Standard Operating Procedure
Pathogen TMDL SOP

Commonwealth of Kentucky
Energy and Environment Cabinet
Department for Environmental Protection
Division of Water
Water Quality Branch
TMDL Section

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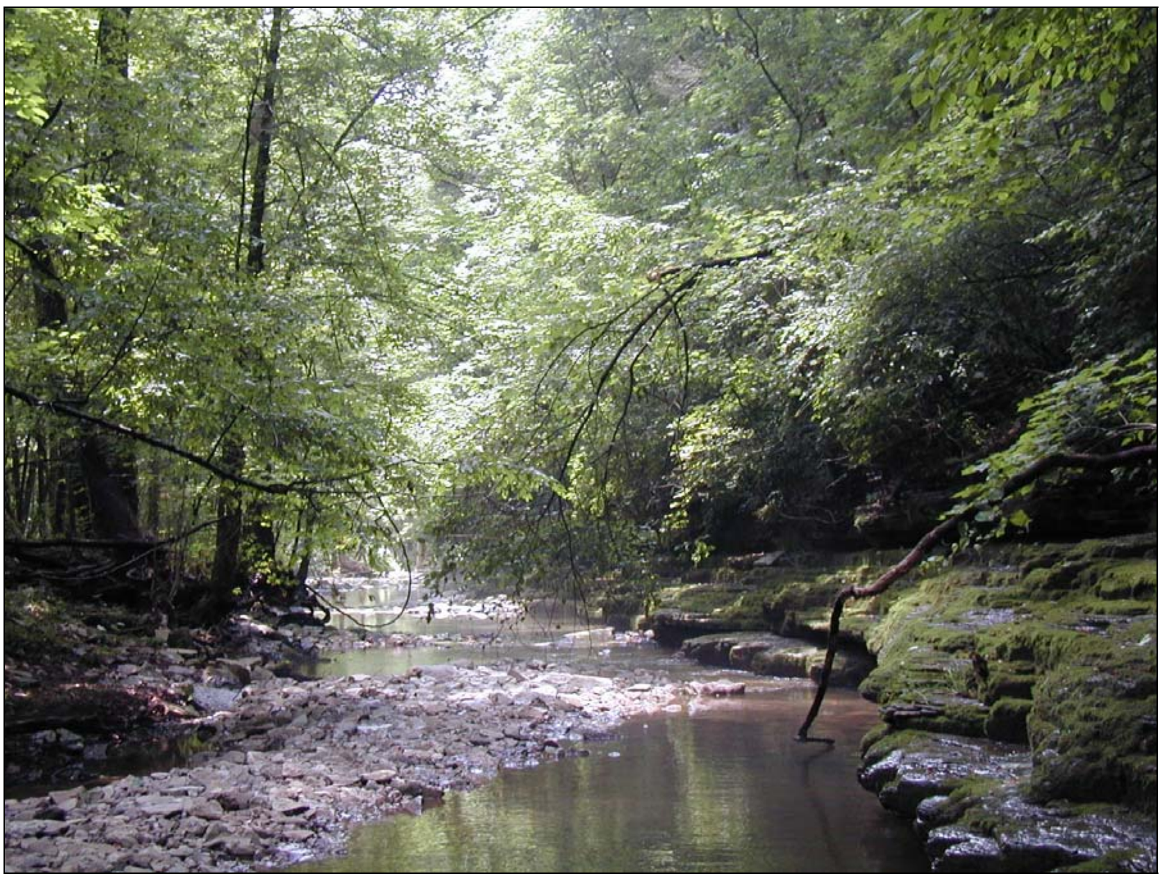

