WATFLOOD®

Canadian Hydrological And Routing Model - CHARM™

SINCE 1972

Supplementary Utilities Manual

WATFLOOD is open source

by

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1. Introduction

1.1. For starters:

DISCLAIMER

The WATFLOOD®/CHARM™ software is furnished by N. Kouwen and the University of Waterloo and is accepted and used by the recipient upon the express understanding that N. Kouwen and the University of Waterloo make no warranties, either express or implied, concerning the accuracy, completeness, reliability, usability, performance, or fitness for any particular purpose or the information contained in this manual, to the software described in this manual, and to other material supplied in connection therewith. The material is provided "as is". The entire risk as to its quality and performance is with the user.

The files produced by this software are for the convenience of WATFLOOD/CHARM users only and are not to be relied upon in any particular situation without the express written consent of N. Kouwen or the University of Waterloo.

1.2. General Approach

This manual is intended to help WATFLOOD users to convert Environment Canada flow, level and met data to Green Kenue (GK) compatible WATFLOOD input files.

There are 4 programs:

1. ECmet.exe – to create precipitation and temperature files
2. ECflw.exe – to create streamflow and diversion flow files
3. ECrel.exe – to create reservoir release and operating rule files and also initial lake level files.
4. EClvl.exe – to create reservoir/lake level files.

For each program, the examples on input files are given.

In the file names, a * generally indicates a date **yyyymmdd** or a watershed name **bsnm**

Names of files, programs, etc. are **bold**

2. Create Precipitation and Temperature Files

To create WATFLOOD precipitation and temperature files, first download the EC data files and then execute the program **ECmet.exe**

2.1. ECmet.exe input files

Begin with requesting the most recent copy of **Station Inventory EN.csv** from Climate Ontario / Climate Ontario (EC/EC) ec.climatontario-climateontario.ec@canada.ca This is a list of over 12000 climate stations in Canada. From this list, select the stations you wish to use.

Next download the Env. Can. met station data using the (new) link:

http://climate.weather.gc.ca/climate_data/bulk_data_e.html?timeframe=2&stationID=***&Month=2&Year=YYYY&format=csv

Note the invisible underscore in climate_data/bulk_data_e.htm
3
where you replace *** by the station ID number and YYYY by the year of the data you wish to download. There is one file per year per station. You must save the files with the name format as **sta_456_1978.csv**

A complete set of instructions for downloading the data is available at
ftp://ftp.tor.ec.gc.ca/Pub/Get_More_Data_Plus_de_donnees/Readme.txt

For documentation of the data please see:
http://climate.weather.gc.ca/prods_servs/documentation_index_e.html

Bulk data from ECCC's website for multiple stations and multiple years can be downloaded using the well-known and free **wget** program.

2.2. ECCC Data Download with wget

Step 1: To download daily ECCC met data begin by creating the following directories: **dr:\watflood\bsnm\raing\EC_data** and **dr:\watflood\bsnm\tempg**

Step 2: In the **EC_data** directory, create a file called **domain_limits.txt** that will specify a domain in Lat-Long for meteorological stations. These limits should be larger than the watershed domain to enable use of met stations that are outside the watershed but will have useful data for the watershed. Example file for the Metro Toronto area watersheds:

```
Domain for met station
43.4  44.2
-78.9  -80.2
2000  2017
12
```

The first data line are the south & north limits, the next east & west limits, then the period for which data is sought and finally the minimum number of years with data. (Include `'Domain for met station'` as the first line in the file).

Step 3: Obtain the file **station_inventory_EC.csv** from ECCC and place in the **EC_data** directory. See Ch. 2.
Rearrange the columns in the EC inventory csv file in this order:

stationID, long, lat, elv, firstYR, lastYR, firstYR_hrly, lastYR_hrly

Step 4: Execute **select.exe** in this directory. This will produce the bat file: **get_data.bat** with **wget** command lines for the stations listed:

```
E:\WATFLOOD\TRCA\raing\EC_data>select
 ******************************************************
   PROGRAM: select_EC_met_sta
   Version 2.0 - added output for wget
 ******************************************************
  4402  -79.870   44.150    221.0 1973 2008    9 ALLISTON    NELSON       c
  4850  -79.830   43.930    274.3 1956 2000    1 ALBION      ONTARIO      c
  4851  -79.830   43.920    281.9 1969 2001    2 ALBION      FIELD        c
  4919  -79.080   43.820     76.2 1959 2004    5 FRENCHMANS  BAY          c
  4923  -79.880   43.640    221.0 1962 2016   17 GEORGETOWN  WWTP         c
  4924  -79.950   43.930    434.3 1959 2003    4 GLEN        HAFFY        c
  4946  -79.730   43.530    182.9 1982 2001    2 HORNBY      TRAFALGAR    c
  4954  -79.520   44.020    352.0 1974 2003    4 KING        SMOKE        c
  4991  -80.090   43.920    411.5 1961 2015   16 ORANGEVILLE MOE          c
  4971  -79.700   43.430     92.0 1990 2006    7 OAKVILLE    GERARD       c
  5014  -78.970   44.150    253.0 1983 2007    8 PORT        PERRY        c
  5016  -79.450   43.880    240.0 1959 2014   15 RICHMOND    HILL         c
  5027  -79.810   43.810    270.0 1981 2010   11 SANDHILL    ONTARIO      c
```

```
 5049  -79.420   43.800    199.3 1965 2007    8 THORNHILL   GRANDVIEW    c
 5051  -79.400   43.670    112.5 1840 2016   17 TORONTO     ONTARIO      c
31688  -79.400   43.670    112.5 2002 2016   17 TORONTO     CITY         c
 5085  -79.400   43.630     76.5 1957 2006    7 TORONTO     ISLAND       c
 5097  -79.630   43.680    173.4 1937 2013   14 TORONTO     LESTER       c
 5148  -79.600   43.780    164.0 1948 2005    6 WOODBRIDGE  ONTARIO      c
 4841  -79.370   43.860    198.1 1986 2015   16 TORONTO     BUTTONVILLE  c
 4846  -79.630   43.480     86.9 1970 2001    2 OAKVILLE    SOUTHEAST    c
26953  -79.470   43.780    187.0 1994 2016   17 TORONTO     NORTH        c
# stations found to meet specs:          22
Output - sta_input.txt for Phython code
Output - get_data.bat for wget command lines
```

Step 5: Download the **wget** programs from https://www.gnu.org/software/wget/ and place the files in the working directory (or it won't work very well):

libeay32.dll
libiconv2.dll
libintl3.dll
libssl32.dll
wget.exe

Example of **wget** command lines created by **select.exe**:

wget -O sta_4402_2000.csv
"http://climate.weather.gc.ca/climate_data/bulk_data_e.html?format=csv&stationID="4402"&Year="2000"&timeframe=2&submit= Download+Data"
wget -O sta_4402_2001.csv
"http://climate.weather.gc.ca/climate_data/bulk_data_e.html?format=csv&stationID="4402"&Year="2001"&timeframe=2&submit= Download+Data"
wget -O sta_4402_2002.csv
"http://climate.weather.gc.ca/climate_data/bulk_data_e.html?format=csv&stationID="4402"&Year="2002"&timeframe=2&submit= Download+Data"
wget -O sta_4402_2003.csv**.**
.
.

