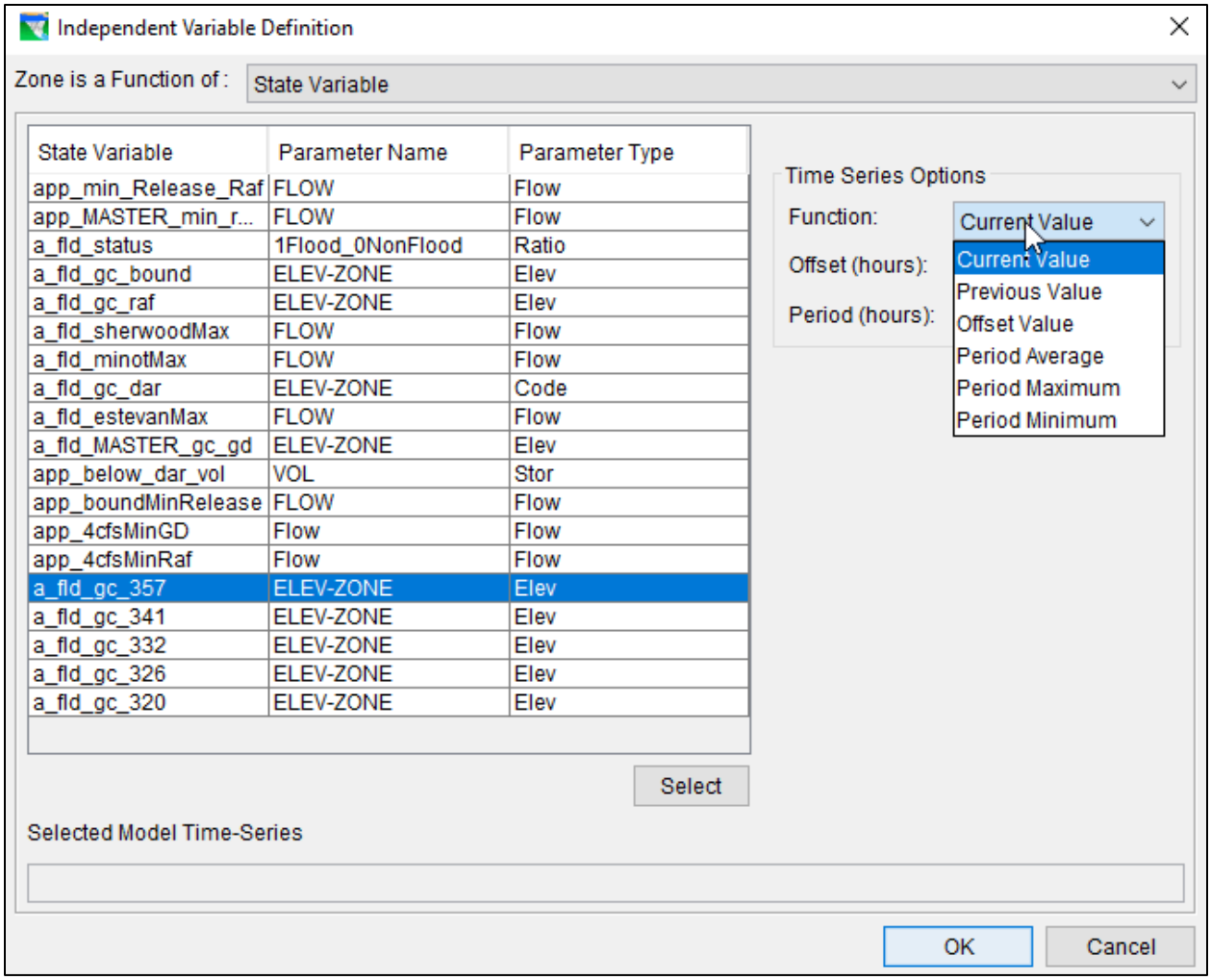
1. Save baseline network as a new network.