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4.0 PROCEDURES

4.A PURPOSE. Section 303(d)(1)(C) of the Clean Water Act (CWA) and its associated policy and program requirements for water quality planning, management, and implementation (40 CFR Part 130) require the establishment of a Total Maximum Daily Load (TMDL) for the achievement of state water quality standards when a waterbody is water quality-limited (i.e., impaired for one or more designated uses). A TMDL identifies the pollutant/waterbody-specific assimilative capacity which will allow the waterbody to meet its designated uses (the designated uses are Primary Contact Recreation (PCR), Secondary Contact Recreation (SCR), Drinking Water Supply, Fish Consumption, Warm Water Aquatic Life/Cold Water Aquatic Life, and Outstanding State Resource Waterway), which includes an appropriate margin of safety (MOS). The designated uses for each waterbody, along with the associated numerical or narrative Water Quality Criteria (WQC) to protect those uses, are found in 401 KAR 10:031. However, the purpose of this document is to provide Standard Operating Procedures (SOPs) for pathogen impairments, which are defined as listings for fecal coliform or E. coli. Pathogens impair for the PCR use, the SCR use, or both. Pathogens do not impair for any of the other designated uses, so only analytical methods to set pathogen TMDLs for PCR and SCR will be described in this SOP.

According to the *General EPA/State Outline for Development of TMDLs* (EPA, 1991) the TMDL, the Wasteload Allocation (WLA, if Kentucky Pollutant Discharge Elimination System (KPDES)-permitted sources are present which discharge the pollutant of concern to the impaired segment) and a Load Allocation (LA, if non-KPDES-permitted sources are present which discharge the pollutant of concern to the impaired segment) must be determined using "…water quality analytical models or other analytical tools." *Modeling* and *data analysis* are tools that assess various loading allocation scenarios which aid the TMDL development process. *Modeling* is defined as a predictive simulation of real-world conditions (e.g., predictive, empirical and/or mechanistic tools such as QUAL2K, Basins, WASP, LSPC, etc.), whereas *data analysis* is defined as a mathematical representation or interpretation of existing data with no predictive value (i.e., any conclusions apply only to the time when the data were collected, but the conclusions can be used to calculate the TMDL). Currently, DOW uses data analysis but not modeling to develop pathogen TMDLs. If modeling is employed in future projects, the SOP will be updated.

In addition to meeting the requirements of this SOP, the pathogen TMDL approach must meet the requirements stated in Kentucky's *Quality Assurance Project Plan for Data Analysis for TMDL Development, Version 1.0* (Draft, DOW, 2009).

4.B APPLICABILITY / SCOPE. This SOP applies to all TMDL documents written by the Kentucky Division of Water (DOW) for pathogens (which currently do not employ predictive modeling; i.e., analytical pathogen TMDLs).

4.C SUMMARY OF PROCEDURE. Analytical pathogen TMDLs will employ a *Load Duration Curve* approach to setting the TMDL Target if sufficient data exist and are available to support this approach (see Section 4.F.1.4). If not, the *Mean Annual Flow* method will be used to set the TMDL Target (see Section 4.F.3). If conditions arise that are not covered by this SOP, the final decision will rest with the TMDL Section Supervisor.

4.D DEFINITIONS

4.D.1 TMDL. According to EPA (2007), A TMDL calculation is performed as follows:

$$TMDL = WLA + LA + MOS$$
(Equation 1)

Where:

TMDL = the maximum load the waterbody can assimilate while still meeting the WQC, which is defined in 401 KAR 10:031.
WLA = the Wasteload Allocation, which is the allowable loading of pollutants into the stream from KPDES-permitted sources such as sewage treatment plants and Municipal Separate Storm Sewer Systems (MS4s).
LA = the Load Allocation, which is the allowable loading of pollutants into the stream from sources not permitted by KPDES and from natural background.
MOS = the Margin of Safety, which can be an implicit or explicit additional reduction applied to sources of pollutants that accounts for uncertainties involving the relationship between discharge limits and instream pollutant levels.
TMDL Target = the TMDL minus the MOS.

4.D.2 Flow Duration Curve. A FDC is a graphical plot showing a cumulative frequency distribution of the percent of time flows are exceeded vs. flow, as described in *An Approach for Using Load Duration Curves in the Development of TMDLs* (EPA, 2007). See Figure 4.D.1 for an example FDC.