Step 6: Next, execute the **get_data.bat** file in a DOS window and you will see the ECCC annual met files for each station. Note the bat file renames all the files.

```
2017-10-13  01:30 PM            11,339 sta_4402_2000.csv
2017-10-13  01:30 PM            11,339 sta_4402_2001.csv
2017-10-13  01:30 PM            11,339 sta_4402_2002.csv
2017-10-13  01:30 PM            11,339 sta_4402_2003.csv
2017-10-13  01:30 PM            11,339 sta_4402_2004.csv
2017-10-13  01:30 PM            11,339 sta_4402_2005.csv
.
.
```

Example of the downloaded EC file: **raing\EC_data\sta_456_1978.csv**

```
"Station Name","BABINE LAKE PINKUT CREEK"
"Province","BRITISH COLUMBIA"
"Latitude","54.45"
"Longitude","-125.46"
"Elevation","713.20"
"Climate Identifier","1070573"
"WMO Identifier",""
"TC Identifier",""
"Legend"
"A","Accumulated"
"C","Precipitation occurred, amount uncertain"
"E","Estimated"
"F","Accumulated and estimated"
"L","Precipitation may or may not have occurred"
"M","Missing"
"N","Temperature missing but known to be > 0"
"S","More than one occurrence"
"T","Trace"
"Y","Temperature missing but known to be < 0"
"[empty]","No data available"
"^","The value displayed is based on incomplete data"
"†","Data for this day has undergone only preliminary quality checking"
"‡","Partner data that is not subject to review by the National Climate
Archives"
"Date/Time","Year","Month","Day","Data Quality","Max Temp (°C)",      ect.
"1978-01-01","1978","01","01","","-21.1","","-27.8","","-24.5","","42.  ect.
etc
```

The program **select.exe** will also create a list of stations **sta_list.xyz** eg.:

```
  -102.280    50.900          2848     BANGOR
  -102.570    50.370          2855     BROADVIEW
  -105.380    50.550          2859     BUFFALO
.
.
```

Next open **sta_list.xyz** in GreenKenue, double click on the file name and open the Spatial dialogue panel; Assign **LatLong** and a datum = **NAD83**. Save the file as sta_list_LL.xyz if the watershed is modelled in LatLong. See example dialogue boxes on the next page.

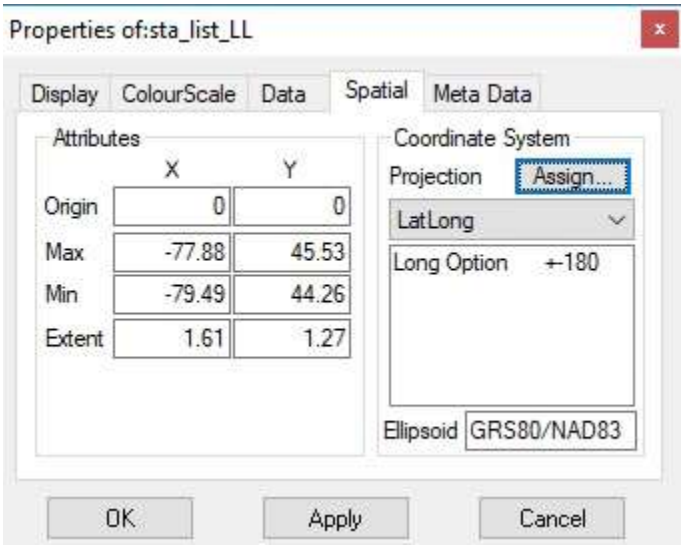
If the watershed is modelled in the UTM, Polar Steriographic or Lambert Conformal coordinate system, change the projection and save the file as **sta_list_UTM.xyz sta_list_PS.xyz** or **sta_list_LC.xyz** respectively**.**

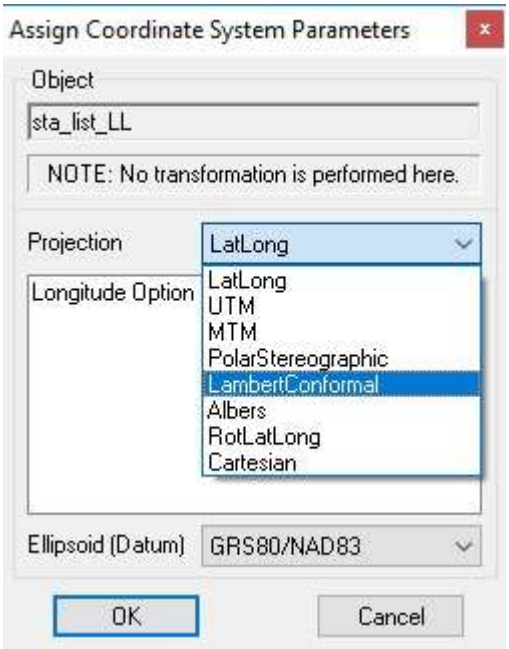
Next, **ECmet.exe** is executed in the **raing\EC_data** directory. All input files are located there as well.

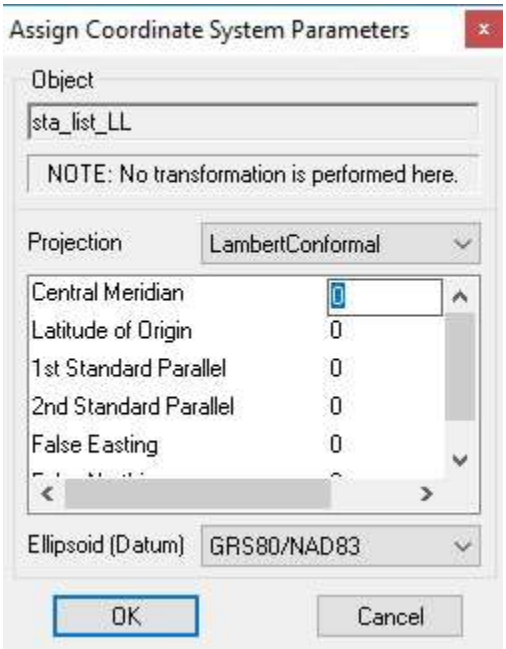
ECmet.exe will read the list of stations **sta_list_**.xyz** and the station data and provided that the station data is available for each station in the working directory (**raing\EC_data**), **ECmet.exe** will create the **raing*_rag.tb0** and **tempg*_tag.tb0** files for the years requested.

Example dialogue boxes in Green Kenue:

First open the Properties window, then the Assign Coordinates window and there enter the appropriate parameters.







2.3. ECmet.exe output files

Example of ECmet output file **raing\19960101_rag.tb0**

```
########################################
:FileType tb0  ASCII  EnSim 1.0
#
# DataType               Time Series
#
:Application             EnSimHydrologic
:Version                 2.1.23
:WrittenBy          ECmet.exe
:CreationDate       2016-04-26  15:41
#
#---------------------------------------
:SourceFile                   met_stations
#
:Name               daily_precip
#
:Projection         LATLONG
:Ellipsoid          WGS84
#
:StartDate
:StartTime          00:00:00.0
#
:UnitConversion            1.0000000
:DeltaT               24
#
:ColumnMetaData
   :ColumnUnits             m         m         m         m      etc.
   :ColumnType           floa      floa      floa      floa
   :ColumnName      BLUE_RIVE MICA_DAM  FORT_ST_J GERMANSEN
   :ColumnLocationX  -119.2900 -118.5900 -120.7400 -124.7000
   :ColumnLocationY    52.1300   52.0500   56.2400   55.7900
   :Elevation             690.      579.      695.      766.
:EndColumnMetaData
:endHeader
                       -999.00   -999.00      2.50      2.50
                       -999.00   -999.00      1.00      1.50
                       -999.00   -999.00      2.30      0.00
                       -999.00   -999.00      0.80      0.00
etc
```