2. The guide curves for the J. Clark Salyer pools (Dam 357, 341, 332, 326, and 320) need to be mapped to an external timeseries or use a state variable. For testing purposes that don't require output at Westhope, the guide curves can be changed to constant.
    a. How to add the new state variable.
        i. Create new, slave state variables for the J. Clark Slayer pools using ELEV-ZONE for the Parameter Name and Elev for the Parameter Type

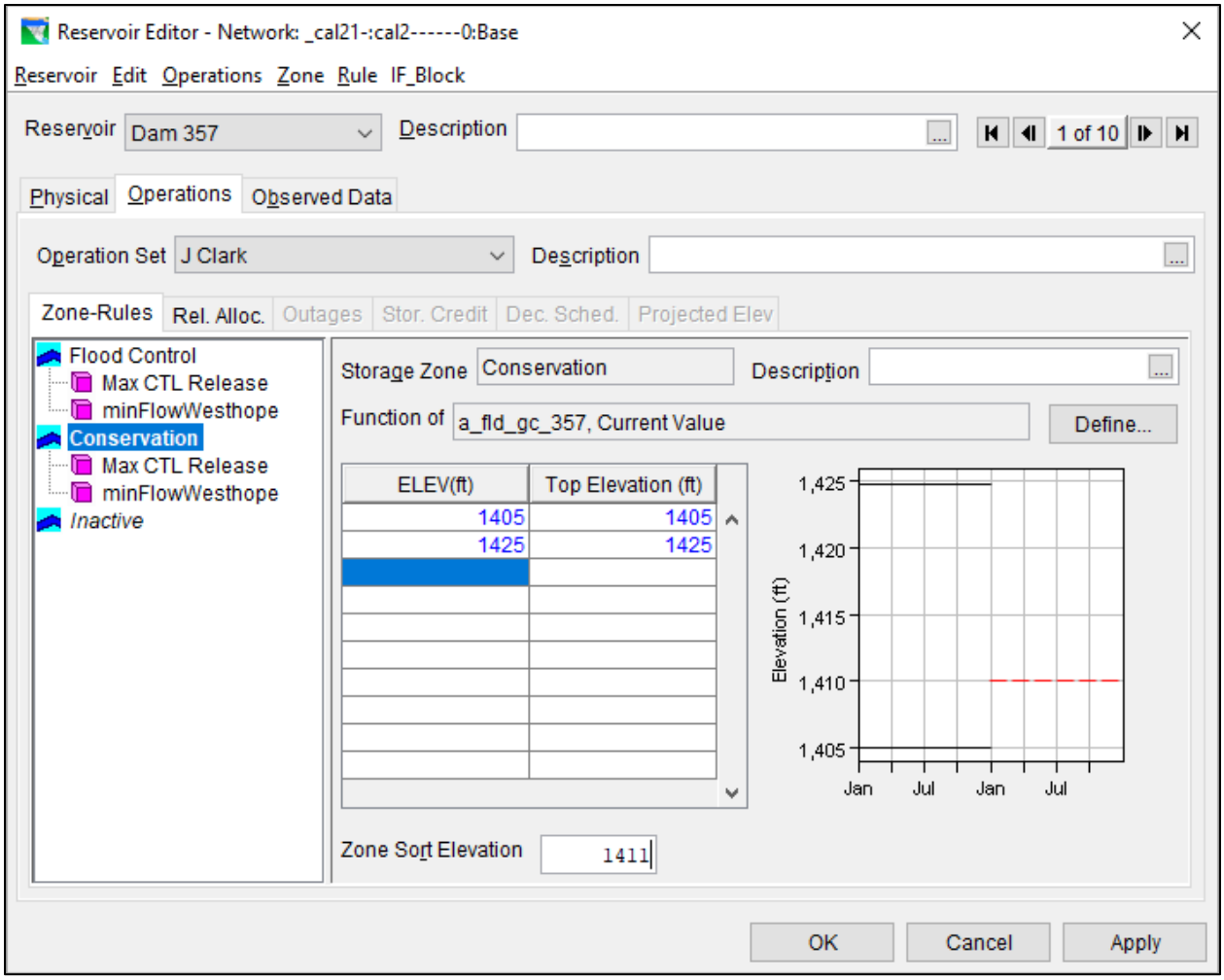

Reservoir Editor - Network: _cal21-:cal2------0:Base
Reservoir Edit Operations Zone Rule IF_Block
Reservoir Dam 341
Description
2 of 10
Physical Operations Observed Data
Operation Set J Clark POR
Description
Zone-Rules Rel. Alloc. Outages Stor. Credit Dec. Sched. Projected Elev
Flood Control
Max CTL release
Min release 341
Conservation
Max CTL release
Min release 341
Inactive
Storage Zone Conservation
Description
Function of Dam 341 - Conservation
Define...
Dam 341 - Cons...
Top Elevation (ft)
Elevation (ft)
1,422
1,420
1,418
1,416
1,414
1,412
1,410
1,408
1,406
Jan
Jul
Jan
Jul
Zone Sort Elevation
1415.0


Independent Variable Definition
Zone is a Function of :
External Variable
Variable Name:
Dam
Date
Date and Time
Model Variable
External Variable
State Variable
Two Variable



ii. Make sure the state variables are named a_fld_gc_357 etc… for each Salyer Refuge pool.