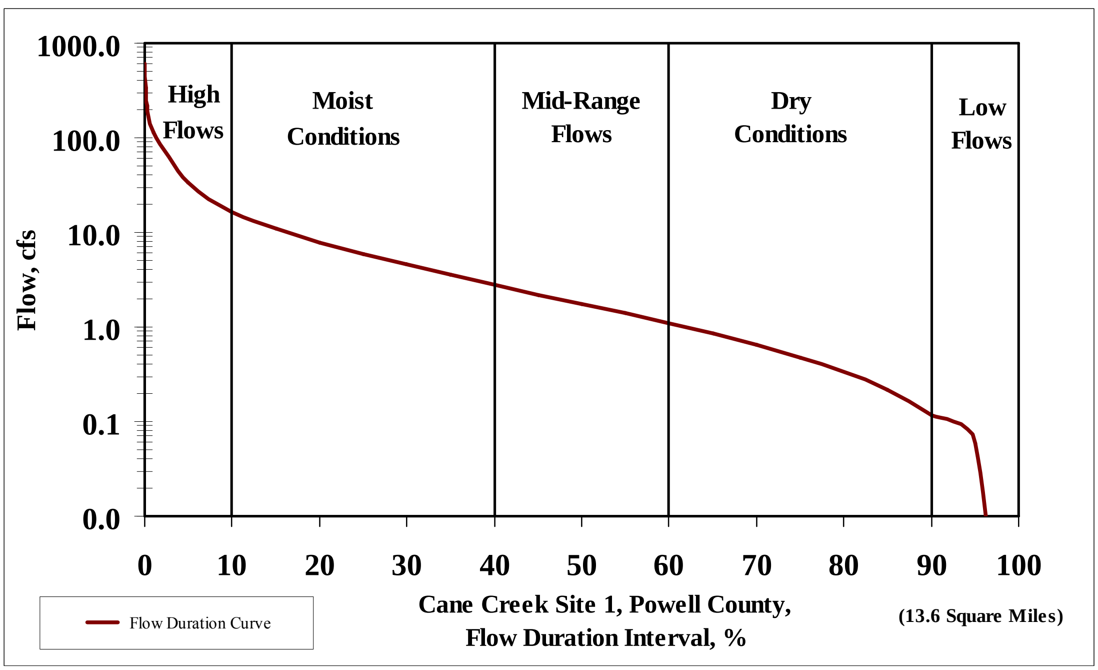

Figure 4.D.1 Flow Duration Curve

4.D.3 Load Duration Curve. A LDC is a graphical plot showing a cumulative frequency distribution of the percent of time flows are exceeded vs. load. The curve is plotted at a load that corresponds to the loading at the TMDL. See *An Approach for Using Load Duration Curves in the Development of TMDLs* (EPA, 2007) for further details. Figure 4.D.2 shows an example LDC.