Example of ECmet output file **tempg\19600101_tag.tb0**

```
########################################
:FileType tb0  ASCII  EnSim 1.0
#
# DataType               Time Series
#
:Application             EnSimHydrologic
:Version                 2.1.23
:WrittenBy          ECmet.exe
:CreationDate       2016-04-26  15:41
#
#---------------------------------------
:SourceFile                   met_stations
#
```

```
:Name                daily_precip
#
:Projection          LATLONG
:Ellipsoid           WGS84
#
:StartDate
:StartTime           00:00:00.0
#
:UnitConversion             1.0000000
 :DeltaT                4
#
:ColumnMetaData
   :ColumnUnits      dC         dC         dC         dC
   :ColumnType       float      float      float      float
   :ColumnName       BLUE_RIVE MICA_DAM   FORT_ST_J GERMANSEN
   :ColumnLocationX   -119.2900 -118.5900 -120.7400 -124.7000
   :ColumnLocationY     52.1300   52.0500   56.2400   55.7900
   :Elevation              690.      579.      695.      766.
:EndColumnMetaData
:endHeader
                         -99.90    -99.90    -16.10    -28.90
                         -99.90    -99.90    -11.95    -22.25
                         -99.80    -99.80     -8.91    -17.38
                         -99.80    -99.80     -7.80    -15.60 … etc
.
.
.
etc.
```

Other output files:

raing\EC_data\ECmet_info.txt

If the program quits prematurely it gives an idea how far it got before quitting.

raing\EC_data\sta_precip_sum.txt

A cumulative amount of the precipitation for each year. This will show missing data and is pretty useless otherwise.

raing\EC_data\ECmet_problems reading.txt

If blank, no problems

3. Create Streamflow Files from HYDAT

ECflw.exe is executed in the **strfw\WSC_data** directory. All input files are located there as well.

str and **div** files are recorded flows at stream gauging locations and observed diversion flows (if applicable). The program **ECflw.exe** will read a list of stations and provided the station data is available in the working directory **strfw\WSC_data**, will create **strfw*_str.tb0** and **diver*_div.tb0** files for the years requested. The flow data can be extracted from the Env. Canada Data Explorer (ECDE). Provisional data obtained by special request from the WSC can also be accommodated.

3.1. ECflw.exe input files

Begin by selecting the flow stations in the ECDE and export the selected HYDAT stations to a file **FavHydatStations.tb0**

Copy this file to **flow_stations.tb0** which will be the file read by **ECflw.exe**

Example of a flow station file for **ECflw.exe** **strfw\WSC_data\flow_stations.tb0**

```
##########################################################################
##########################################################################
# NOTICE: This application and its data are provided AS-IS.
#
# In no event shall Environment Canada be liable for any damages whatsoev
# (including, without limitation, damages for loss of business profits,
# business interruption, loss of business information, or other pecuniary
# arising out of the use of, or inability to use this Environment Canada
# even if Environment Canada has been advised of the possibility of such
##########################################################################
##########################################################################
:FileType tb0  ASCII  EnSim 1.0
# National Research Council/Canadian Hydraulics Centre (c) 2010
# DataType                 EnSim Table Data
#
:Application              ECDataExplorer
:Version                  1.2.17
:WrittenBy                kouwen
:CreationDate             Thu, Jan 14, 2016 09:39 PM
#
#------------------------------------------------------------------------
#
:ColumnMetaData
:ColumnName Station Fav StationName HydStatus Prov Latitude Longitude Dra
:ColumnUnits "" "" "" "" "" Degrees Degrees km² "" "" "" "" "" "" "" "" "
:ColumnType text boolean text text text float float float integer integer
:EndColumnMetaData
#
```

```
#
:EndHeader
07AA002 True "ATHABASCA RIVER NEAR JASPER" Active AB 52.9102 -118.059 387
07AD002 True "ATHABASCA RIVER AT HINTON" Active AB 53.4243 -117.569 9764.
07AE001 True "ATHABASCA RIVER NEAR WINDFALL" Active AB 54.2075 -116.063 1
07AG004 True "MCLEOD RIVER NEAR WHITECOURT" Active AB 53.990 -115.84 9109
```

etc. **Note: file & lines are truncated.**

This file is the same format as the **FavHydatStations.tb0** that can be saved from the ECDE. However, it has been renamed to protect it from being accidentally overwritten with a newly saved file from the ECDE because at times, the gauge locations need to be moved slightly in order to ensure correct drainage areas in the model. For instance, if 2 WSC gauges are located in one grid, say one on the main river and another on a tributary, one or the other needs to be located in another grid that will reflect the proper contributing area upstream.

Another reason for the different name is that on occasion additional stations may need to be added to the list – which may have been edited as per above. These new stations can then be simply added to the list. The list can be re-sorted in Excel if so desired.

Example HYDAT *_ts.csv file: **\strfw\WSC_data\07GA007_Daily_Flow_ts.csv**

```
ID,PARAM,Date,Flow,SYM
07AG007,1,1984/05/07,55.6,A
07AG007,1,1984/05/08,53.3,
07AG007,1,1984/05/09,53,
07AG007,1,1984/05/10,55.6,
07AG007,1,1984/05/11,58.9,
07AG007,1,1984/05/12,57.1,
07AG007,1,1984/05/13,54.2,
etc.
```

Example of a provisional data file: **\strfw\WSC_data\Flow_07AH003.csv**

```
Station,Date,ProvsionalDailyMean,ProvisionalApprovalLevel,ProvisionalGrade
07AH003,2012-01-01,***,4,30
07AH003,2012-01-02,***,4,30
07AH003,2012-01-03,***,4,30
07AH003,2012-01-04,***,4,30
07AH003,2012-01-05,***,4,30
07AH003,2012-01-06,***,4,30
07AH003,2012-01-07,***,4,30
etc.
```

Notes:

1. ECDE data and provisional data cannot be used in the same year.
2. Take special note of the date formats!!! (Excel default = mm/dd/yyy)

3.2. ECflw dialogue

Once these files have been placed in this folder, in a DOS window with this folder as the working directory, a program **ECflw.exe (ECflw32.exe for 32 bit)** is be executed by answering 3 questions:

```
Would you like to run with natural flows y/n?
y
 What year would you like to start with yyyy?
1960
 enter the last year
2015
```

As written to the screen, the observed flow files, one file for each year, have been written to the **\strfw** folder for use by CHARM.

3.3. ECflw.exe output files

The main output file is the ***_str.tb0** file in the **/strfw** directory containing the observed river flows. Its most important use if for the optimization process where the objective function can be based on one of 7 user selected statistics. The value of the objective function is calculated as the model is executed. The observed flows are also paired with the computed flows and written to **results\spl.csv** and **results\spl.tb0** for various plotting options.

Example of ECflw.exe output: **strfw\19900101_str.tb0**

```
########################################
:FileType tb0  ASCII  EnSim 1.0
#
# DataType               Time Series
#
:Application             EnSimHydrologic
:Version                 2.1.23
:WrittenBy          mh_write_flow_tb0.f=ECflow.exe
:CreationDate       2016-04-01  21:35
#
#----------------------------------------
:SourceFile                    flow_data
#
:Name               streamflow
#
:Projection         LATLONG
:Ellipsoid          WGS84
#
:StartDate          1990/01/01
:StartTime          00:00:00.0
#
:AttributeUnits            1.0000000
:DeltaT               24
:RoutingDeltaT         1
```

```
#
:ColumnMetaData
   :ColumnUnits              m3/s        m3/s        m3/s   .   .   .  etc.
   :ColumnType              float       float       float
   :ColumnName             07AA002     07AD002     07AE001
   :ColumnLocationX     -118.0590   -117.5690   -116.0630
   :ColumnLocationY       52.9102     53.4243     54.2075
   :coeff1            0.00000E+00 0.00000E+00 0.00000E+00
   :coeff2            0.00000E+00 0.00000E+00 0.00000E+00
   :coeff3            0.00000E+00 0.00000E+00 0.00000E+00
   :coeff4            0.00000E+00 0.00000E+00 0.00000E+00
   :value1                      1           1           1
:EndColumnMetaData
:endHeader
                           17.800      46.900      -1.000
                           17.500      46.400      -1.000
                           17.200      45.800      -1.000
etc.
```

Other output files:

strfw\WSC_data\ECflw_info.txt

If the program quits prematurely it gives an idea how far it got before quitting.

nudge_flags.new --- example

```
-118.059  52.910  1  07AA002  ATHABASCA RIVER NEAR JASPER    3873.
-117.569  53.424  1  07AD002  ATHABASCA RIVER AT HINTON       9765.
-116.063  54.208  1  07AE001  ATHABASCA RIVER NEAR WINDFALL 19600.
-115.840  53.990  1  07AG004  MCLEOD RIVER NEAR WHITECOURT    9109.
-116.162  53.697  1  07AG007  MCLEOD RIVER NEAR ROSEVEAR      7143.
.
-121.909  56.027  2  07EF001  PEACE RIVER AT HUDSON HOPE    73100.
.
etc.
```

The columns are long – lat and then the nudgeflg , gauge ID, gauge name and drainage area. This file can be edited, renamed to **nudge_flags.txt** and located in the ***\strfw*** directory to set the nudgeflg for each station once the **nudgeflg** = 1 in the event file. These flags apply to the whole run (multiple events) when the **nudgeflg** = 1

In this example the flows at Hudson Hope 07EF001 are nudged. The others are not.