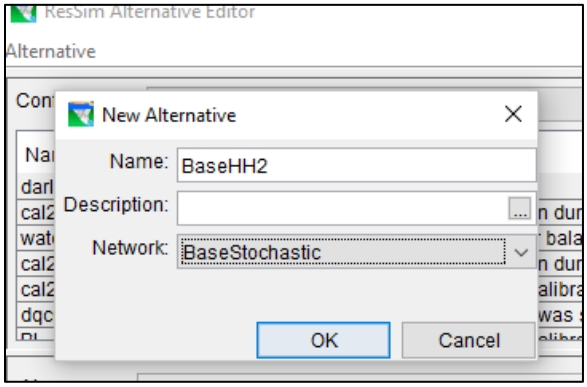
iii. Relate the guide curve to the state variable as a one to one function.



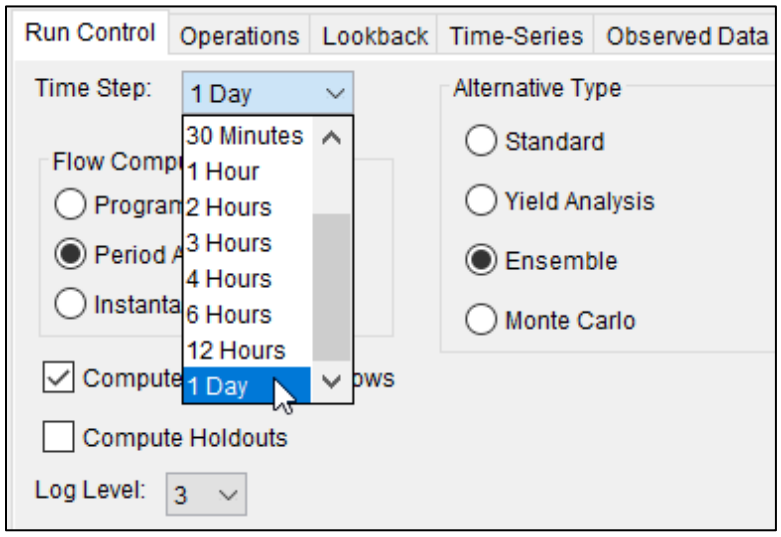
i. Import the a_fld_MASTER_gc_gd_w_salyer20190711.py into the a_fld_MASTER_gc_gd.py and save

Create a New Alternative

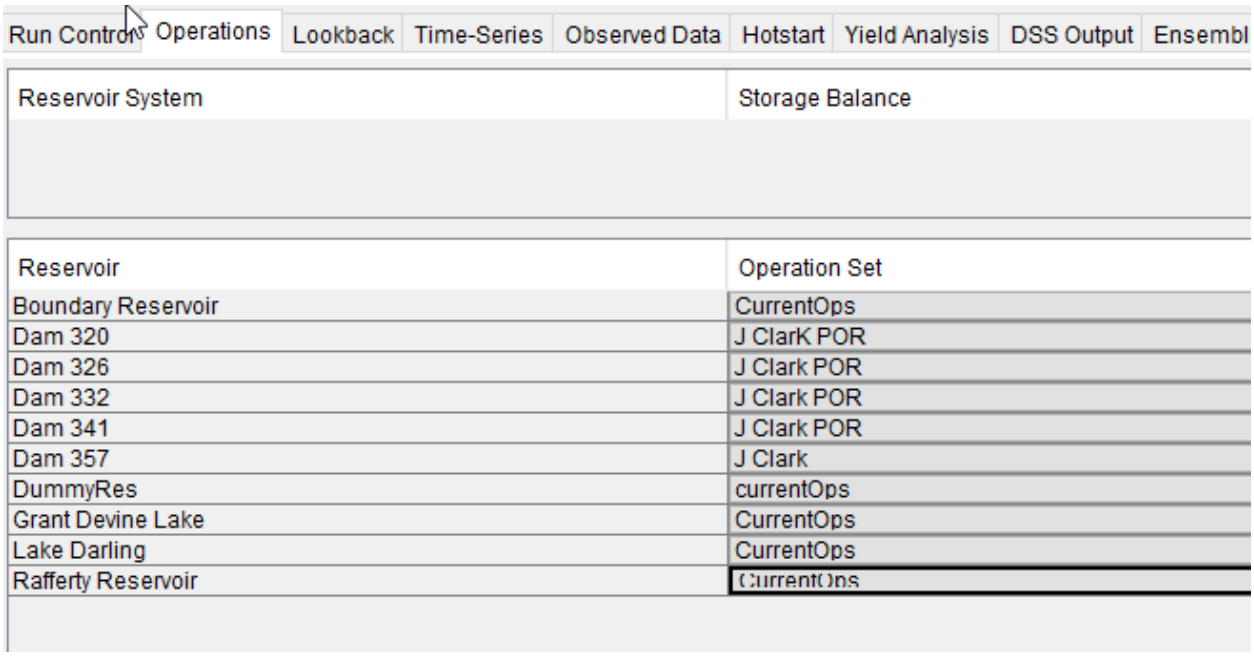
1. Create a new alternative with the stochastic network.



