Metropolitan Council Environmental Services	SOP	Environmental Quality Assurance (EQA) Standard Operating Procedure

Standard Operating Procedure: Estimation of Annual Tributary Stream Pollutant Loads with Flux32	
Version	1.3 (Updated 09/20/2010; update 12/9/2011; update 9/13/2012)
Author(s)	Karen Jensen, updated by Emily Resseger
Procedure Description	To calculate the annual pollutant loads for tributary streams using Flux32 software and water quality and flow data collected by the EQA – Environmental Monitoring and Assessment Unit or other project partners
Materials	Flux32 software (most recent version). Download at ftp://ftp.usace.army.mil/pub/erdc/EL/Simple_Tools/FLUX_Updates/ • Daily average flows (continuous record of measured and estimated daily flows) • Event composite and grab sample flows and pollutant concentrations
References	• Manual_IR-W-96_2.pdf: "Simplified Procedures for Eutrophication Assessment and Prediction: User Manual". William W. Walker. Instruction Report W-96-2. September 1996. Updated April 1999. U.S. Army Corps of Engineers • SOP_Flux32_River_Load_Estimates_v1.3.docx • MCES Steps for Flux Analysis_draft_200307.doc • MPCA_FLUX32_Process_Checklist.doc • Memo_20100714_WQ_Dataset_Review.docx
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Summary:

This SOP outlines the methodology for estimating annual pollutant loads for tributary streams from monitored daily average flow and grab/composite event sample chemistries using the U.S. Army Corps of Engineers' software Flux32. Due to differences in input data processing and load estimation methodology, a separate SOP will be developed for estimating annual loads for monitoring stations located on the three major rivers (Mississippi, Minnesota, and St. Croix).

Flux32 can easily be used mindlessly, resulting in inaccurate loads and statistics. It is crucial to use Flux32 mindfully with good technical judgment and familiarity with the stream or river dynamics, to ensure loads are accurate and defensible. This SOP is intended to provide typical procedures followed by MCES when calculating stream pollutant loads. Some stream sites or some years of data may be aberrant, and pollutant load calculation methodology must deviate from this SOP. <u>All deviations from SOP procedures will be recorded in both the .TXT output file and in the results database "notes" field.</u>

Due to the flashy hydrology and associated complicated sample collection in tributary streams, MCES staff have determined that using **<u>three years of flow and chemistry data</u>** (i.e. the year of interest plus the two preceding years) to estimate annual loads typically reduces the statistical uncertainty of the load estimates. In comparison the three major rivers responds relatively slowly to precipitation events, allowing the river load estimates to rely on only one year of daily flow and chemistry data.

Annual load estimates for the streams will be used in annual water quality summary reports, comprehensive assessment reports (to be completed every 3-to-5 years), special studies, and shared with external stakeholders. Annual load estimates for the major rivers will be used for similar activities and reports such as the annual benchmark report produced by the Metropolitan Council.

Basic steps for estimation of annual loads include:

- Creation of two Flux32 input files: average daily flow and water quality (Table 1)
- Estimation of loads using Flux32 software, adjusting flow or seasonal stratification breaks to reduce the coefficient of variance (C.V.) to 0.2 or lower and to reduce slope in residual plots
- Creation of output text files in specified format to document Flux32 results
- Transfer the results to master database of stream load results
- Creation of Flux32 Session (.FSS) File.

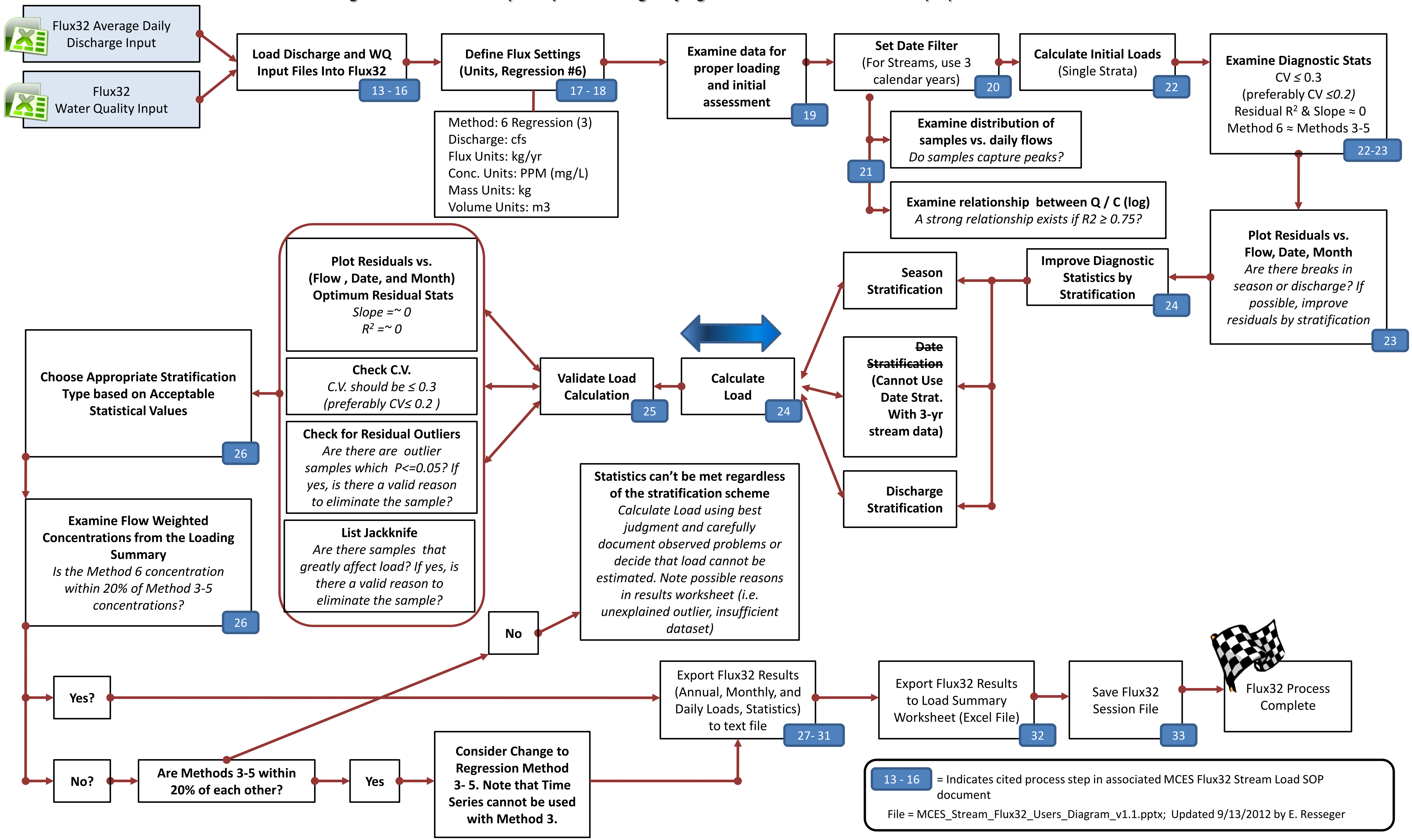
Table 1: Historic MCES, Stakeholder, and Other Major Metro Area Tributary Stream Sites and Station Abbreviations

Stream Name and Mile of Monitoring Station	Major Basin	Abbreviation (Site Code)	Year Established	Monitoring Staff / Data Owner	Notes / Partners
Bassett Creek 1.9	Mississippi	BS1.9	2000	Harrod	Minneapolis Park and Rec Board
Battle Creek 2.2	Mississippi	BA2.2	1995	Champion	RWMWD
Beltline Interceptor 0.5	Mississippi	BELT0.5	1995	Champion	RWMWD
Cannon River 11.9	Mississippi	CN11.9	2000	Harrod	Dakota SWCD
Crow River 23.1	Mississippi	CW23.1	2000	Harrod	Wright County SWCD
Crow River, South Fork 20.3	Mississippi	CWS20.3	2001	Champion	Carver County Environmental Services
Elm Creek near Champlin	Mississippi	ELM	1978	USGS and Elm Creek Watershed Management Commission	Not MCES cooperative station; USGS Station 05287890 operated in cooperation with Elm Creek Watershed Management Commission http://waterdata.usgs.gov/mn/nwis/
Fish Creek 0.2	Mississippi	FC0.2	1995	Champion	RWMWD
Minnehaha Creek 1.7	Mississippi	MH1.7	2000	Harrod	Minneapolis Park and Rec Board
Rice Creek 3.7	Mississippi	RC3.7	Unknown	Rice Creek Watershed District	Not MCES cooperative station; Rice Creek Watershed District http://ricecreek.org/
Rum River 0.7	Mississippi	RUM0.7	1996	Champion	Anoka Conservation District
Shingle	Mississippi	SC-0	Unknown	Shingle	Not MCES cooperative station; belongs to