Example of grapehr_titles.csv: **strfw\WSC_data\grapher_titles.csv**

```
1,07AA002,"ATHABASCA RIVER NEAR JASPER        ",     3873.
2,07AD002,"ATHABASCA RIVER AT HINTON          ",     9765.
3,07AE001,"ATHABASCA RIVER NEAR WINDFALL      ",    19600.
4,07AG004,"MCLEOD RIVER NEAR WHITECOURT       ",     9109.
5,07AG007,"MCLEOD RIVER NEAR ROSEVEAR         ",     7143.
etc.
```

The contents of this file are extracted from the *flow_stations.txt* file and can be used in setting up the graph titles in Grapher.

Example of dischrge_sites.csv **strfw\WSC_data\discharge_sites.xyz**

```
xsta(i)  ysta(i)  i  idsta(i)  sta_name(i) dr_area(i)
-118.059  52.910 1  07AA002  "ATHABASCA RIVER NEAR JASPER          "    3873.
-117.569  53.424 2  07AD002  "ATHABASCA RIVER AT HINTON            "    9765.
-116.063  54.208 3  07AE001  "ATHABASCA RIVER NEAR WINDFALL        "   19600.
-115.840  53.990 4  07AG004  "MCLEOD RIVER NEAR WHITECOURT         "    9109.
-116.162  53.697 5  07AG007  "MCLEOD RIVER NEAR ROSEVEAR           "    7143.
```
etc.

This file can be used to import the graph titles in Grapher plots.

Each one of these files is a little different format as required for various post-processing applications. Optional output is to write a diversion file – not needed for this project.

4. Create Streamflow Files from CWS provisional data

ECprvl.exe is executed in the **strfw\WSC_data** directory. All input files are located there as well.

str files are recorded flows at stream gauging (no diversions) The program **ECprvl.exe** will read a list of stations and provided the station data is available in the working directory **strfw\WSC_data**, will create **strfw*_str.tb0** the years requested. Only flow data obtained by special request from the WSC is accommodated.

4.1. ECprvl.exe input files

Begin by selecting the flow stations in the ECDE and export the selected HYDAT stations to a file **FavHydatStations.tb0**

Copy this file to **flow_stations.tb0** which will be the file read by **ECprvl.exe**

Example of a flow station file for **ECprvl.exe** **strfw\WSC_data\flow_stations.tb0**

```
##########################################################################
##########################################################################
# NOTICE: This application and its data are provided AS-IS.
#
# In no event shall Environment Canada be liable for any damages whatsoev
# (including, without limitation, damages for loss of business profits,
# business interruption, loss of business information, or other pecuniary
# arising out of the use of, or inability to use this Environment Canada
# even if Environment Canada has been advised of the possibility of such
```

```
##########################################################################
##########################################################################
:FileType tb0  ASCII  EnSim 1.0
# National Research Council/Canadian Hydraulics Centre (c) 2010
# DataType                 EnSim Table Data
#
:Application              ECDataExplorer
:Version                  1.2.17
:WrittenBy                kouwen
:CreationDate             Sat, Oct 07, 2017 10:51 AM
#
#--------------------------------------------------------------------------
#
:ColumnMetaData
:ColumnName Station Fav StationName HydStatus Prov Latitude Longitude Dra
:ColumnUnits "" "" "" "" "" Degrees Degrees km² "" "" "" "" "" "" "" "" "
:ColumnType text boolean text text text float float float integer integer
:EndColumnMetaData
#
#
:EndHeader
02HC005 True "DON_RIVER_AT_YORK_MILLS" Active ON 43.7402 -79.4031 88.1 61
02HC056 True "DON-RIVER-EAST-BRANCH-NEAR-THORNHILL" Active ON 43.8266 -79
02HC024 True "DON_RIVER_AT_TODMORDEN" Active ON 43.6859 -79.3615 318.5 54
02HC057 True "HUMBER-RIVER-NEAR-BALLYCROY" Discontinued ON 43.9703 -79.88
.
.
etc.
```

Note: file & lines are truncated.

This file is the same format as the **FavHydatStations.tb0** that can be saved from the ECDE. However, it has been renamed to protect it from being accidentally overwritten with a newly saved file from the ECDE because at times, the gauge locations need to be moved slightly in order to ensure correct drainage areas in the model. For instance, if 2 WSC gauges are located in one grid, say one on the main river and another on a tributary, one or the other needs to be located in another grid that will reflect the proper contributing area upstream.

Another reason for the different name is that on occasion additional stations may need to be added to the list – which may have been edited as per above. These new stations can then be simply added to the list. The list can be re-sorted in Excel if so desired.

Note: The data can be in various formats. The program will ask which format #

1.1.11 Format 1

Example file name: **\strfw\WSC_data\Q_02HC005_2014.csv**

```
Time,Parameter,LocationId,DataId,NumRanges,NumPoints**
2017-10-16T17:47:43.340+00:00,QR,02HC005,QR.Working@02HC005**
RangeNumber,StartTime,EndTime,NumPoints
```

```
1,2013-12-31T19:00:00.000-05:00,2017-10-15T19:00:00.000-05:00,342185
RangeNumber,Time,Value,Quality,Interpolation,Approval
1,2013-12-31T19:00:00.000-05:00,0.429626458902813,,1,4
1,2013-12-31T19:15:00.000-05:00,0.43372465812813,,1,4
1,2013-12-31T19:30:00.000-05:00,0.42557615274911,,1,4
1,2013-12-31T19:45:00.000-05:00,0.417485118252784,,1,4
1,2013-12-31T20:00:00.000-05:00,0.441975573004925,,1,4
1,2013-12-31T20:15:00.000-05:00,0.421551204415154,,1,4
etc.
```

1.1.12 Format 2

Added Dec. 02/18

Example file name: **\strfw\WSC_data\ 02HC005_Q.csv**

```
,Discharge.Working@02EC002,Discharge.Working@02EC002,Discharge.Working
@02EC002,Discharge.Working@02EC002
dd/mm/yyyy HH:MM:SS,m^3/s,,,
Date-Time,Value,Grade,Approval,Interpolation Code
31/12/1999 00:00:00,29.8,10,4,8
01/01/2000 00:00:00,27.2,10,4,8
02/01/2000 00:00:00,26.1,10,4,8
03/01/2000 00:02:40,,,4,1
03/01/2000 00:02:40,25.5480055166865,,4,1
03/01/2000 00:07:40,25.5480071046874,,4,1
03/01/2000 01:02:40,25.5896133577438,,4,1
```

1.1.11 Format 3

Added Dec. 02/18

Example file name: **\strfw\WSC_data\ 02HC005.csv**

Same format as Format 2

1.1.12 Other formats not supported

Notes:

** line truncated

1. ECDE (HYDAT) data and provisional data cannot be used in the same year.
2. Take special note of the date formats!!! (Excel default = mm/dd/yyy)

4.2. ECprvl dialogue

Once these files have been placed in this folder, in a DOS window with this folder as the working directory, a program **ECflw.exe (ECflw32.exe for 32 bit)** is be executed by answering 3 questions:

```
Would you like to run with natural flows y/n?
y
 What year would you like to start with yyyy?
This is the year in the file names...
2014
 enter the last year
This is the last year in the data file
2016
```

As written to the screen, the observed flow files, one file for each year, will have been written to the **\strfw** folder for use by CHARM.