2. Under the Run Control tab select a 1 Day timestep and the Ensemble alternative type if you would like to run multiple traces at once. A standard alternative type can be selected if you are interested in running one trace at a time.



3. Under the operations tab copy and paste the operation set from the baseline model or use the dropdown to select the operations below.



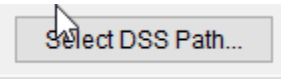
4. Under the Lookback tab copy and paste the lookback information from the alternative BL_Normal or another alternative depending on what initial conditions you would like. Make sure to define Lookback values for the new “a_fld_gc_357”, etc., state variables. Values of “1420” are recommended.

Reservoir Network: BaseStochastic

Run Control | Operations | Lookback | Time-Series | Observed Data | Hotstart | Yield Analysis | DSS Output | Ensemble | Monte Carlo

Location	Variable	Type	Default Value
Dam 357-Pool	Lookback Elevation	Constant	1411.0
Dam 357-Pool	Lookback Storage	Computed	
Dam 357-Uncontrolled Outlet 1	Lookback Spill	Constant	0.0
Dam 357-Controlled Outlet	Lookback Release	Constant	0.0
Dam 341-Pool	Lookback Elevation	Constant	1413.6
Dam 341-Pool	Lookback Storage	Computed	
Dam 341-Controlled Outlet	Lookback Release	Constant	0.0
Dam 341-Uncontrolled Outlet	Lookback Spill	Constant	0.0
Dam 332-Pool	Lookback Elevation	Constant	1417.3
Dam 332-Pool	Lookback Storage	Computed	
Dam 332-Controlled Outlet	Lookback Release	Constant	0.0
Dam 332-Uncontrolled Outlet	Lookback Spill	Constant	0.0
Dam 326-Pool	Lookback Elevation	Constant	1417.7
Dam 326-Pool	Lookback Storage	Computed	
Dam 326-Spillway	Lookback Spill	Constant	0.0
Dam 326-3 Radial Gates	Lookback Release	Constant	0.0
Dam 320-Pool	Lookback Elevation	Constant	1421.8
Dam 320-Pool	Lookback Storage	Computed	
Dam 320-Spillway	Lookback Spill	Constant	0.0
Dam 320-3 Radial gates	Lookback Release	Constant	0.0
Boundary Reservoir-Pool	Lookback Elevation	Constant	1836.8
Boundary Reservoir-Pool	Lookback Storage	Computed	
Boundary Reservoir-Main Gates	Lookback Release	Constant	0.0
Boundary Reservoir-Diversion	Lookback Release	Constant	0.0
Lake Darling-Pool	Lookback Elevation	Constant	1595.74
Lake Darling-Pool	Lookback Storage	Computed	
Lake Darling-Tainter Gates	Lookback Release	Constant	0.0
Lake Darling-Low Flow Gates	Lookback Release	Constant	0.0
Grant Devine Lake-Pool	Lookback Elevation	Constant	1840.99
Grant Devine Lake-Pool	Lookback Storage	Computed	
Grant Devine Lake-Main Spillway Ou...	Lookback Release	Constant	0.0
Grant Devine Lake-Low Flow Outlet	Lookback Release	Constant	0.0
Grant Devine Lake-IrrigationOutlet	Lookback Release	Constant	0.0
Rafferty Reservoir-Pool	Lookback Elevation	Constant	1802.46
Rafferty Reservoir-Pool	Lookback Storage	Computed	
Rafferty Reservoir-Main Spillway Gate	Lookback Release	Constant	0.0
Rafferty Reservoir-Low Flow Gate	Lookback Release	Constant	0.0
Rafferty Reservoir-Irrigation	Lookback Release	Constant	0.0
Rafferty Reservoir-Raf2BoundOutlet	Lookback Release	Constant	0.0
DummyRes-Pool	Lookback Elevation	Constant	80.0