Creek Outlet		(Water Management Commission station name)		Creek Water Management Commission	Shingle Creek Watershed Management Commission http://www.shinglecreek.org/wqlstrmon.shtml
Vermillion River 2.0	Mississippi	VR2.0	1995	Champion	Dakota SWCD
Bevens Creek (Lower) 2.0	Minnesota	BE2.0	1989	Haire	MCES Non-point Source Station
Bevens Creek (Upper) 5.0	Minnesota	BE5.0	1992	Haire	MCES Non-point Source Station
Bluff Creek 3.5	Minnesota	BL3.5	1991	Haire	MCES Non-point Source Station
Carver Creek 1.7	Minnesota	ca1.7	1989	Haire	MCES Non-point Source Station
Credit River 0.9	Minnesota	cr0.9	1989	Haire	MCES Non-point Source Station
Eagle Creek 0.8	Minnesota	ea0.8	2000	Harrod	Lower Minnesota Watershed District
Nine Mile Creek 1.8	Minnesota	nm1.8	1989	Haire	MCES Non-point Source Station
Riley Creek 1.3	Minnesota	ri1.3	2000	Harrod	Riley-Purgatory-Bluff Creek Watershed District
Sand Creek 8.2	Minnesota	sa8.2	1990	Pattock	MCES Non-point Source Station
Sand Creek – Scott County Ditch 10	Minnesota	sd10	~1994; Discontinued 2010	Pattock	Operated in partnership with Scott SWCD. Station discontinued in 2010
Sand Creek – West Raven	Minnesota	wr	~1994; Discontinued 2010	Pattock	Operated in partnership with Scott SWCD. Station discontinued in 2010
Willow Creek 1.0	Minnesota	wi1.0	2000; Discontinued 2010	Harrod	Dakota SWCD; Station discontinued in 2010
Browns Creek 0.3	St. Croix	br0.3	1997	Champion	Washington Conservation District
Carnelian Marine 3.0	St. Croix	cm3.0	1995; Discontinued 2010	Champion	Washington Conservation District; station discontinued in 2010
Silver Creek 0.1	St. Croix	si0.1	1998	Champion	Washington Conservation District; site originally located at si0.7
Valley Creek 1.0	St. Croix	va1.0	2000	Harrod	Valley Branch WD, St. Croix Watershed Research Station

MCES Flux32 SOP Overview for Stream Load Calculations

Note: Intended as guidance document only. Analyst must use good judgment and mindfulness to ensure proper calculation of loads with Flux32.



Action 1: Create Flux32 Input File: Daily Average Flow

☑ (STEP 1) For streams: download daily average flows from http://environment/EQA/EMA/WaterQuality/ContStreamData.asp

☑ (STEP 2) Examine flow dataset for completion for the period of interest, with no missing data. Staff of the EQA-Environmental Monitoring and Assessment Unit should have estimated missing data to create continuous set of daily flows.

☑ (STEP 3) Create Excel spreadsheet using the following format or append new data to existing input file and update notes page to reflect addition of data.

- Create two worksheets within file. First worksheet labeled "flow" on bottom tab; second worksheet labeled "notes"

☑ (STEP 4) Each Excel worksheet should use the following format or append new data to existing input file and update notes page. The notes worksheet should be updated when new data is added each year.

- Cell A1 has no effect on Flux and should contain site description and any other relevant information.
- Cell B1 should define the flow unites used (i.e. CFS, ft3/s or ft3/sec, m3/s, m3/sec, or CMS
    - hm3/y or million m3/y)

- Format "flow" worksheet as follows:

	A	B	C	D
1	Site description	ft3/sec		
2	Date	Flow	Qualifier	
3	01/01/99	10		
4	01/02/99	15	e	

- Format "notes" worksheet as follows. This worksheet will be updated as new data is added each year.

	A	B	C	D
1	Site description			
2	Date	Note	Author	
3	05/26/09	Added 2008 data	Kmj	
4	05/28/10	Added 2009 data	Kmj	

☑ (STEP 5) Name flow input file according to following naming convention:

- Siteabbreviation_latestyearofdata_flow.xls
- Example: sa8.2_2008_flow.xls

  See example file:
  NATRES\Assessments\WQ_Load_Calculations\Sample_files\Sample_stream_flux32_flow_input_file.xls

Note: if adding new data to existing Flux32 input file, update Notes page and resave file in appropriate file folder with new file name appropriate for the most recent data added (eg. sa8.2_2010_flow.xls). **Do not alter existing files**, as they will be used to recreate loads if questions/problems arise in future. MCES internal file structure for the storage of Flux32 files is outlined in the Annual WQ Assessment SOP
File Location: \NATRES\Assessments \Documents\SOP\SOP_WaterQuality_Assessment_V1.doc

Action 2: Create Flux32 Input File: Water Quality

☑ (STEP 6) Download verified water quality data from EIMS or Water Quality Database. Data flagged as censored (‘X’) should be excluded, while data flagged as suspect (‘S’) should be included. Make sure file includes fields “flux date” and “flux flow”. “Flux date” is either the date of grab sample collection or the mid-storm date for composite samples. “Flux flow” is either the instantaneous sample flow for grab samples or the average sample flow for the period of composite sample collection. Also make sure the file includes field comments to be used if a sample point is being assessed as an outlier to be removed from analysis. Additional assistance in processing data can be found in ***Memo_20100714_WQ_Dataset_Review.docx***

☑ (STEP 7) To avoid calculation error in Flux32, make sure there is only one sample per date

- For two (or more) grab samples per date: average flows and concentrations
- For one grab and one composite per date: delete the grab sample and keep composite results
- For two (or more) composite samples per date:
  - → Are the samples representing portions of the same storm? If so, estimate the average flow and concentration for the two composites as follows:

    Average Flow Flow:
    Composite 1 Volume: Event Length (Seconds) * Flux flow (cfs) = (ft^3)
    Composite 2 Volume: Event Length (Seconds) * Flux flow (cfs) = (ft^3)

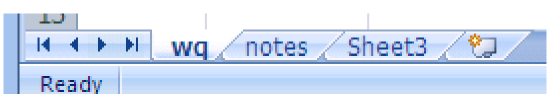
    $$\text{Average Composite Flow (cfs)} = \frac{Comp1\ Volume\ (ft3) + Comp2\ Volume(ft3)}{Comp1(Seconds) + Comp2\ (Second)}$$

    Flow Weighted Mean Concentration (FWMC):
    Composite 1 Mass = Flow * Concentration
    Composite 2 Mass = Flow * Concentration
    ∑ Sample Volume = Total Volume (ft^3)

    $$\text{FWMC} = \frac{\Sigma\ (Compsite\ 1\ Mass + Composite\ 2\ Mass)}{\Sigma\ (Compsite\ 1\ Volume + Composite\ 2\ Volume)}$$

  - → Are the two composites separate events? If so, delete one event and note in data processing log, as only one sample is allowed per date.

☑ (STEP 8) Create an Excel spreadsheet with separate worksheets for notes and water quality (wq). This file will serve as the Flux32 Water Quality Input File.



☑ (STEP 9) Create two worksheets. First worksheet labeled “wq”; second worksheet labeled “notes”

- Format “wq” worksheet as follows.
- Cell A1 has no effect on Flux and should contain site description and any other relevant information.
- Cell B1 should define the concentration units (ppb, mg/L, or ppm)
- Cell C1 should define the sample flow units (cfs, ft3/s, m3/s, hm3/yr)

- For ease of future data analysis, some water files will also contain fields for turbidity in NTU and NTRU. Obviously, a turbidity load cannot be calculated with Flux.