4.3. ECprvl.exe output files

The main output file is the ***_str.tb0** file in the **/strfw** directory containing the observed river flows. Its most important use if for the optimization process where the objective function can be based on one of 7 user selected statistics. The value of the objective function is calculated as the model is executed. The observed flows are also paired with the computed flows and written to **results\spl.csv** and **results\spl.tb0** for various plotting options.

Example of ECflw.exe output: **strfw\19900101_str.tb0**

```
########################################
:FileType tb0  ASCII  EnSim 1.0
#
# DataType               Time Series
#
:Application             EnSimHydrologic
:Version                 2.1.23
:WrittenBy          mh_write_flow_tb0.f=ECprvl.exe
:CreationDate       2017-12-01  15:36
#
#----------------------------------------
:SourceFile                   flow_data
#
:Name               streamflow
#
:Projection         LATLONG
:Ellipsoid          WGS84
#
:StartDate          2014/01/01
:StartTime          00:00:00.0
#
```

```
:AttributeUnits             1.0000000
:DeltaT                 1
:RoutingDeltaT          1
#
:ColumnMetaData
   :ColumnUnits              m3/s        m3/s        m3/s
   :ColumnType              float       float       float
   :ColumnName            02HC005     02HC056     02HC024
   :ColumnLocationX      -79.4031    -79.4381    -79.3615
   :ColumnLocationY       43.7402     43.8266     43.6859
   :coeff1            0.00000E+00 0.00000E+00 0.00000E+00
   :coeff2            0.00000E+00 0.00000E+00 0.00000E+00
   :coeff3            0.00000E+00 0.00000E+00 0.00000E+00
   :coeff4            0.00000E+00 0.00000E+00 0.00000E+00
   :value1                      1           1           1
:EndColumnMetaData
:endHeader
                            0.459       0.341       1.669
                            0.418       0.335       1.603
                            0.426       0.335       1.538
etc.
```

Other output files:

strfw\WSC_data\ECflw_info.txt

If the program quits prematurely it gives an idea how far it got before quitting.

nudge_flags.new --- example

```
-118.059  52.910  1  07AA002  ATHABASCA RIVER NEAR JASPER    3873.
-117.569  53.424  1  07AD002  ATHABASCA RIVER AT HINTON       9765.
-116.063  54.208  1  07AE001  ATHABASCA RIVER NEAR WINDFALL 19600.
-115.840  53.990  1  07AG004  MCLEOD RIVER NEAR WHITECOURT    9109.
-116.162  53.697  1  07AG007  MCLEOD RIVER NEAR ROSEVEAR      7143.
.
-121.909  56.027  2  07EF001  PEACE RIVER AT HUDSON HOPE    73100.
.
etc.
```

The columns are long – lat and then the nudgeflg , gauge ID, gauge name and drainage area. This file can be edited, renamed to **nudge_flags.txt** and located in the *\strfw* directory to set the nudgeflg for each station once the **nudgeflg** = 1 in the event file. These flags apply to the whole run (multiple events) when the **nudgeflg** = 1

In this example the flows at Hudson Hope 07EF001 are nudged. The others are not.

Example of grapehr_titles.csv: **strfw\WSC_data\grapher_titles.csv**

```
1,02HC005,"DON_RIVER_AT_YORK_MILLS                          ",      88.
2,02HC056,"DON-RIVER-EAST-BRANCH-NEAR-THORNHILL             ",      37.
3,02HC024,"DON_RIVER_AT_TODMORDEN                           ",     318.
```

```
    4,02HC057,"HUMBER-RIVER-NEAR-BALLYCROY                          ",       59.
etc.
```

The contents of this file are extracted from the *flow_stations.txt* file and can be used in setting up the graph titles in Grapher.

Example of dischrge_sites.csv **strfw\WSC_data\discharge_sites.xyz**

```
xsta(i)  ysta(i)  i  idsta(i)  sta_name(i) dr_area(i)
-79.403   43.740   1  02HC005  "DON_RIVER_AT_YORK_MILLS               "  88.
-79.438   43.827   2  02HC056  "DON-RIVER-EAST-BRANCH-NEAR-THORNHILL "  37.
-79.362   43.686   3  02HC024  "DON_RIVER_AT_TODMORDEN                " 318.
-79.888   43.970   4  02HC057  "HUMBER-RIVER-NEAR-BALLYCROY           "  59.
etc.
```

This file can be used to show the flow stations in GK..

Each one of these files is a little different format as required for various post-processing applications.

5. Create reservoir release and initial lake level files

ECrel.exe is executed in the **strfw\CWS_data** directory. All input files are located there as well.

The rel files have several functions. First, in the header are the coefficients for the storage-discharge function for lake natural outlets. This function can be either a power function or a polynomial function up to order 5. The WATFLOOD/CHARM manual has more detail in Section 8.2 on how to apply this, Second, for lake/reservoirs with known releases the release values can be entered into the rel file.

Reservoir and lakes need to be given initial lake elevations if lake or reservoir levels need to be compared to observed lake levels.

ECrel.exe two types of input files. The first is a single file with the operation rules for the lake and their initial conditions. The second are HYDAT files for reservoir releases if the lake outflows are controlled.

5.1. ECrel.exe Input files

Example of the rule file: **\strfw\WSC_data\lake_rules.csv**
(can be edited in Excel)

```
LongDecimal,LatDecimal,No,StationID,coef1,coef2,coef3,coef4,coef5,start_elv,datum,depth
-122.217,56.0167,1,07EF001,0.00E+00,0.00E+00,0.00E+00,0.00E+00,0.00E+00,34.8,34,100
-111.283,58.777,2,Athabaska,1.00E-15,1.75E+00,0.00E+00,0.00E+00,0.00E+00,208,206.4,26.1
-117.38085,61.202787,3,Gr_Slave,1.40E-15,1.75E+00,0.00E+00,0.00E+00,0.00E+00,156.4,155.3,41
```

```
-123.474,65.144,4,Gr_Bear,1.60E-16,1.75E+00,0.00E+00,0.00E+00,0.00E+00,6.25,5.3,71.7
-117.758,65.598,5,Clut_L,1.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,107,100,12
-114.217,62.8083,6,Prosperous_L,1.50E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,101.4,100,12
-114.756,55.305,7,Lssr_Slave_L,4.00E-15,1.75E+00,0.00E+00,0.00E+00,0.00E+00,576.4,575.7,11.4
-117.2698,63.1444,8,LacLaMatre,2.00E-15,1.75E+00,0.00E+00,0.00E+00,0.00E+00,101.2,100,12
-121.131,60.757,9,Trout_lake,2.00E-13,1.75E+00,0.00E+00,0.00E+00,0.00E+00,100.3,100,12
-108.175,58.967,10,Davy_Lake,1.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,102,100,12
-104.608,58.386,11,Theriau_Lake,2.50E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,101.7,100,12
-105.539,59.147,12,BlackLake,1.50E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,101.8,100,12
-107.67,61.876,13,PorterLake,1.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,105,100,12
-108.466,62.894,14,ArtilleryLake,1.50E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,101,100,12
-113.59,62.5,15,ReidLake,7.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,100.7,100,12
-126.323,60.222,16,UnknownLake,1.00E-15,1.75E+00,0.00E+00,0.00E+00,0.00E+00,116.5,100,12
-109.786,58.322,17,CluffLake,1.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,106,100,12
-118.19,65.23,18,HottahLake,2.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,100.5,100,12
-107.27,63.745,19,ClintonGoldenL,7.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,100.1,100,12
-109.871,64.133,20,MacKayLake,7.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,100.1,100,12
-115.365,64.063,21,ChalcoLake,5.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,101.4,100,12
-114.7,64.23,22,WekwetiLake,1.00E-12,1.75E+00,0.00E+00,0.00E+00,0.00E+00,100.05,100,12
-115.02,64.415,23,IndinRiver,5.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,100.15,100,12
-103.54,58.45,24,WollastonL,8.00E-14,1.75E+00,0.00E+00,0.00E+00,0.00E+00,100.55,100,12
```

This example is the complete file for the Mackenzie River WATFLOOD model. The lines have long-lat and the location number so the locations can be plotted in GK. This is followed by the station name**, then 5 coefficients that will appear in the rel file header, followed by the initial lake/reservoir elevation, the datum (usually the sill level or the river invert at the outlet) and the average depth of the lake if known (needed for the lake evaporation model). If actual lake elevations are now know, a datum of 100 can be assumed. This allows lake levels to fall below the datum due to evaporation.