5. Under the Time-Series tab copy and paste the timeseries information from a baseline alternative as a starting point.
    a. Select a timeseries and Select the DSS path using the GUI button.



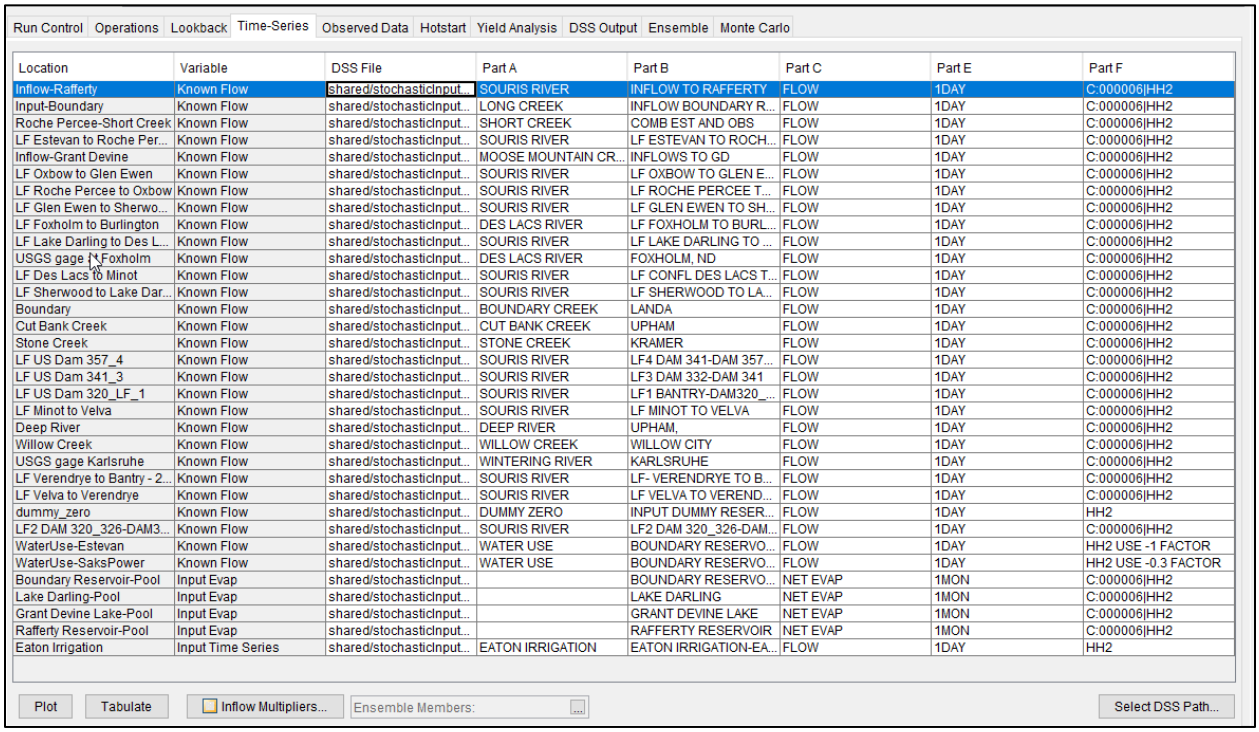
    b. Navigate to “shared/stochasticInputs.dss” and select the appropriate path.
    c. Change the copy and paste the DSS File field and fPart field to other paths.