	A	B	C	D	E	F	G
1	Site description	Concentration units	Flow units				
2	Date	Sample_flow	Field_data_ID	Type	TP	TSS	NO3
3	01/01/99	10	345678	grab	0.105	549	4.5
4	01/02/99	15	356780	composite	0.255	1549	1.2

☑ (STEP 10) Format "notes" worksheet as follows. If modifications are made to an existing water quality dataset, the changes should be reflected in this page.

	A	B	C	D	E	F
1	Site description					
2	Date	Note	Data download date	Data filename	Author	
3	05/26/09	Added 2008 data	05/13/09	Allstreams_2008 .xls	Kmj	
4	05/28/10	Added 2009 data	05/20/10	Allstreams_2009 .xls	Kmj	

☑ (STEP 11) Name flow input file according to following naming convention:
Siteabbreviation_latestyearofdata_wq.xls
Example: sa8.2_2008_wq.xls

See example input file:
NATRES\Assessments\WQ_Load_Calculations\Sample_files\Sample_stream_flux32_wq_input_file.xls

Note: if adding new data to existing Flux32 input file, update Notes page and resave file in appropriate file folder with new file name appropriate for the most recent data added (eg. sa8.2_2010_wq.xls). **Do not alter existing files**, as they will be used to recreate loads if questions/problems arise in future. MCES internal file structure for the storage of Flux32 files is outlined in the Annual WQ Assessment SOP.
File Location: NATRES\Assessments\Documents\SOP\SOP_WaterQuality_Assessment_V1.doc

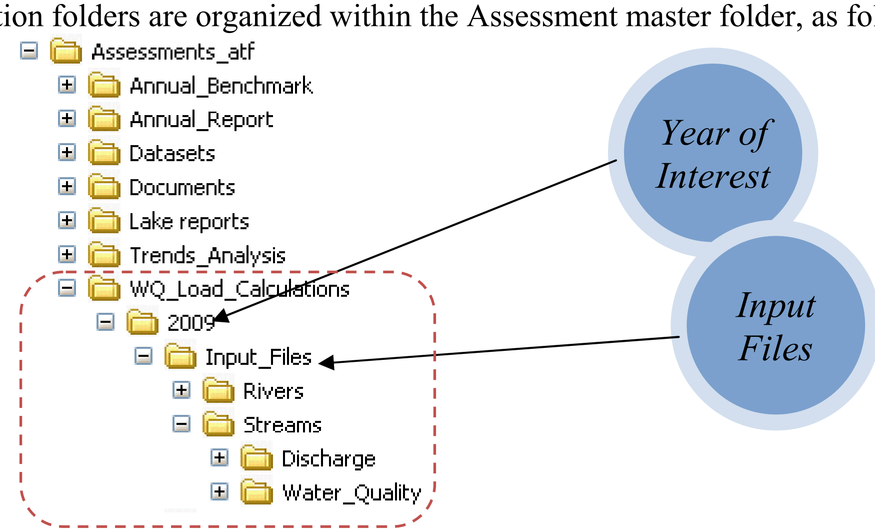
Action 3: Load Flux32 Input Files for New Project

☑ (STEP 12) Open Flux32 executable

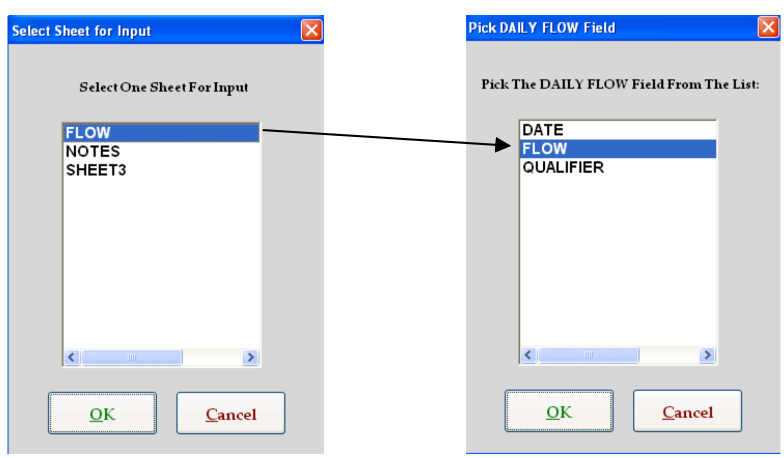
☑ 

If starting a New Project: **Data** → **Read** → **New Sample and Flow Data** → **New Stratification**
If opening an existing project: **Session** → **Resumed Saved Session** (.FSS File)

☑ (STEP 13) After selecting New Stratification, Flux32 will prompt the user to locate the file directory of the discharge (eg. sa8.2_2009_flow.xls) and water quality samples (eg. sa8.2_2009_wq.xls). The water quality load calculation folders are organized within the Assessment master folder, as follows:

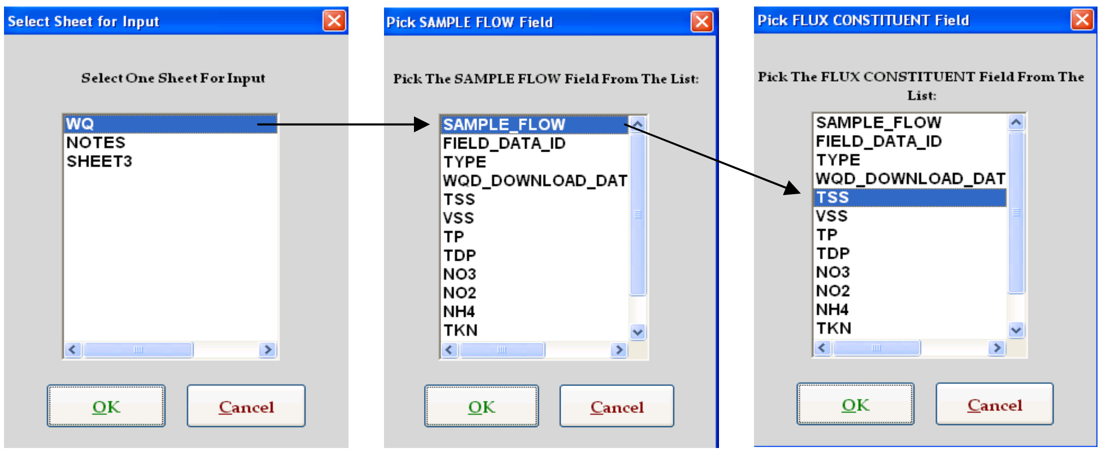


☑ (STEP 14) Flux32 will first read in the daily discharge worksheet. If the daily flow file contains multiple worksheets, the user must indicate what worksheet (i.e. FLOW) is going to be used and the column identifier that the flow data is located in.



☑ (STEP 15) Flux32 will next read the water quality worksheet. Similar to the discharge input, if the water quality file contains multiple worksheets, Flux32 will prompt user to select the worksheet that contains the appropriate site information (i.e. WQ) to be used. Flux32 will next prompt user to select SAMPLE_FLOW Field from a list of fields. For stream load estimation, the user should select the field named SAMPLE_FLOW from the list, as each sample should have an associated composite or instantaneous flow.

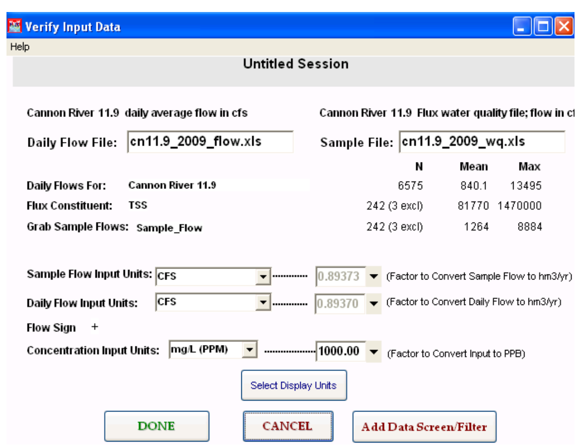
Note: This differs from river load estimation. MCES typically uses the daily average flow to represent the sample flow when calculating major river loads. Most major river samples are collected as grab samples and the major river flows change relatively slowly – thus use of daily average flow as an approximation of sample flow is appropriate.