If reservoir releases are to be routed downstream then release data in the WSC *ts.csv format must be read by **ECrel.exe To accomplish this, the WSC station ID needs to be given (as in the first line of the data) instead of the lake or reservoir name. The program will then look for the HYDAT station data with this name and insert the releases into the rel file.

WSC flow data (HYDAT & provisional) are handled exactly as in Section 3.1

5.2. ECrel.exe dialogue

After entering the **ECrel** command to run this program, the following dialogue appears:

```
 Would you like to run with natural flows y/n?
  Natural flows are based on the weir formula
  Release data is ignored
  and coefficients are taken from lake_rules.csv
n
  What year would you like to start with yyyy?
1960
enter the last year:
2015
  Please enter 1 or 2 depending on:
  1   lake_rules.csv
  2   lake_rules_mrbhm.csv
```

With this last question, the answer is 1 or 2 depending on whether files for the MRBHM are needed or not. The two sets of rel files are written to separate folders: **watflood\mrb22\resrl** or **watflood\mrb22\resrl_mrbhm**

5.3. EC_rel.exe output files

Example of a rel file: **resrl\19900101_rel.tb0**

```
########################################
:FileType tb0  ASCII  EnSim 1.0
#
# DataType               Time Series
#
:Application             WATFLOOD
:Version                 2.1.23
:WrittenBy          ECrel.exe
:CreationDate       2016-04-03  14:14
#
#----------------------------------------
:SourceFile                   WSC flow_data
#
:Name               ReservoirReleases
#
:Projection         LATLONG
:Ellipsoid          WGS84
#
:StartDate          1990/01/01
:StartTime          00:00:00.0
#
:DeltaT               24
#
:ColumnMetaData
   :ColumnUnits             m3/s        m3/s        m3/s        m3/s  ..  etc
   :ColumnType             float       float       float       float
   :ColumnName            07EF001     Athabas     Gr_Slav     Gr_Bear
   :ColumnLocationX    -122.2170   -111.2830   -117.3809   -123.4740
   :ColumnLocationY      56.0167     58.7770     61.2028     65.1440
   :coeff1            0.0000E+00  0.1000E-14  0.1400E-14  0.1600E-15
   :coeff2            0.0000E+00  0.1750E+01  0.1750E+01  0.1750E+01
   :coeff3            0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
   :coeff4            0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
   :coeff5            0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
:EndColumnMetaData
:endHeader
                       1030.000      -1.000      -1.000      -1.000
                       1390.000      -1.000      -1.000      -1.000
                       1500.000      -1.000      -1.000      -1.000
                       1560.000      -1.000      -1.000      -1.000
etc.
```

In this example, only the releases from Williston Lake are known and coefficients are 0.0 as a flag to indicate releases are to be used in the model. Where there is no release data, or where release data is to be ignored, at least 2 coefficient values are required.

Example of an initial lake level file: **level\19600101_ill.pt2**

```
########################################
:FileType pt2  ASCII  EnSim 1.0
#
# DataType               EnSim PT2 Set
#
:Application             WATFLOOD
:Version                 2.1.23
:WrittenBy          ECrel.exe
:CreationDate       2016-04-03  14:14
#
#---------------------------------------
:SourceFile                   WSC flow_data
#
:Name             Initial Lake Elevation
#
:Projection         LATLONG
:Ellipsoid          WGS84
#
 :SampleTime        1960/01/01  00:00:00.0
#
:AttributeName 1     StationName
:AttributeType 1     text
:AttributeName 2     InitialElevation
:AttributeType 2     float
:AttributeName 3     Datum
:AttributeType 3     float
:AttributeName 4     Depth
:AttributeType 4     float
:endHeader
 -122.2170   56.0167 "07EF001"       34.800      34.000     100.000
 -111.2830   58.7770 "Athabas"      208.000     206.400      26.100
 -117.3809   61.2028 "Gr_Slav"      156.400     155.300      41.000
 -123.4740   65.1440 "Gr_Bear"        6.250       5.300      71.700
 -117.7580   65.5980 "Clut_L "      107.000     100.000      12.000
 -114.2170   62.8083 "Prosper"      101.400     100.000      12.000
 -114.7560   55.3050 "Lssr_Sl"      576.400     575.700      11.400
 -117.2698   63.1444 "LacLaMa"      101.200     100.000      12.000
 -121.1310   60.7570 "Trout_l"      100.300     100.000      12.000
 -108.1750   58.9670 "Davy_La"      102.000     100.000      12.000
 -104.6080   58.3860 "Theriau"      101.700     100.000      12.000
 -105.5390   59.1470 "BlackLa"      101.800     100.000      12.000
 -107.6700   61.8760 "PorterL"      105.000     100.000      12.000
 -108.4660   62.8940 "Artille"      101.000     100.000      12.000
 -113.5900   62.5000 "ReidLak"      100.700     100.000      12.000
 -126.3230   60.2220 "Unknown"      116.500     100.000      12.000
 -109.7860   58.3220 "CluffLa"      106.000     100.000      12.000
 -118.1900   65.2300 "HottahL"      100.500     100.000      12.000
 -107.2700   63.7450 "Clinton"      100.100     100.000      12.000
 -109.8710   64.1330 "MacKayL"      100.100     100.000      12.000
 -115.3650   64.0630 "ChalcoL"      101.400     100.000      12.000
 -114.7000   64.2300 "Wekweti"      100.050     100.000      12.000
 -115.0200   64.4150 "IndinRi"      100.150     100.000      12.000
 -103.5400   58.4500 "Wollast"      100.550     100.000      12.000
```

Other output files:

strfw\WSC_data\ECrel_info.txt

If the program quits prematurely it gives an idea how far it got before quitting.

6. Create Lake Level files

EClvl.exe is executed in the **\level** directory. All input files are located there as well.

The lake level files are read by the model which upon execution writes paired observed and computed lake levels in the file **results\levels.txt** This file can then be used for plotting the observed and modelled lake levels. This data cannot be used for optimization as no error is calculated. However, by comparing the computed to the observed lake levels, the storage-discharge coefficients can be fitted for each lake by trial and error.

6.1. EClvl.exe input files

As for the flow data, a favourite hydat station list can be created for the level stations and called **LevelStations.tb0** The stations listed in this file are then exported from HYDAT in the *ts.tb0 format. **EClvl.exe** will read the **LevelStations.tb0** file and then used the files listed to create the *lvl.tb0 file for use by CHARM.