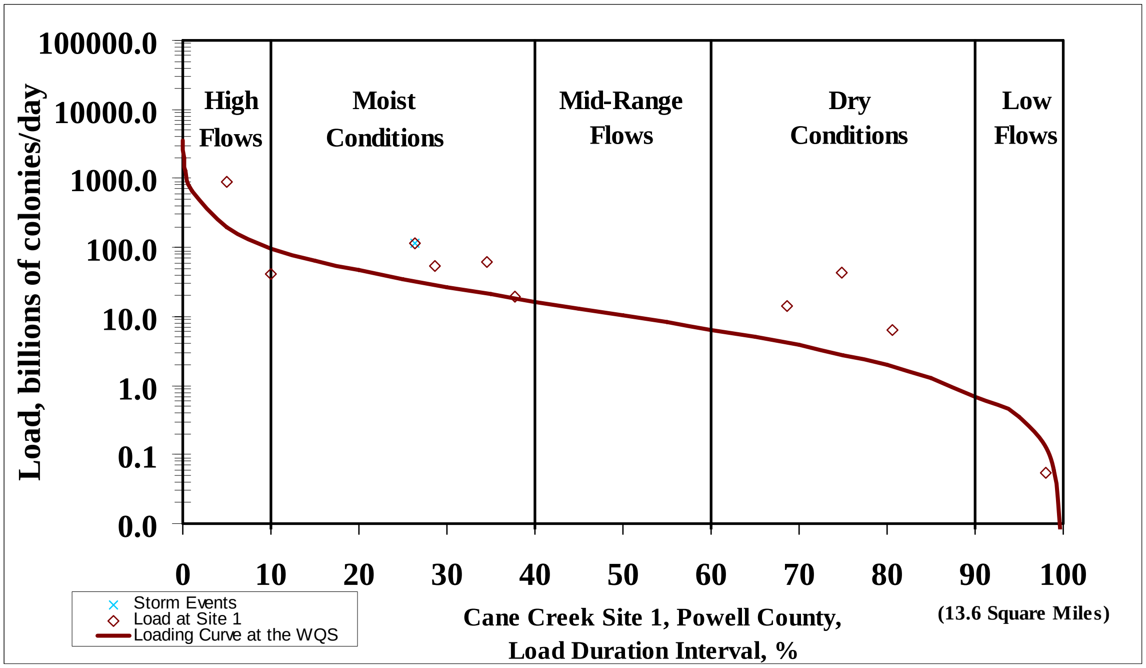

Figure 4.D.2 Load Duration Curve

4.D.4 MAF. According to *Estimating Mean Annual Streamflow of Rural Streams in Kentucky* (USGS, 2002), the MAF (Q_a) is defined as the mean of the series of annual mean streamflow values at a given site or station. It is calculated using the following equation:

$$Q_a = \left(\sum_{i=1}^{N_a} Q_{ai} \right) / N_a ,$$

(Equation 2)

Where Q_{ai} is the annual mean streamflow for the ith year, and N_a is the number of annual mean streamflows at the site or station for its period of record.

4.E PERSONNEL QUALIFICATIONS / RESPONSIBILITIES. No specialized training is required for DOW TMDL writers. New TMDL Section staff members are trained by the TMDL Section Supervisor or designee as needed. All DOW staff members must meet the minimum educational and/or experiential requirements for their position title, as determined by the Kentucky Personnel Cabinet (KPC). KPC maintains employment records documenting minimum educational and/or experiential requirements, and the DOW Resource Planning and Program Support Branch maintains training records. While no specific training courses are required, in the case of current staff, two TMDL Section members have received Load Duration Curve training.

4.F PROCEDURE

4.F.1 Determine the TMDL Approach

4.F.1.1 Acquire Dataset. TMDL analysis must begin with a validated pathogen dataset at a station or stations within a pathogen-impaired segment. Data validation procedures can be found in *Quality Assurance Project Plan, Water Quality Monitoring for TMDL Development, Version 1.0* (Draft, DOW, 2008,) and *Quality Assurance Project Plan for Data Analysis for TMDL Development, Version 1.0* (Draft, DOW, 2008).

4.F.1.2 Set the TMDL at the WQC. The TMDL concentration is set at the numeric WQC, which is determined in accordance with 401 KAR 10:031. Later in this document the procedure will be described for expressing the TMDL in units of load by multiplying it by a flow value (see Sections 4.F.2 and 4.F.3). The WQC used to set the TMDL is based on the two designated uses, which can both be impaired:

> PCR Use. Pathogens can impair for the PCR use, which is in effect for the recreational season (i.e., May through October). If 5 samples or more are available from within a 30-day period, the geometric mean WQC (which is 200 colonies/100ml for fecal coliform and 130 colonies/100ml for E. Coli) must be met, therefore the TMDL must allow the waterbody to meet the geometric mean. In practice, seldom will 5 or more samples be available from within a 30-day period. When the data do not allow a calculation of the 30-day geometric mean, the instantaneous maximum WQC (which is 400 colonies/100ml for fecal coliform and 240 colonies/100ml for E. Coli) will be used to set the TMDL. If both types of data are available, the dataset that produces a higher percent reduction needed to meet the TMDL will be used, since both the geometric mean WQC and the instantaneous maximum WQC must be satisfied as stated in 401 KAR 10:031.
>
> SCR Use. Fecal coliform can impair for the SCR use. The WQC for SCR is a geometric mean of 1000 colonies/100ml, and an instantaneous maximum of 2000 colonies/100ml, and this applies year round.
>
> Dual Impairments (PCR and SCR Both Impaired). Because fecal coliform (but not E. coli) can impair for both PCR and SCR, if both uses are impaired the TMDL will be set at the lower WQC value (i.e., either 400 colonies/100ml, or 200 colonies/100ml if sufficient data exist to calculate a 30-day geometric mean, as opposed to 2000 or 1000 colonies/100ml) in order to allow the stream to meet both uses.