☑ (STEP 16) Flux32 will next prompt user to select the **FLUX CONSTITUENT Field** from a list of fields. Select field name of parameter to be estimated.

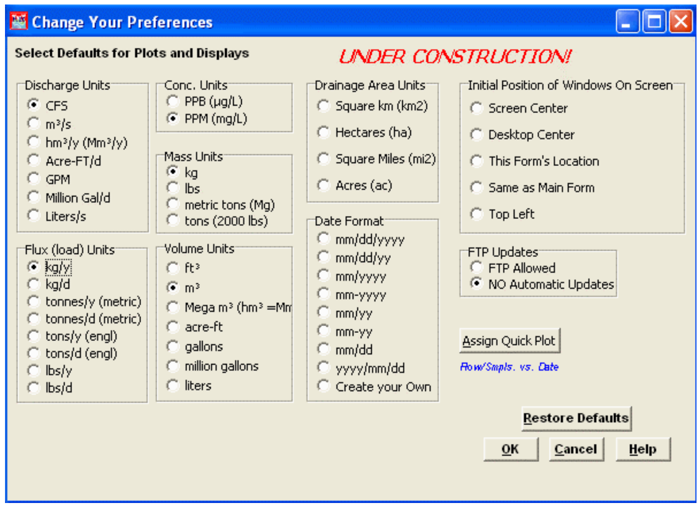
☑ (STEP 17) Flux32 will then prompt user to complete the following:

- o Enter/Modify Site Name: Enter appropriate site name and location.
- o Confirm input data. Examine the page to make sure number of daily flows and number of samples seems appropriate
- o Confirm appropriate values for unit conversion. Ensure the conversion factors are correct: 0.894 if using cfs; 1,000 if using mg/l. Use dropdown menus to change values, if necessary.



- Click on the ‘Select Display Units’ button. Select the default units for estimating stream loads (these are different than river loads).
  - Discharge Units: *CFS*
  - Flux (load) Units: *kg/y*
  - Conc. Units: *PPM (mg/L)*
  - Mass Units: *kg*
  - Volume Units: *m*^{3}

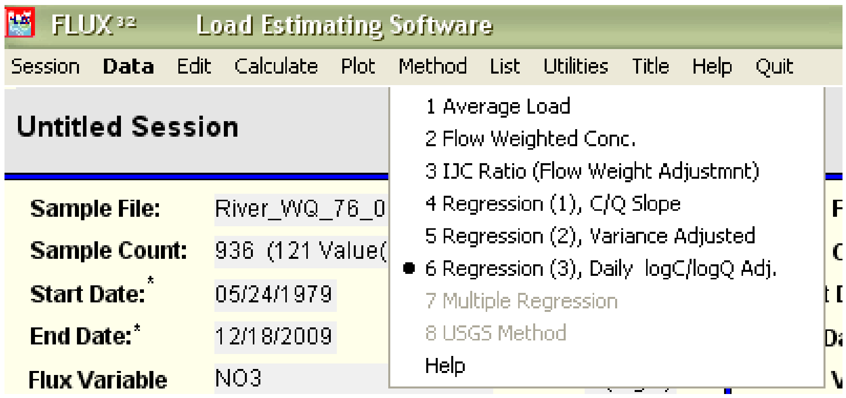
  The right two columns of the dialog box can be left blank.



Note: If Flux32 detects duplicate samples, open the water quality input file and manually delete duplicates as described previously in this SOP. Reload data into Flux32. Do not use the Flux32 prompts to delete duplicate samples.

☑ (STEP 18) Set initial default settings

- Select Method #6: **Method → 6 Regression (3): Daily log c/log q, adj**
  Note: Method 6 is the preferred calculation method as it designed for use with the time series function, which will be used later in this SOP to save data output for yearly, monthly, and daily time steps. (If a load is unable to be calculated using Method 6, the user may use an alternate method. A complete explanation of the Method 6 departure criteria is outlined in Step 26.)



- Name Session Title: **Title→Session Title**
  - Name session using stream name and monitoring location mile, for example Vermillion River 2.0.

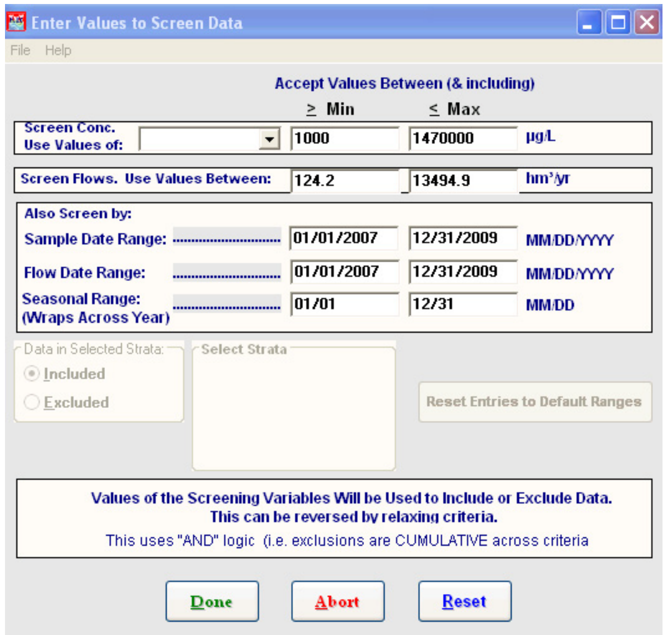
☑ (STEP 19) Examine entire dataset to ensure proper loading and assess potential stratification schemes. Confirm that flow data are complete without breaks and that number of samples indicated seems appropriate. Examine plots for concentration vs. flow or concentration vs. season relationships.

☑ (STEP 20) Set Data filter/screen to include only data period of interest.

- **Data → Screen/filter data → Apply Date & Value screens → Sample Date Range**:
  For stream sites, **three calendar years** of data are used to develop regression equations used in estimating loads. The max date should be set to the last day of the year of interest (12/31/2009 when estimating 2009 loads). The min date should be set to the first day of third previous year (for estimating 2009 loads, the min date would be 01/01/2007). If the analyst is calculating the load for the first year of monitoring data, it is necessary to use the two following years to create a three-year record. For example, if 2005 is the first year of monitoring, the 2005 load will be calculating using data from 2005-2007. The load for the second year of monitoring (2006) must also be calculated using 2005-2007.

  Similarly, if a year of data is missing due to equipment failure, use judgment to define three year period of data. For example, if loads are to be calculated for 2007, but the station was inoperative during 2006, the analyst may decide to use 2004, 2005, and 2007 as the three year period. Of course, the date range will be noted in the output .TXT file and the output database.

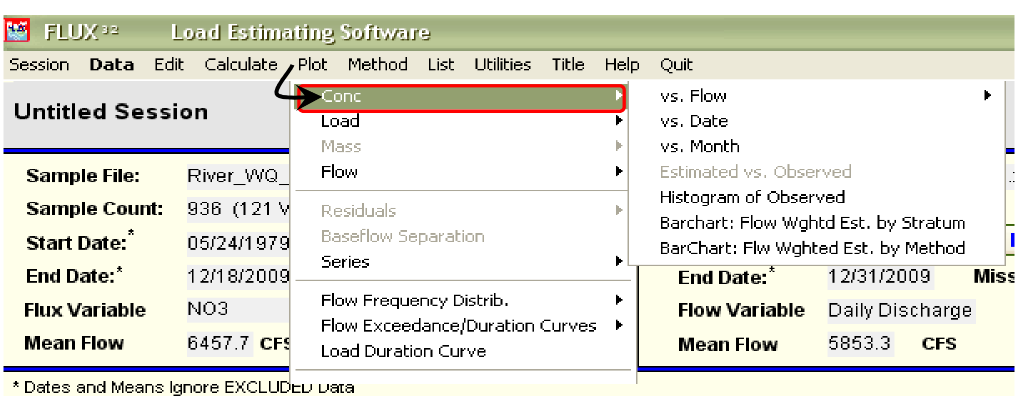
- **Data → Screen/filter data → Apply Date & Value screens → Flow Date Range:** For stream sites, **<u>three calendar years</u>** of data are used. The max date should be set to the last day of the year of interest (eg. 12/31/2009 when estimating 2009 loads). The min date should be set to the first day of third previous year (for estimating 2009 loads, the min date would be 01/01/2007). See above paragraph on **Sample Date Range** for more guidance setting dates for unusual circumstances.