Location	Variable	DSS File	Part A	Part B	Part C	Part E	Part F
Inflow-Rafferty	Known Flow	C:/Users/b6ecm...	SOURIS RIVER	INFLOW TO RAF...	FLOW	1DAY	C:000006|HH2
Input-Boundary	Known Flow	/shared/stochast...	LONG CREEK	INFLOW BOUN...	FLOW	1DAY	C:000006|HH2
Roche Percee-Sh...	Known Flow	/shared/stochast...	SHORT CREEK	COMB EST AND ...	FLOW	1DAY	C:000006|HH2
LF Estevan to Roc...	Known Flow	/shared/stochast...	SOURIS RIVER	LF ESTEVAN TO...	FLOW	1DAY	C:000006|HH2

    d. For records with a bPart that include a “, ND”, (i.e. Boundary, Cut Bank Creek, Stone Creek, Deep River, Willow Creek, USGS gage Karlsruhe) remove the “, ND” or manually select the record with the GUI. Be sure to select the record in the “Condensed – Group Collections” view if running ensemble mode. If a comma is left in place the simulation won’t run and an error message is only output in the console, not the GUI.

e. Select records using the “Select DSS Path” starting with the Input Evap time series as these records no longer align with the base model.

f. After you are finished the inputs should look like the screenshot below and the attached Excel file (alternativeInputTsHH2.xlsx).