Example of a HYDAT level file: **level\WSC_data\LevelStations.tb0**

```
##########################################################################
##########################################################################
# NOTICE: This application and its data are provided AS-IS.
#
# In no event shall Environment Canada be liable for any damages whatsoever
# (including, without limitation, damages for loss of business profits,
# business interruption, loss of business information, or other pecuniary loss)
# arising out of the use of, or inability to use this Environment Canada product,
# even if Environment Canada has been advised of the possibility of such damages.
##########################################################################
##########################################################################
:FileType tb0  ASCII  EnSim 1.0
# National Research Council/Canadian Hydraulics Centre (c) 2010
# DataType                 EnSim Table Data
#
:Application              ECDataExplorer
:Version                  1.2.17
:WrittenBy                kouwen
:CreationDate             Wed, Mar 30, 2016 01:31 PM
#
#--------------------------------------------------------------------------
#
:ColumnMetaData
:ColumnName Station Fav StationName HydStatus Prov Latitude Longitude DrainageAre
:ColumnUnits "" "" "" "" "" Degrees Degrees km² "" "" "" "" "" "" "" "" "" "" ""
:ColumnType text boolean text text text float float float integer integer integer
:EndColumnMetaData
#
#
:EndHeader
07BJ006 True "LESSER SLAVE LAKE AT SLAVE LAKE" Active AB 55.3057 -115.772 13567 3
```

```
07EF002 True "WILLISTON LAKE AT LOST CABIN CREEK" Active BC 56.05 -123.748 0 37 1
07EF003 True "WILLISTON LAKE NEAR SCHOOLER CREEK" Active BC 56.1056 -122.732 0 34
07JA001 True "UTIKUMA LAKE NEAR NIPISI" Discontinued AB 55.9141 -115.171 2478.8 4
07JA002 True "SOUTH WABASCA LAKE NEAR DESMARAIS" Active AB 55.9397 -113.805 1600
07KF002 True "LAKE CLAIRE NEAR OUTLET TO PRAIRIE RIVER" Active AB 58.6333 -111.69
07MC002 True "LAKE ATHABASCA AT GOLDFIELDS" Discontinued SK 59.4514 -108.515 0 12
BEAR LAKE AT HORNBY BAY" Active NT 66.5997 -117.619 341.26 31
etc.
```

Note: lines are truncated
The format of the *LevelStations.txt* file is the same as the file FavHydatStations.tb0 However, the downloaded file may be edited to ensure that the long-lat locations fall in a grid marked as a reach in the WATFLOOD shd file.

The station ID given in the first field is used to open the WSC time series file for lake levels.

Example of HYDAT level file: **level\WSC_data\07BJ006_Daily_Level_ts.csv**

```
ID,PARAM,Date,Level,SYM
07BJ006,2,1979/02/01,,
07BJ006,2,1979/02/02,,
07BJ006,2,1979/02/03,,
07BJ006,2,1979/02/04,,
07BJ006,2,1979/02/05,,
07BJ006,2,1979/02/06,,
07BJ006,2,1979/02/07,,
07BJ006,2,1979/02/08,,
07BJ006,2,1979/02/09,,
07BJ006,2,1979/02/10,,
07BJ006,2,1979/02/11,,
07BJ006,2,1979/02/12,,
07BJ006,2,1979/02/13,,
07BJ006,2,1979/02/14,576.798,A
07BJ006,2,1979/02/15,576.805,
07BJ006,2,1979/02/16,576.805,
07BJ006,2,1979/02/17,576.813,
etc.
```

And for provisional data: **level\WSC_level\Level_07BJ006,csv**

```
Station,Date,ProvsionalDailyMean,ProvisionalApprovalLevel,ProvisionalGrade
07BJ006,2012-01-01,576.56,4,-1
07BJ006,2012-01-02,576.558,4,-1
07BJ006,2012-01-03,576.565,4,-1
07BJ006,2012-01-04,576.559,4,-1
07BJ006,2012-01-05,576.572,4,-1
07BJ006,2012-01-06,576.566,4,-1
07BJ006,2012-01-07,576.55,4,-1
07BJ006,2012-01-08,576.559,4,-1
07BJ006,2012-01-09,576.554,4,-1
07BJ006,2012-01-10,576.561,4,-1
07BJ006,2012-01-11,576.543,4,-1
07BJ006,2012-01-12,576.545,4,-1
etc.
```

6.2. EClvl.exe ouput files

Example of level data file: **level\19900101_lvl.tb0**

```
########################################
:FileType tb0  ASCII  EnSim 1.0
#
# DataType               Time Series
#
:Application             EnSimHydrologic
:Version                 2.1.23
:WrittenBy          EC_lvl.exe
:CreationDate       2016-04-02  00:01
#
#----------------------------------------
:SourceFile                    level_data
#
:Name               level
#
:Projection         LATLONG
:Ellipsoid          WGS84
#
:StartDate          1990/01/01
:StartTime          00:00:00.0
#
:AttributeUnits            1.0000000
:DeltaT               24
:RoutingDeltaT         1
#
:ColumnMetaData
   :ColumnUnits             m           m           m           m       etc
   :ColumnType            float       float       float       float
   :ColumnName           07BJ006     07EF002     07EF003     07JA001
   :ColumnLocationX    -115.7720   -123.7480   -122.7320   -115.1710
   :ColumnLocationY      55.3057     56.0500     56.1056     55.9141
:EndColumnMetaData
:endHeader
                         576.475      31.191      31.181    -999.000
                         576.474      31.154      31.139    -999.000
                         576.481      31.086      31.086    -999.000
                         576.476      31.031      31.039    -999.000
                         576.464      30.955      30.981    -999.000
                         576.473      30.895      30.940    -999.000
etc.
```

Missing values are set as -999

7. Blending CCC Daily and Hourly Precipitation – BLEND.exe

Often hourly precipitation data from non-Env. Can. sources is of poor quality, especially for snow. Usually tipping bucket rain gauges are used which can not record SWE amounts unless heated. CCC daily data usually is of better quality as each day new snow is measured and converted to SWE.

BLEND.exe will use the better quality CCC daily data to give the daily precipitation totals and use the hourly poor quality hourly data to give the time distribution. In other words, the recorded hourly precipitation is used to disaggregate the daily values keeping the daily values unchanged.

First both daily and hourly data are gridded and then the disaggregation is done on a grid-by-grid basis. In this way, precipitation gauges do not need to be paired and missing data is automatically accommodated.

Normally, point precipitation is converted to gridded precipitation by RAGMET.exe which reads a raing\ yyyymmdd_rag.tb0 file and converts it to a gidded file in radcl\yyyymmdd_met.r2c

For bending daily and hourly precip, four new folders are created:

hrlpp	hourly point precipitation
dlypp	daily point precipitatip
hrlgp	hourly gridded precipitation
dlygp	daily gridded precipitation

As noted in the code, assigned unit numbers are:

```
!     buf = DDP - distribute daily precip
!     buf = dhp - distribute hourly precip
! unit=201  fln(201)- Point Hourly Precip          hrlpp\yyyymmdd_pcp.tb0
! unit=202  fln(202)- Point Daily Precip           dlypp\yyyymmdd_pcp.tb0
! unit=203  fln(203)- Gridded Hourly Precip        hrlgp\yyyymmdd_pcp.r2c
! unit=204  fln(204)- Gridded Daily precip         dlygp\yyyymmdd_pcp.r2c
```

In the event file there are four additional (new) entries shown in **bold**:

```
:pointprecip                  raing\yyyymmdd_rag.tb0
:pointHourlyPrecip            hrlpp\yyyymmdd_rag.tb0
:pointDailyPrecip             dlypp\yyyymmdd_rag.tb0

:griddedrainfile              radcl\yyyymmdd_met.r2c
:griddedHourlyPrecip          hrlgp\yyyymmdd_met.r2c
:griddedDailyPrecip           dlygp\yyyymmdd_met.r2c
```

The data in these four new directories are of the same type as in the usual :pointprecip and :griddedrainfile directories. It is just that they are designated as daily and hourly data for use by BLEND.exe

Blending daily and hourly data is done on a grid-by-grid basis using these steps (Note: RAGMET is run with an argument ddp OR ddh for reading the daily or hourly tb0 files respectively:

1. RAGMET***.exe ddp - distribute daily precip
2. RAGMET***.exe ddh - distribute hourly precip
3. BLEND**.exe - blend daily and hourly precipitation grids

BLEND**.exe executes the following steps:

1. read EC 24 hour precip for each cell from **dlypp**yyyymmdd **_rag.tb0**
2. read TRCA hourly precip. for 24 hours from **hrlpp** yyyymmdd **_rag.tb0** and sum for each cell
3. divide daily precip / 24 hr sums -> scale factor for each cell
4. multiply each grid's hourly amount by scale factor.
5. write to yyyymmdd_met.r2c

8. Convert XML to tb0 format

At the time of writing (Mar. 2018) WATFLOOD is being enhanced with additional i/o capability to allow it to be a FEWS compatible model https://oss.deltares.nl/web/delft-fews/

This project is supported by FloodNet http://www.nsercfloodnet.ca/

FEWS exports and imports data in the XML format. WATFLOOD time series data is in the Green Kenue tb0 format. The program **mktb0.exe** will read XML precipitation, temperature and flow data and convert these to WATFLOOD yyyymmdd_tag.tb0, yyyymmdd_tag.tb0 and yyyymmdd_str.tb0 files respectively.

An XML file looks like this:

```
<?xml version="1.0" encoding="UTF-8"?>
<TimeSeries xmlns="http://www.wldelft.nl/fews/PI"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.wldelft.nl/fews/PI
http://fews.wldelft.nl/schemas/version1.0/pi-schemas/pi_timeseries.xsd"
version="1.2">
    <timeZone>0.0</timeZone>
    <series>
        <header>
            <type>accumulative</type>
            <locationId>HY002</locationId>
            <parameterId>PP01</parameterId>
            <timeStep unit="second" multiplier="3600"/>
            <startDate date="2008-12-31" time="23:00:00"/>
            <endDate date="2015-12-31" time="23:00:00"/>
            <missVal>-999.0</missVal>
            <stationName>HY002</stationName>
            <units>MM</units>
        </header>
        <event date="2008-12-31" time="23:00:00" value="0" flag="0"/>
        <event date="2009-01-01" time="00:00:00" value="0" flag="0"/>
        <event date="2009-01-01" time="01:00:00" value="0" flag="0"/>
.
.
        <event date="2015-12-31" time="23:00:00" value="0.03" flag="0"/>
    </series>
    <series>
        <header>
.                                (header for next location)
.                                (data for next location)
        <event date="2015-12-31" time="23:00:00" value="0.3" flag="0"/>
    </series>
</TimeSeries>                    (key word for the end of the file)
```

mktb0.exe patiently reads this file and converts it to the tb0 format. Sadly, this format does not include the station's coordinates or elevation in the case of the meteorological data. A separate file called **staton_location.xyz** with the coordinates and elevation is required. All stations for

flow, precipitation and temperature are in one file. This example is for the Don & Humber watersheds in Metro Toronto:

```
-79.504161,43.674304,4,02HC027,,BLACK CREEK NEAR WESTON,QIN,,,WSC,Humber
-79.86437474,43.86839823,5,HY012,291,Caledon Pumping Station,MET,,,TRCA,Humber
-79.834249,43.924493,6,02HC051,,CENTREVILLE CREEK NEAR ALBION,QIN,,,WSC,Humber
-79.630276,43.73689862,7,HY014,291,Claireville Dam,MET,,,TRCA,Humber
-79.719811,43.890334,8,02HC023,,COLD CREEK NEAR BOLTON,QIN,,,WSC,Humber
-79.322989,43.682363,9,HY016,115,Danforth and Coxwell,MET,,,TRCA,Don
-79.472295,43.793015,10,HY017,182,Don at Glenshields,QIN,,,TRCA,Don
-79.391008,43.739651,11,HY018,121,Don at Knightswood,QIN,,,TRCA,Don
-79.361417,43.685829,12,HY019,100,Don at Todmorden,QIN,,,TRCA,Don
-79.438084,43.826613,13,02HC056,999,DON RIVER EAST BRANCH NEAR THORNHILL,QIN,,,WSC,Don
-79.4792,43.831949,14,HY021,226,Dufferin Reservoir,MET,,,TRCA,Don
-79.4792,43.831949,15,HY021,226,Dufferin Reservoir,MET,,,TRCA,Humber
-79.61174089,43.90302698,16,HY038,229.6,East Humber at Mill Road,MET,,,TRCA,Humber
-79.611546,43.90308,17,02HC032,,EAST HUMBER RIVER AT KING CREEK,QIN,,,WSC,Humber
-79.584219,43.790138,18,02HC009,,EAST HUMBER RIVER NEAR PINE GROVE,QIN,,,WSC,Humber
-79.460893,43.771397,19,HY027,175,G Ross Dam,MET,,,TRCA,Don
-79.461341,43.771691,20,HY027,184,G Ross Dam,QIN,,,TRCA,Don
-79.460893,43.771397,21,HY027,175,G Ross Dam,MET,,,TRCA,Humber
-79.95195529,43.93706822,22,HY030,427.8,Glenn Haffey,MET,,,TRCA,Humber
-79.704344,43.768504,23,HY035,,Humber at Goreway,QIN,,,TRCA,Humber
-79.627386,43.811364,24,02HC025,,HUMBER RIVER AT ELDER MILLS,QIN,,,WSC,Humber
-79.520191,43.698993,25,02HC003,,HUMBER RIVER AT WESTON,QIN,,,WSC,Humber
-79.82282,43.928554,26,02HC047,,HUMBER RIVER NEAR PALGRAVE,QIN,,,WSC,Humber
-79.306037,43.818582,27,HY036,190,Kennedy Pump Station,MET,,,TRCA,Don
-79.71758685,43.88794054,28,HY037,211.6,King and Albion-Vaughan,MET,,,TRCA,Humber
-79.59280495,43.83515124,29,HY039,207.5,Kortright,MET,,,TRCA,Humber
-79.75968489,43.796955,30,HY041,235.2,Laidlaw Bus Depot,MET,,,TRCA,Humber
-79.52051681,43.69894783,31,HY076,116,Lawrence and Weston Rd,MET,,,TRCA,Humber
-79.45583282,43.94361274,32,HY083,294,Oak Ridges,MET,,,TRCA,Humber
-79.601811,43.777704,33,HY053,,Plunkett Creek,QIN,,,TRCA,Humber
-79.598675,43.836405,34,HY054,,Purpleville Creek,QIN,,,TRCA,Humber
-79.32825,43.701564,35,HY062,90,Taylor Creek South,QIN,,,TRCA,Don
-79.51367,43.771096,36,HY064,188,TRCA Head Office,MET,,,TRCA,Don
-79.51367,43.771096,37,HY064,188,TRCA Head Office,MET,,,TRCA,Humber
-79.678774,43.758343,38,02HC031,,WEST HUMBER RIVER AT HIGHWAY NO. 7,QIN,,,WSC,Humber
-79.47464,43.916657,39,HY069,325,York Pumping Station,MET,,,TRCA,Don
-79.47464,43.916657,40,HY069,325,York Pumping Station,MET,,,TRCA,Humber
-79.382514,43.884282,41,HY070,217,York Region Works Yard,MET,,,TRCA,Don
```

The XML files must be named as follows:

```
*flow.XML
*precip.XML
*temp.XML
```

“flow”, “precip” and “temp” are key words and must be the last characters of the file name. The first part of the file name, before the underscore, can be any name.

mktb0.exe is executed in the working bsnm directory with the following commands and arguments as follows:

mktb0 fromFEWS*flow.XML
mktb0 fromFEWS*precip.XML
mktb0 fromFEWS*temp.xml

where * can be any descriptor e.g. 2009-2017, HumberDon, etc. or nothing at all.

The output files are automatically created for all years of data in the XML files, names and written to the strfw, raing and tempr subdirectories.