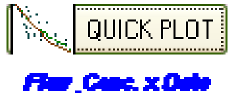
<u>Note</u>: Once dates are changed using data screen, do not simply change the dates again to re-filter data, as an error occurs and data will not be loaded properly. To reset dates: **Data → Screen/filter data → Apply Date & Value screens → Reset** and then repeat date filter process described above.

☑ (STEP 21) Examine filtered dataset to ensure proper loading and assess potential stratification schemes. Make sure flow data is complete without breaks and that number of samples indicated seems appropriate. Examine plots for concentration vs. flow or concentration vs. season relationships. Look for logical breaks in relationship where stratification breaks could be made.

- **Plot → Conc → vs. Flow > linear**
- **Plot → Conc → vs. Flow > log**
- **Plot → Conc → vs. Date**
- **Plot → Conc → vs. Month**



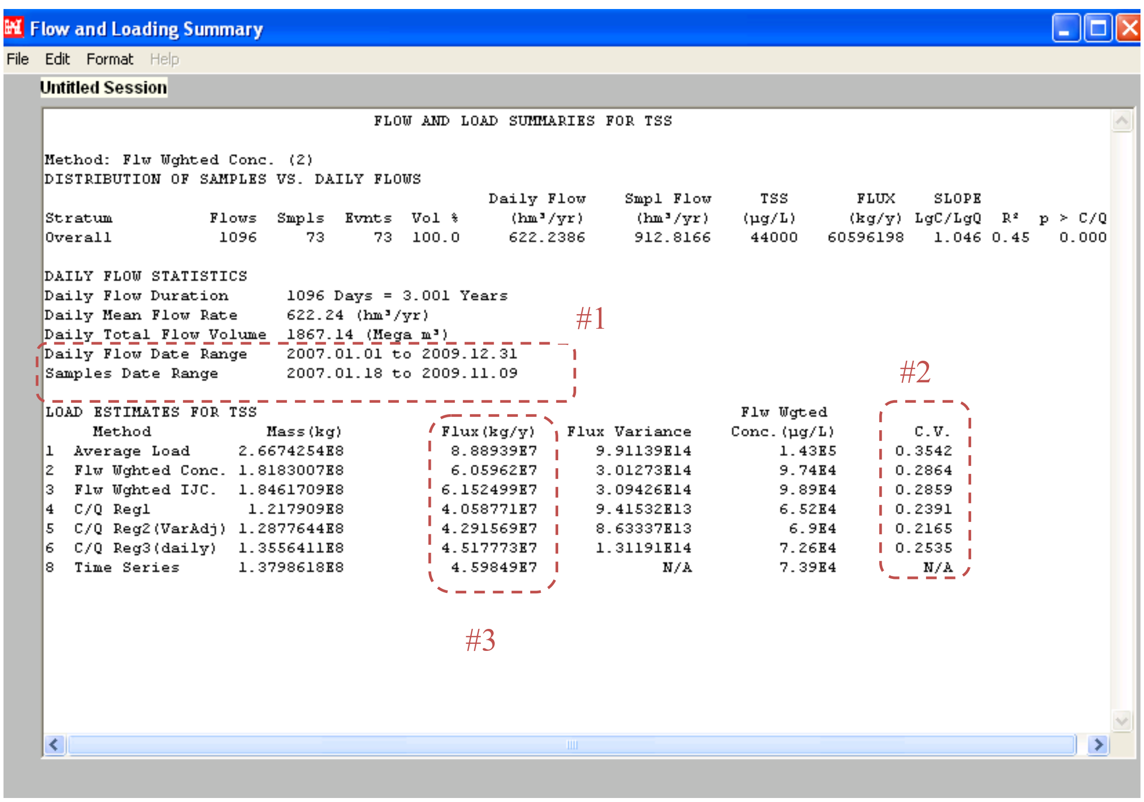
- Verify the distribution of samples versus daily flows to ensure that the samples capture the peaks. This information can be obtained using the Quick Plot tool on the main screen of Flux32.



While there are no specific criteria for appropriate flow vs. concentration or the distribution of samples to daily flows, weak relationships can hinder the user's ability to calculate loads and can be used to justify the inability to calculate a load (Step 26).

☑ (STEP 22) Calculate initial loads using one stratum

- **Calculate → Loads**
  - Examine *Flow and Load Summary* output. In particular:
    - Do the daily flow statistics agree with the dates selected in the data filtering process (#1 below)?
    - Is the Flux (kg/y) similar between the various statistical Methods 2-6 (#2 below)? Is the Method 6 C.V. < 0.2? How do the Method 6 results compare to the other methods (#3 below)?
    - The inability to meet the following criteria does not necessarily mean a load cannot be calculated; however, additional modifications to the data as outlined in subsequent steps (i.e. stratification, method change) may be needed.

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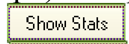
                     FLOW AND LOAD SUMMARIES FOR TSS

Method: Flw Wghted Conc. (2)
DISTRIBUTION OF SAMPLES VS. DAILY FLOWS
                                              Daily Flow   Smpl Flow    TSS      FLUX    SLOPE
Stratum          Flows  Smpls  Evnts  Vol %    (hm³/yr)     (hm³/yr)   (µg/L)    (kg/y) LgC/LgQ  R²  p > C/Q
Overall           1096     73     73  100.0    622.2386     912.8166    44000  60596198   1.046 0.45   0.000

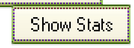
DAILY FLOW STATISTICS
Daily Flow Duration       1096 Days = 3.001 Years
Daily Mean Flow Rate      622.24 (hm³/yr)
Daily Total Flow Volume   1867.14 (Mega m³)
Daily Flow Date Range     2007.01.01 to 2009.12.31
Samples Date Range        2007.01.18 to 2009.11.09