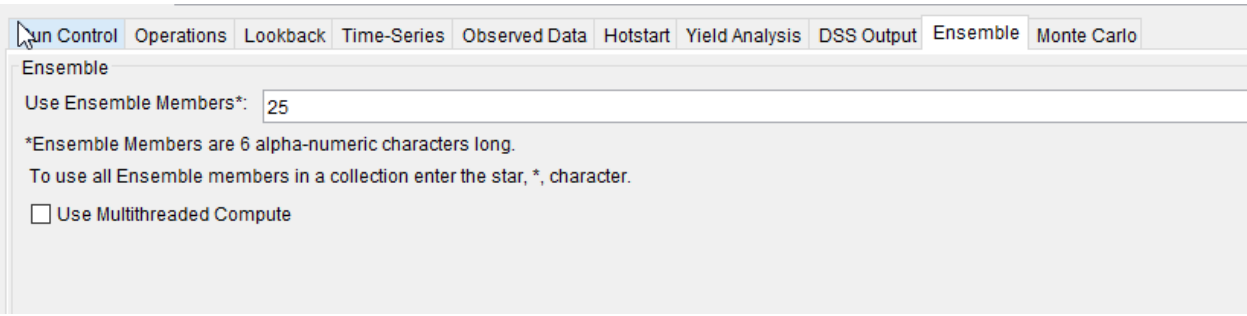
Location	Variable	DSS File	Part A	Part B	Part C	Part E	Part F
Inflow-Rafferty	Known Flow	shared/stochasticInput...	SOURIS RIVER	INFLOW TO RAFFERTY	FLOW	1DAY	C:000006|HH2
Input-Boundary	Known Flow	shared/stochasticInput...	LONG CREEK	INFLOW BOUNDARY R...	FLOW	1DAY	C:000006|HH2
Roche Percee-Short Creek	Known Flow	shared/stochasticInput...	SHORT CREEK	COMB EST AND OBS	FLOW	1DAY	C:000006|HH2
LF Estevan to Roche Per...	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF ESTEVAN TO ROCH...	FLOW	1DAY	C:000006|HH2
Inflow-Grant Devine	Known Flow	shared/stochasticInput...	MOOSE MOUNTAIN CR...	INFLOWS TO GD	FLOW	1DAY	C:000006|HH2
LF Oxbow to Glen Ewen	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF OXBOW TO GLEN E...	FLOW	1DAY	C:000006|HH2
LF Roche Percee to Oxbow	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF ROCHE PERCEE T...	FLOW	1DAY	C:000006|HH2
LF Glen Ewen to Sherwo...	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF GLEN EWEN TO SH...	FLOW	1DAY	C:000006|HH2
LF Foxholm to Burlington	Known Flow	shared/stochasticInput...	DES LACS RIVER	LF FOXHOLM TO BURL...	FLOW	1DAY	C:000006|HH2
LF Lake Darling to Des L...	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF LAKE DARLING TO ...	FLOW	1DAY	C:000006|HH2
USGS gage Foxholm	Known Flow	shared/stochasticInput...	DES LACS RIVER	FOXHOLM, ND	FLOW	1DAY	C:000006|HH2
LF Des Lacs to Minot	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF CONFL DES LACS T...	FLOW	1DAY	C:000006|HH2
LF Sherwood to Lake Dar...	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF SHERWOOD TO LA...	FLOW	1DAY	C:000006|HH2
Boundary	Known Flow	shared/stochasticInput...	BOUNDARY CREEK	LANDA	FLOW	1DAY	C:000006|HH2
Cut Bank Creek	Known Flow	shared/stochasticInput...	CUT BANK CREEK	UPHAM	FLOW	1DAY	C:000006|HH2
Stone Creek	Known Flow	shared/stochasticInput...	STONE CREEK	KRAMER	FLOW	1DAY	C:000006|HH2
LF US Dam 357_4	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF4 DAM 341-DAM 357...	FLOW	1DAY	C:000006|HH2
LF US Dam 341_3	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF3 DAM 332-DAM 341	FLOW	1DAY	C:000006|HH2
LF US Dam 320_LF_1	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF1 BANTRY-DAM320_...	FLOW	1DAY	C:000006|HH2
LF Minot to Velva	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF MINOT TO VELVA	FLOW	1DAY	C:000006|HH2
Deep River	Known Flow	shared/stochasticInput...	DEEP RIVER	UPHAM,	FLOW	1DAY	C:000006|HH2
Willow Creek	Known Flow	shared/stochasticInput...	WILLOW CREEK	WILLOW CITY	FLOW	1DAY	C:000006|HH2
USGS gage Karlsruhe	Known Flow	shared/stochasticInput...	WINTERING RIVER	KARLSRUHE	FLOW	1DAY	C:000006|HH2
LF Verendrye to Bantry - 2...	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF- VERENDRYE TO B...	FLOW	1DAY	C:000006|HH2
LF Velva to Verendrye	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF VELVA TO VEREND...	FLOW	1DAY	C:000006|HH2
dummy_zero	Known Flow	shared/stochasticInput...	DUMMY ZERO	INPUT DUMMY RESER...	FLOW	1DAY	HH2
LF2 DAM 320_326-DAM3...	Known Flow	shared/stochasticInput...	SOURIS RIVER	LF2 DAM 320_326-DAM...	FLOW	1DAY	C:000006|HH2
WaterUse-Estevan	Known Flow	shared/stochasticInput...	WATER USE	BOUNDARY RESERVO...	FLOW	1DAY	HH2 USE -1 FACTOR
WaterUse-SaksPower	Known Flow	shared/stochasticInput...	WATER USE	BOUNDARY RESERVO...	FLOW	1DAY	HH2 USE -0.3 FACTOR
Boundary Reservoir-Pool	Input Evap	shared/stochasticInput...		BOUNDARY RESERVO...	NET EVAP	1MON	C:000006|HH2
Lake Darling-Pool	Input Evap	shared/stochasticInput...		LAKE DARLING	NET EVAP	1MON	C:000006|HH2
Grant Devine Lake-Pool	Input Evap	shared/stochasticInput...		GRANT DEVINE LAKE	NET EVAP	1MON	C:000006|HH2
Rafferty Reservoir-Pool	Input Evap	shared/stochasticInput...		RAFFERTY RESERVOIR	NET EVAP	1MON	C:000006|HH2
Eaton Irrigation	Input Time Series	shared/stochasticInput...	EATON IRRIGATION	EATON IRRIGATION-EA...	FLOW	1DAY	HH2

6. Under the Observed Data tab clear all inputs

7. If you are using ensemble mode, all traces can be run if an “*” is entered in the Use Ensemble Members field. One can specify specific traces by entering the trace numbers separated by commas (e.g. 6, 25, 100). A range of traces can be specified by entering the starting and ending trace number separated by a hyphen (e.g. 6-100).

a. The multi-threaded compute checkbox can be selected to allow multiple traces to be calculated at the same time.

8. A single trace can be run in ensemble mode, **but it will not plot with the default plots and cannot be run if the multi-thread compute button is selected**. The data will be written to the DSS file.
    a. To run a single trace without changing the alternative editor time-series linking enter in the trace number in the Use Ensemble Members and deselect the Multithreaded Compute checkbox.



9. A single trace that will plot in the default plots in ResSim by selecting “Standard” under the Alternative Type in the Run Control tab and entering in the appropriate alternative fPart under the Time-Series tab.