4.F.1.3 Determine the MOS and the TMDL Target Concentration. The MOS accounts for uncertainty in the relationship between discharge limits and instream pollutant levels. The MOS is set at 10% of the TMDL unless another approach is approved by the TMDL Section Supervisor. For fecal coliform, this means a concentration of 40 colonies/100ml (unless the geometric mean WQC is used, in which case the MOS is 20 colonies/100ml), and for E. coli the MOS is a concentration of 24 colonies/100ml (13 colonies/100ml if the geometric mean WQC is used). The TMDL Target is the TMDL minus the MOS (e.g., 400-40=360, or 240-24=226, etc.). Note the MOS and the TMDL Target concentration must ultimately be converted to units of load (i.e., mass (which is interpreted as colonies in the case of pathogens) per day) to satisfy federal requirements (DC Cir, 2006), see Sections 4.F.2 and 4.F.3.

4.F.1.4 Determine the TMDL Approach. If there is an appropriate United States Geological Survey (USGS) flow gage with which to generate a flow record for the sampling station(s) used in the TMDL, this will be used in conjunction with the LDC method as described in Section 4.F.2 to set the TMDL Target and allocate loads. The appropriateness of a given gage will be evaluated based on the how well the following conditions are met: 1) the flows at the sampling station and the flows at the gage from the same dates and times (use either instantaneous gage flows or the closest 15-minute flow measurement to the time the sample was taken) are well correlated (i.e., there is a high 'r^2' coefficient), 2) the watershed area upstream of the gage is within 0.5 to 1.9 times the area of the watershed upstream of the sampling station, 3) there are no flow regulating structures present above either the sampling station or the gage, 4) the percentage of landuse upstream of the station is similar to that upstream of the gage, 5) the sampling station and gage are in the same major watershed, and 6) there is a sufficiently long period of record available at the gage to smooth out the effects of very wet and/or very dry years.

In practice, it is difficult or impossible to meet all of the above conditions explicitly. Because USGS gages are often placed on larger streams and streams of all sizes can be impaired (and require TMDLs), the ratio of the watershed area to the gage area is unlikely to fall within the 0.5 to 1.9 range specified. If in the best professional judgment of the TMDL writer an appropriate gage is available (or the use of modeling and/or regression equations produces an appropriate average daily flow record), the TMDL will utilize the LDC method. Otherwise the MAF method will be used. Such a decision will be made with the concurrence of the TMDL Section Supervisor.

4.F.2 Load Duration Curve Method

4.F.2.1 LDC Procedure. To build a LDC, a Flow Duration Curve (FDC) must be constructed first. Creating a FDC involves finding all recorded flow values within a creek at a particular sampling station and calculating the percent rank of each value. This percent rank is plotted on the X-axis of a graph, and the corresponding flow is plotted on the Y-axis using a $\log_{10}$ scale. This procedure displays higher flows on the left part of the graph, and lower flows (and the period where the creek goes dry, if any) on the right part of the graph. The FDC is divided into five flow zones (also called flow conditions); High Flows (which are flows that are not exceeded for more than 10% of the period of record, on the far left part of the graph), Moist Conditions (with flows exceeded between 10% and 40% of the period of record), Mid-Range Flows (which are exceeded between 40% and 60% of the period of record), Dry Conditions (with flows exceeded between 60% and

90% of the period of record), and Low Flows (which are exceeded between 90% and 100% of the period of record, on the far right part of the graph).