LOAD ESTIMATES FOR TSS                                                 Flw Wgted
     Method             Mass(kg)            Flux(kg/y)   Flux Variance   Conc.(µg/L)      C.V.
1  Average Load      2.6674254E8             8.88939E7     9.91139E14        1.43E5      0.3542
2  Flw Wghted Conc.  1.8183007E8             6.05962E7     3.01273E14        9.74E4      0.2864
3  Flw Wghted IJC.   1.8461709E8           6.152499E7     3.09426E14        9.89E4      0.2859
4  C/Q Reg1           1.217909E8           4.058771E7     9.41532E13        6.52E4      0.2391
5  C/Q Reg2(VarAdj)  1.2877644E8           4.291569E7     8.63337E13         6.9E4      0.2165
6  C/Q Reg3(daily)   1.3556411E8           4.517773E7     1.31191E14        7.26E4      0.2535
8  Time Series       1.3798618E8             4.59849E7            N/A        7.39E4         N/A
```

☑ (STEP 23) Examine initial qualitative (graph) and quantitative (statistics) diagnostics.

- **Plot → Residuals → vs. Flow →** 

- **Plot → Residuals → vs. Date →** 

- **Plot → Residuals → vs. Month →** 

Note: Input data and associated loads for streams may be influenced by flow and by date/season, in which case the flow residual plot may look acceptable (no slope, high slope significance, low R^2) while the date or month residual plots may be sloped, indicating a date or seasonal bias. Flux32 does not include both date and flow relationships in the load estimates; however, the USGS load estimation tool (LOADEST) does have that capability. With Flux32, the user must choose to either minimize flow residuals or minimize date/seasonal residuals using stratification.

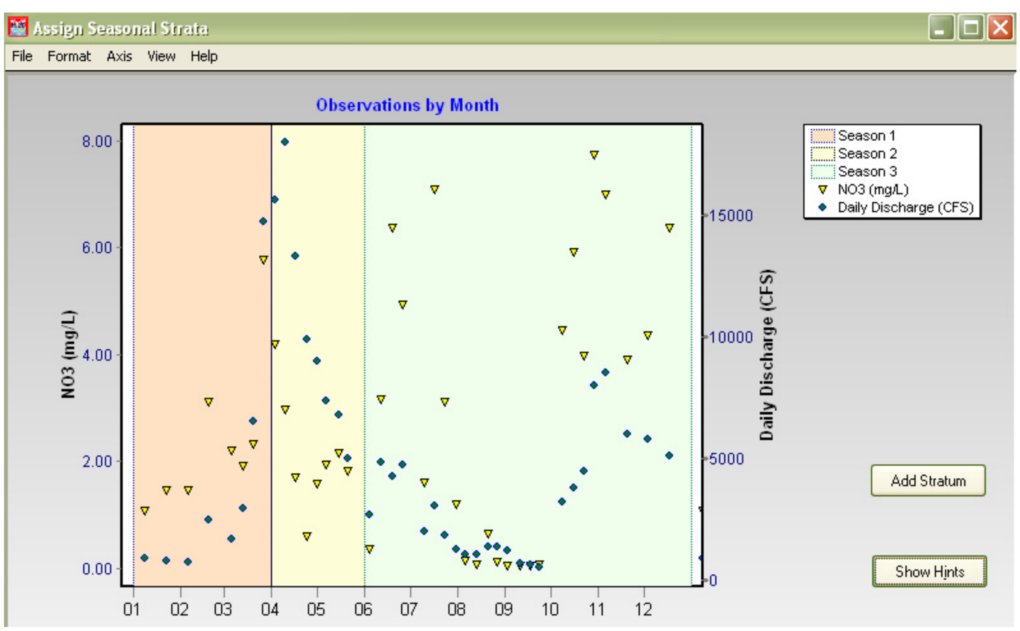
☑ (STEP 24) Upon examining the initial load results using a single stratum, the user has the option of assigning multiple strata based on discharge or seasonal / date. The objective is to reduce the C.V., minimize residual slopes, and achieve convergence between flux and concentration for Methods 2-6.

- Stratify data: **Data → Stratify → On Flow**
  On Hydrograph
  On Season
  ~~On Date~~ ←

Date Stratification is not an option for stream load calculations, since three years of data are used to develop statistics.

- On <u>Flow Stratification</u>: Typically relies on two strata (split at Qmean) or three strata (split at ½ Qmean and split at 2x Qmean). Upon choosing one of the flow strata, the user can then manually edit the strata boundaries through numeric or graphical means. If the user would prefer to manually enter all of the strata breaks, use **Data → Stratify → On Flow → Other.**

- On <u>Season Stratification</u>: Stratification breaks often correlate with winter (mid-October – January), spring (February – mid May), summer (mid-May – mid-August), and fall (mid-August – mid-October). Examining the graphical interface will assist the user in appropriately identifying strata breaks.



☑ (STEP 25) Check diagnostic plots and statistics: Once strata breaks are set, go through the following process to check diagnostic plots and statistics. Table 2 outlines diagnostic tests and goals.

Table 2: Flux32 Diagnostics for Load Calculation Acceptability

Flux32 Diagnostic Plot or Statistic	Description	Optimum Goal
Plot → Residuals → vs. Flow, vs. Date, vs. Month	Examine residual plots for bias; Click "Show Stats" on plot. Often bias can be eliminated for Flow or Date, but not both	No slope (slope ≈ 0) Minimize R^2 (R^2 ≈ 0) Maximize Slope Significance (≈1)
Calculate → Loads	Creates summary table of load by method; also gives C.V. by method	Flow weighted concentration estimate for Method 6 should be within 20% of Methods 3-5.
		<u>C.V. range</u> 0 - 0.1 (Excellent) 0.1 - 0.2 (Good) > 0.2 (Fair) > 0.3 (Generally unacceptable)
Calculate → Compare Sample Flow with Total Flow Distribution	Provides a variety of statistics comparing sample flow with total flow distribution	Provides information about distribution that may help with data interpretation
List → Residuals → Outliers	Provides lists of statistical outliers (P<=0.050)	Outliers should only be deleted with some evidence of problem with sample. Deletion of outliers can greatly affect load estimates. If outlier is deleted, be sure to note in output text file.
List → Jackknife Table	Jackknife procedure systematically deletes individual samples and recalculates load without that sample, then presents % change in load estimate.	Look through table and identify individual samples that greatly influence load estimate. May add in interpretation or aid in elimination of outliers.
List → Breakdown by Stratum and Optimum Sampling	Can provide information about optimizing sample collection during future efforts.	Can aid in data interpretation.

☑ (STEP 26) If diagnostics are acceptable (based on calculation method and statistical relationships), proceed to Step 27. If diagnostics are unacceptable, first attempt to adjust stratification breaks or change stratification scheme (for example, change from flow stratification to seasonal stratification). Evaluate outliers and jackknife to identify aberrant samples. **Outliers should be deleted cautiously and only with reason; always make note of deleted outliers in output file**.

- ***As a general guideline***, if the Method 6 flow weighted concentration is greater than +/- 20% of Methods 3-5 concentrations/loads, then use of Method 6 may be abandoned for an alternative methods (Methods 3 – 5, preferably Method 4 or 5). <u>It is advised not to use the time series function with Methods 2 or 3. The user will therefore only be able to cite annual modeled loads</u> (rather than monthly or daily). Dave Soballe of ACOE reports that Method 6 time series (calendar year, monthly, and daily results) are most accurate as long as the C/Q relationship has a high r^2 (~0.75) or if Methods 2-6 converge on a similar result. Analyst notes on method selection should be included in both .TXT output file and output database "notes" field.

- If none of the methods produce a statistically significant load (C.V. > 0.3 and loads do not converge on similar value) and indicators exist such as weak representation of samples to the daily flow regime and poor residual statistics regardless of stratification scheme, you may not be able to calculate a load for the specified calendar year. If there is some variability between the flow weighted concentrations of Methods 3-5, but all indicators suggest an appropriate dataset, proceed will load calculation and make note of variability.

☑ (STEP 27) Once diagnostics are evaluated and optimized, calculate final loads and create output file as defined in Action 5.

Action 5: Create Output File

☑ (STEP 28) Open text editor like "Notepad" or "Notetab Light"

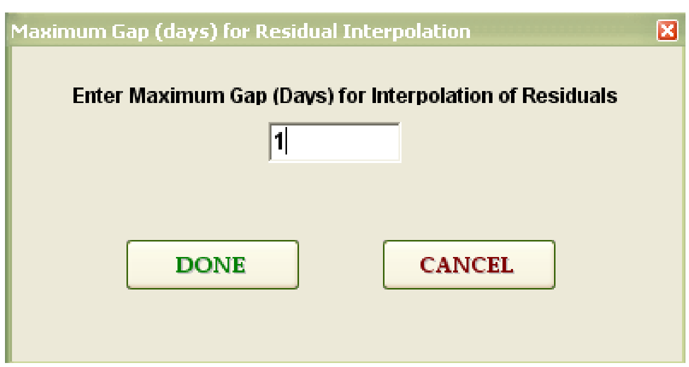
☑ (STEP 29) Enter introductory information as follows:

Line 1: Site name, parameter, year of interest
Line 2: Date of analysis and analyst name
Line 3: Version of Flux32
Line 4: Input file names
Line 5: Stratification breaks
Line 6: Outliers deleted
Line 7: Notes

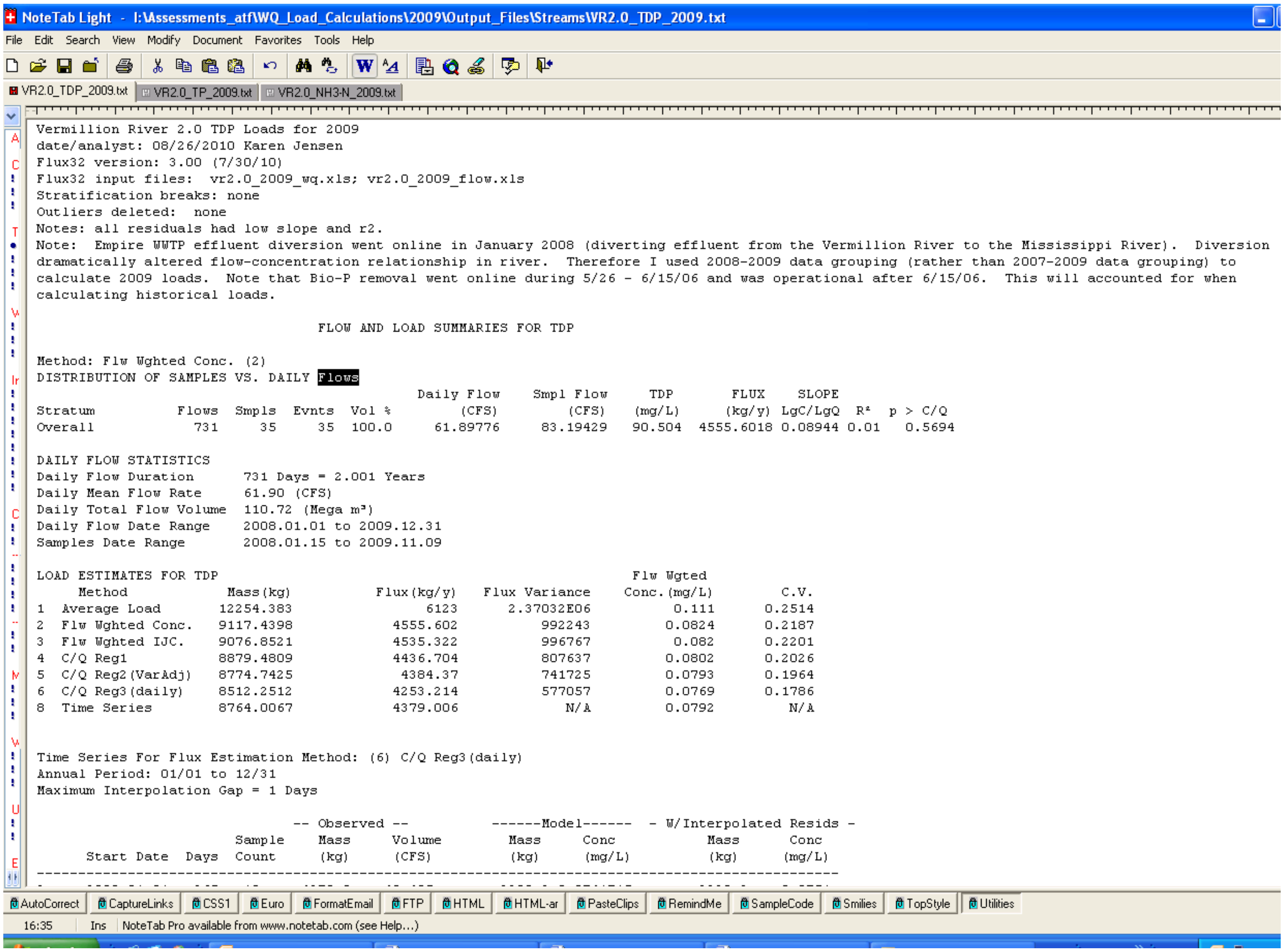
Example
Sand Creek 8.2 TSS loads for 2009
Date/analyst: 05/26/10; Karen Jensen
Flux 32 Version: 1.1.2 (3/10/09)
Flux32 input files: sa8.2_2009_flow.xls; sa8.2_2009_wq.xls
Satrification breaks: 0-20 cfs, 20-120 cfs, 120-540 cfs
Outliers deleted: Deleted one outlier (08/04/2009)
Notes: Best agreement among methods 3-6.

☑ (STEP 30) Once above information has been added, cut and paste the following into the text file, in this order: **Only paste the results for the year of interest to avoid future confusion**. For example, if calculating 2009 loads, eliminate estimates for 2007 and 2008 (which would have been used as part of the three-year dataset to develop statistical relationships).

- **Calculate → Loads**
- To calculate time series loads (daily, monthly, calendar) Use 1 Day as Maximum Gap for Interpolation
  → **Calculate** → **Series** → **Calendar Year** (1 Day as Maximum Gap for Interpolation)
  → **Calculate** → **Series** → **Monthly** (1 Day as Maximum Gap for Interpolation)
  → **Calculate** → **Series** → **Daily** (1 Day as Maximum Gap for Interpolation)



Example Notepad Output file:



NoteTab Light - I:\Assessments_atf\WQ_Load_Calculations\2009\Output_Files\Streams\VR2.0_TDP_2009.txt

```
Vermillion River 2.0 TDP Loads for 2009
date/analyst: 08/26/2010 Karen Jensen
Flux32 version: 3.00 (7/30/10)
Flux32 input files:  vr2.0_2009_wq.xls; vr2.0_2009_flow.xls
Stratification breaks: none
Outliers deleted:  none
Notes: all residuals had low slope and r2.
Note:  Empire WWTP effluent diversion went online in January 2008 (diverting effluent from the Vermillion River to the Mississippi River).  Diversion
dramatically altered flow-concentration relationship in river.  Therefore I used 2008-2009 data grouping (rather than 2007-2009 data grouping) to
calculate 2009 loads.  Note that Bio-P removal went online during 5/26 - 6/15/06 and was operational after 6/15/06.  This will accounted for when
calculating historical loads.

                                  FLOW AND LOAD SUMMARIES FOR TDP

Method: Flw Wghted Conc. (2)
DISTRIBUTION OF SAMPLES VS. DAILY Flows
                                              Daily Flow     Smpl Flow      TDP        FLUX     SLOPE
Stratum          Flows  Smpls  Evnts  Vol %        (CFS)         (CFS)    (mg/L)      (kg/y) LgC/LgQ  R²   p > C/Q
Overall            731     35     35  100.0     61.89776      83.19429   90.504   4555.6018 0.08944 0.01    0.5694

DAILY FLOW STATISTICS
Daily Flow Duration       731 Days = 2.001 Years
Daily Mean Flow Rate      61.90 (CFS)
Daily Total Flow Volume   110.72 (Mega m³)
Daily Flow Date Range     2008.01.01 to 2009.12.31
Samples Date Range        2008.01.15 to 2009.11.09

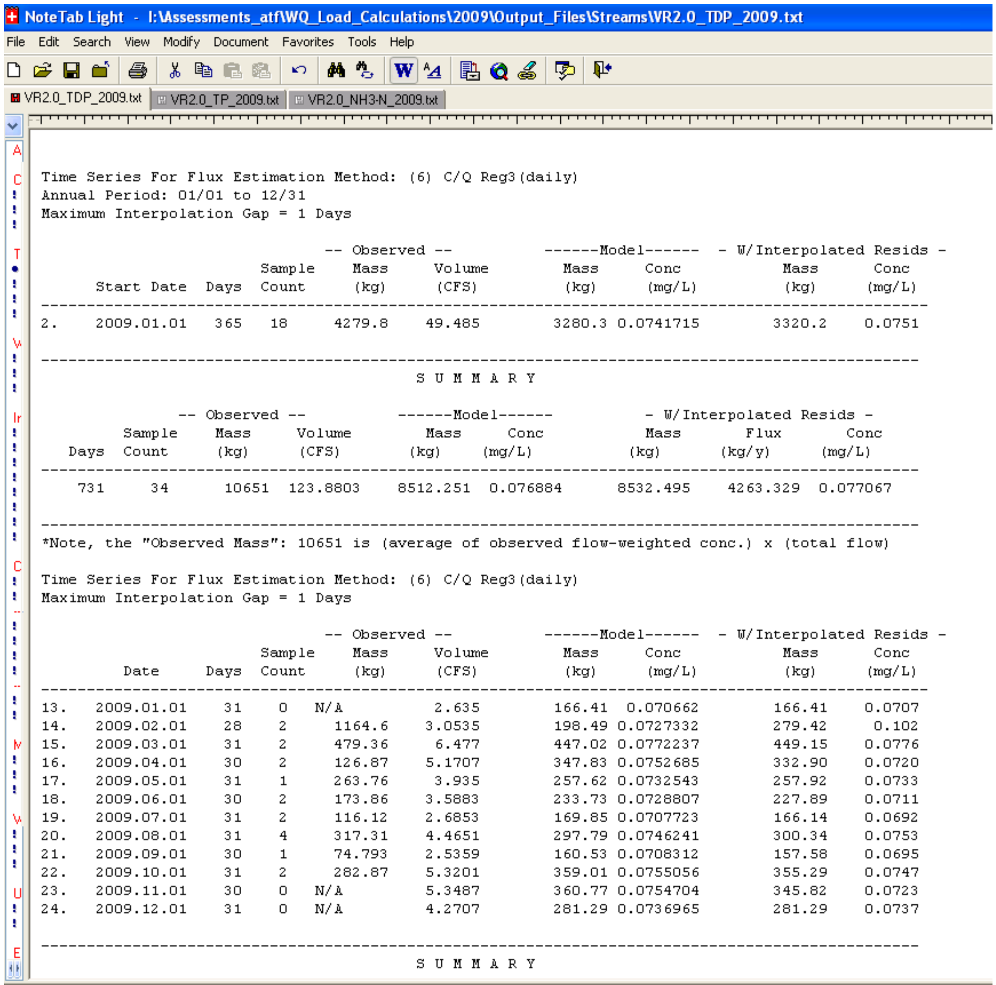
LOAD ESTIMATES FOR TDP                                                  Flw Wgted
     Method              Mass(kg)           Flux(kg/y)   Flux Variance    Conc.(mg/L)        C.V.
1  Average Load         12254.383                 6123      2.37032E06          0.111      0.2514
2  Flw Wghted Conc.     9117.4398             4555.602          992243         0.0824      0.2187
3  Flw Wghted IJC.      9076.8521             4535.322          996767          0.082      0.2201
4  C/Q Reg1             8879.4809             4436.704          807637         0.0802      0.2026
5  C/Q Reg2(VarAdj)     8774.7425              4384.37          741725         0.0793      0.1964
6  C/Q Reg3(daily)      8512.2512             4253.214          577057         0.0769      0.1786
8  Time Series          8764.0067             4379.006             N/A         0.0792         N/A