A folder on the V: drive (V:\DOWWQB\TMDL_Section\]QAQC\]TMDL SOPs\LDC SOP Documents) contains an Excel™ file called *Flow_Duration_Tool_(Template)_V_1-0* (Cleland, 2004), which has been modified by the addition of tabs that calculate TMDL values and graph the LDC (DOW, 2008). The TMDL writer will follow this template or generate an equivalent template to reflect the needs of the individual user. A separate LDC will be computed for each impaired segment. Two or more sampling stations on the same impaired segment will have their data pooled, but this is subject to the concurrence of the TMDL Section Supervisor. The TMDL writer should be aware when using Excel's™ copy/paste function that it is important to distinguish whether values or formulas are being copied/pasted, as unobvious errors can occur. The tabs are used as follows:

> **Site Info**. Delete the existing gage information from this tab. Copy sufficient gage information to identify the proxy gage. At a minimum, this includes the gage name and number (e.g., 3282500, Red River at Hazel Green, Kentucky). The gage's upstream drainage area must be entered in the appropriate cell (A5), and the drainage area of the downstream end of the impaired segment must be entered (cell G5).
>
> **Gage_Raw_Data**. Delete the existing example values in columns A, B G and H. Next, download the daily average final flow values (e.g., values that have undergone USGS's data quality review procedures, as opposed to provisional values) from the USGS gage from the National Water Information System (NWIS) website (http://nwis.waterdata.usgs.gov/ky/nwis/discharge) and copy these flow data along with the dates into columns G and H.
>
> Concerning columns A and B: For PCR TMDLs (as opposed to TMDLS that also account for SCR impairments), only flow values from the PCR season are used (i.e., use May through October values, therefore delete November through April values before pasting data into the spreadsheet; it is helpful to sort these in a separate spreadsheet and delete the unwanted values, and enter the dates and flows in columns A and B). However, if only PCR is impaired and a truncated dataset is entered in columns A and B, the entire dataset must be still be entered in columns G and H: The full (i.e., Jan-Dec) dataset is used to determine where the flow zones described in Section 4.F.2.1 are located along the x-axis: This is necessary because removal of Nov-April flows from the dataset takes out mostly mid-range and high flows, which artificially shifts the FDC (and thus the LDC) to the left. This left-shift would result in misidentification of the flow zones, which are used during implementation to infer potential sources. However, this is corrected by relocating the flow zones, as described in the **LDC-May_Oct** tab.
>
> Often the downstream end of an impaired segment is not co-located with a USGS flow gage. In such cases, the Area-Weighted Flow (AWF) at the end of the impaired segment is determined by dividing the upstream drainage area of

the end of the impaired segment by the upstream drainage area of the gage then multiplying the averaged daily flows at the gage by this ratio of areas. This calculation is performed for the user by Excel™ in columns C and I of this tab.

Site_Flow Duration. This tab is populated by Excel™.

Calc_Sample_Percentile. This tab is optional. It is used to generate the flow rank of the flows measured during sampling so the sampling results can be plotted as loads on the LDC. However, its results are duplicated in the LDC tab. The user may wish to use this tab as workspace then paste its results into the LDC tab. To complete this tab, measured flows are entered in the "Flow" column (column A) in the order in which the samples were taken, and Excel™ calculates the percentile in the "Percentile" column (column B). It will be necessary to click inside cell B4 and copy/paste the formula down further in column B (i.e., into cells B5, B6, etc.) until there are as many cells in column B with the formula as there are flow values in column A.

Load_Duration_Data. Enter the WQC into cell F10. The other cells are populated by Excel™.

LDC-May-Oct. This tab allows three functions to be accomplished:

1) <u>Generate the Loading Curve at the WQC on the Graph</u>. Excel™ populates Cells B46 through E70, which graphs the LDC at the WQC (expressed as a load) in the graph (or chart) included in this tab. Excel™ creates the LDC by multiplying the FDC by the WQC, along with an appropriate conversion factor (for example, flow (cfs) times concentration (colonies/100ml) times 24,405,408 gives load in colonies/day: another appropriate unit is billions of colonies/day, which is the example presented). However, if the proxy gage goes dry during its period of record, the AWF values will also show zero values, and an error message will result when opening the Excel™ file stating the log of zero cannot be graphed. In this situation, the loading curve at the WQC displayed on the graph will terminate above the x-axis. To correct this, extremely small values of flow can be entered to approximate zero and visually no error can be seen in the graph at the scale used for the y-axis (in the example provided, cell D69 is actually not zero, it is 1E-6 which graphs in a way that appears to be zero). If more than one cell holds zero values, the same approximation (1E-6) can be entered for all zero cells in column E.