Time Series For Flux Estimation Method: (6) C/Q Reg3(daily)
Annual Period: 01/01 to 12/31
Maximum Interpolation Gap = 1 Days

                               -- Observed --          ------Model------  - W/Interpolated Resids -
                        Sample    Mass      Volume         Mass     Conc            Mass      Conc
      Start Date  Days  Count      (kg)      (CFS)          (kg)    (mg/L)           (kg)    (mg/L)
------------------------------------------------------------------------------------------------
```

16:35 Ins NoteTab Pro available from www.notetab.com (see Help…)

Time Series portion of NotePad output file. Note that 2007 and 2008 results have been deleted, leaving only year of interest (2009).




```
Time Series For Flux Estimation Method: (6) C/Q Reg3(daily)
Annual Period: 01/01 to 12/31
Maximum Interpolation Gap = 1 Days

                                   -- Observed --         ------Model------  - W/Interpolated Resids -
                          Sample    Mass      Volume        Mass      Conc         Mass      Conc
      Start Date  Days   Count     (kg)      (CFS)         (kg)      (mg/L)        (kg)      (mg/L)
-------------------------------------------------------------------------------------------------
2.    2009.01.01   365    18       4279.8    49.485        3280.3 0.0741715        3320.2    0.0751

-------------------------------------------------------------------------------------------------
                                         S U M M A R Y

                   -- Observed --         ------Model------           - W/Interpolated Resids -
         Sample    Mass      Volume        Mass      Conc            Mass       Flux       Conc
   Days  Count     (kg)      (CFS)         (kg)      (mg/L)          (kg)       (kg/y)     (mg/L)
-------------------------------------------------------------------------------------------------
    731    34      10651  123.8803     8512.251  0.076884       8532.495    4263.329  0.077067

-------------------------------------------------------------------------------------------------
*Note, the "Observed Mass": 10651 is (average of observed flow-weighted conc.) x (total flow)

Time Series For Flux Estimation Method: (6) C/Q Reg3(daily)
Maximum Interpolation Gap = 1 Days

                                   -- Observed --         ------Model------  - W/Interpolated Resids -
                          Sample    Mass      Volume        Mass      Conc         Mass      Conc
         Date      Days   Count     (kg)      (CFS)         (kg)      (mg/L)        (kg)      (mg/L)
-------------------------------------------------------------------------------------------------
13.   2009.01.01    31     0    N/A          2.635        166.41  0.070662        166.41    0.0707
14.   2009.02.01    28     2       1164.6    3.0535        198.49 0.0727332        279.42     0.102
15.   2009.03.01    31     2       479.36     6.477        447.02 0.0772237        449.15    0.0776
16.   2009.04.01    30     2       126.87    5.1707        347.83 0.0752685        332.90    0.0720
17.   2009.05.01    31     1       263.76     3.935        257.62 0.0732543        257.92    0.0733
18.   2009.06.01    30     2       173.86    3.5883        233.73 0.0728807        227.89    0.0711
19.   2009.07.01    31     2       116.12    2.6853        169.85 0.0707723        166.14    0.0692
20.   2009.08.01    31     4       317.31    4.4651        297.79 0.0746241        300.34    0.0753
21.   2009.09.01    30     1       74.793    2.5359        160.53 0.0708312        157.58    0.0695
22.   2009.10.01    31     2       282.87    5.3201        359.01 0.0755056        355.29    0.0747
23.   2009.11.01    30     0    N/A          5.3487        360.77 0.0754704        345.82    0.0723
24.   2009.12.01    31     0    N/A          4.2707        281.29 0.0736965        281.29    0.0737

-------------------------------------------------------------------------------------------------
                                         S U M M A R Y
```

☑ (STEP 31) Save output file using the following naming convention:
SiteCode_parameter_year.txt
Example: CN11.9_NO3_2009.txt

in the folder:
NATRES\ Assessments\WQ_Load_Calculations\Output_Files\Streams\Text_Files

☑ (STEP 32) Load values and statistics are manually extracted and summarized within a historic stream loads database. The location of the MCES Stream Loads dataset is:
NATRES\ Assessments\WQ_Load_Calculations\Output_Files\Streams\Streams_WQ_Load_Dataset.xlsx

If additional load data is added to the Streams_WQ_Load_Dataset.xlsx the user should update the *Notes* worksheet.

Information that needs to be added to the Streams_WQ_Load_Dataset.xlsx file is:

- Site Code
- Site Type
- Parameter
- Version (if input data is updated and the model is rerun, the output text file should be saved as SiteCode_Parameter_year_V#.txt, where # is run of the model. # should be indicated here)
- Database Query Date
- Analysis Period
- Load Year
- Stratification Scheme
- Stratification Divisions
- Calculation Method
- Samples Excluded
- Total Samples Used
- Samples for Year of Interest
- Annual volume (either in cfs or m^3)
- Model-Mass (kg)
- Model-Conc (mg/L)
- Interp-Mass (kg)
- Interp-Conc (mg/L)
- CV (Coefficient of Variation)
- Updated By
- Updated On
- Comments (should match notes in text file)

Columns shaded in blue are should calculate automatically. These calculations include:

- Site Name
- Major Watershed
- Muliple Versions? (yes or no)
- Output Text File Name
- Output Flux32 Session File Name
- Annual Volume (cfs) (calculated based on whether you enter volume in cfs or m^3)
- 95% CI Upper Limit (kg)
- 95% CI Lower Limit (kg)
- Quality Check: Back-Calculate concentration (mg/L)
- Quality Check: Highlight if >3% diff

The upper and lower confidence limits of the 95% confidence interval are calculated using the method cited within the Flux user's manual entitled *Simplified Procedures for Eutrophication Assessment and Prediction: User Manual* (William Walker, 1999) as follows:

Lower Limit value = $Y_m * e^{(-2 * CV)}$
Upper Limit value = $Y_m * e^{(2 * CV)}$

where Y_m is the predicted mean value and CV is the error mean coefficient of variation.

☑ (STEP 33) Save Flux32 Session File using similar naming scheme as used in Step 31.

- **Session → Save This Session**

- Save output file using the following naming convention: *SiteCode_parameter_year.txt.* The file should be saved in *NATRES\Assessments\WQ_Load_Calculations\Output_Files\Streams\Session_Files*.

  Note that session file names cannot include "." or "-". Use only alpha-numeric characters and underscores in session file names.

- Example: CN119_NO3_2009.FSS