This tab provides an example where only the PCR use is impaired, therefore only the recreational season's flows are used to build the LDC in this tab (i.e., column C in the **Gage_Raw_Data** tab). As stated above, if only May through October gage data are used to construct the LDC, this has the effect of deleting the (mostly higher) winter flows, which artificially shifts the LDC to the left. As a result, a sample that was taken during the Low Flow period may erroneously plot to the left, inside the Dry Conditions zone, etc. This can hamper TMDL implementation, since each zone tends to be associated with a different group of sources (although overlap does occur). For instance, point sources and cattle standing in the creek most often produce their greatest impact at the lowest flows, and any sample taken on a Low Flow day should be plotted as such so an initial list of potential source types can be inferred. Therefore, the x-axis location of the vertical lines on the graph that denote the flow zones should be calculated using the entire year's flows, and then plotted on the LDC which shows only May through October flows. Cells L4 through L11 reference the x-values of the flow zone boundary lines, which are derived from linear interpolation of the loads at the boundary lines on the next tab (**LDC-All_Data**), which creates a similar FDC but using all the data instead of only the May-Oct data. Cells F49, F52, F56 and F65 provide example linear interpolations. Notes are appended in column G that show the load value (from tab **LDC-All_Data**) which is the basis for the interpolation.

2) Plot Sample Loads on the Graph. To complete the LDC, the sample results from the sampling station(s) within the impaired segment are plotted at their corresponding flow values (also multiplied by the same conversion factor), thus exceedances of the WQC plot above the curve, and vice versa. Enter the sample dates in column B, beginning in cell B32. Enter the associated (i.e., field-measured) flow values in column C, beginning in cell C32, and enter the associated pathogen concentration in column F, beginning in cell F32. Sort these entries (columns B through F) by either *flow* or *% Flow Rank* (column C or D, the same order results whichever is used). This allows the sample loads to be examined by flow duration zone (i.e., moist, dry, etc.). If necessary, expand the formulas resident in columns D, E, G, H and I downwards until there are as many cells with the formula as there are samples entered.

The rows associated with each flow zone (as defined by the % Flow Rank of the sample flow in column D) can be color-labeled (i.e., shaded) for clarity (currently the convention is dark blue=wet, green=moist, light blue=mid-range, yellow=dry and tan=low flows. However, any color scheme is acceptable). In the example there were no samples in the mid-range zone, so light blue is not used.

Modify all labels in this tab as appropriate, the LDC graph will require renaming of several of its features (station name, drainage area, etc. Also, the y-axis scale may need to be changed to increase or decrease the load range shown depending on the nature of the flows and sample loads to be displayed). If different units of load are desired (the example uses billions of colonies per day instead of colonies/day), change the appropriate formulas in this tab (i.e., remove the portion of the mathematical expression which effects division by one billion) and the **TMDL_Calcs tab**, and change unit labels to colonies/day wherever billions of colonies per day is indicated.

Column I, beginning with cell I32, is a first look at possible TMDL critical condition and calculations, but the final calculations are performed in the next tab, because the number of samples within a flow zone is not accounted for here, nor is the MOS.

3) Plot Storm Flow Events. Refer to Section 4.F.2.2, Running HYSEP. After running HYSEP, the dates which are determined to represent storm (i.e., runoff) events are entered in column G, starting in cell G46. The associated Flow Rank and Sample Load on the storm event dates are entered in column H starting in cell H46, and column I starting in cell I46, respectively. The graph's source data references will need to be changed if there are more than 5 storm events in the sampling dataset (the chart draws from cells H46 through H50 (x-values) and I46 through I50 (y-values)). These dates then have their load point on the graph designated with a blue cross by Excel™.

LDC-All_Data. This tab creates a LDC similar to the last tab, but using all of the data instead of only the May-Oct data; this tab was included assuming the TMDL is being written for only the PCR use: Otherwise, this tab is unnecessary, as the full range of values would be input into columns A and B in the **Gage_Raw_Data** tab. But, if PCR is the only impaired use, the output needed from this tab consists of the loads that define the flow zones (i.e., the loads at the vertical lines at 10, 40, 60 and 90th percentile flow values). These can be found in cells E51, E57, E61 and E67. They are used in the preceding tab to relocate the flow zones to match the whole year's data instead of only the recreational season's data.

TMDL_Calcs. This tab allows four functions to be accomplished.

1) Determine the TMDL Load for each Flow Zone. The TMDL load is calculated for each zone within the LDC. However, different methods will be used depending on whether there is a sample (or samples) within the flow zone which show an exceedance of the TMDL.

> No exceedances within a zone: The TMDL is set at the 90th percentile of loads at the WQC for each % Flow Rank within the zone. Cells O30 through O34 provide this calculation for each zone. However, although examples are provided for all zones, if there are samples showing exceedances within a zone, the next method is used to set the TMDL load.

> One or more exceedances within a zone: The TMDL load for the zone is set at the 90th percentile of the WQC load for all samples (i.e., the load at the sample's flow multiplied by the TMDL concentration and by the conversion factor (e.g., 24,405,408 gives load in colonies/day)) within that zone. Cells P15, P16 and P18 provide example calculations.

2) Determine the TMDL Target Loads for each Flow Zone, as well as Existing Conditions and Percent Reduction from Existing Conditions to Achieve the TMDL Target Load, if Applicable. The TMDL Target load is calculated for each zone within the LDC. However, existing conditions and the percent reduction (to bring existing conditions in line with the TMDL Target load) are only calculated for zones with samples exceeding the WQC. Therefore, two different methods will be used to set the TMDL Target load within each zone (and to calculate existing conditions and a percent reduction, if applicable):

No exceedances within a zone: If there are no samples showing exceedances within a flow zone at a station, the TMDL Target load for that zone will be set at the 90th percentile of the TMDL Target loads for each percent % Flow Rank within that zone. Cells Q30 through Q34 provide example calculations. Since no samples exceed the WQC, no existing conditions or percent reduction are determined.

One or more exceedances within a zone: The existing conditions will be set at the 90th percentile of all sample loads from within the zone (examples are presented in cells O15, O16 and O18). The TMDL Target load for the zone is the 90th percentile of the TMDL Target load for all samples within the zone (the TMDL Target load is the load at the sample's flow multiplied by the TMDL target concentration (i.e., the TMDL minus the MOS) and by the conversion factor (e.g., 24,405,408 gives load in colonies/day)). Cells R15, R16 and R18 provide example calculations. The percent reduction will be calculated as follows:

Percent Reduction = [(Existing Load - TMDL Target Load) / (Existing Load)] X 100%
(Equation 3)

Cells S15, S16 and S18 provide example percent reduction calculations.

3) Determine the Critical Condition. The flow zone with the greatest percent reduction required is the critical condition. This is labeled within the graph in the LDC tab using the drawing toolbar features. The critical condition zone determines the overall TMDL, TMDL Target and percent reduction for the impaired segment.

4) List the Appropriate Values in the TMDL Table. Cells B2 through K8 are a TMDL Table used to organize and present the parameters required by EPA for a TMDL submittal. Fill in the values determined by the procedures above and those in Section 4.F.2.3., Allocating Loads.

4.F.2.2 Running HYSEP to Determine Stormflow Events. The folder V:\DOWWQB\TMDL_Section\QAQC\TMDL SOPs\LDC SOP Documents) contains an Excel™ file called *Get_Flow_Duration Info_(VB_Tool)_Template_V1-0* (Cleland, 2004) which has been modified by the addition of calculations to determine the presence of data breaks (DOW, 2008). This spreadsheet has two tabs:

Flow_Data. Delete the existing values from columns A and B in this tab. Paste the gage data for the proxy gage into column A (date), and column B (flow). Enter the drainage area (at the bottom of the impaired segment) into cell D6, it cannot be omitted because HYSEP uses this in the calculation of % Storm Flow. The flow data from the proxy gage must have a continuous dataset in order to run the HYSEP visual basic code, and any breaks in the data will cause the visual basic routine in the Sample_Dates tab to fail. Therefore, flow values must not exclude the November through April range of dates, as the previous spreadsheet did. Also, if there are any periods of missing flow data, the blanks must be filled in by linear extrapolation from the flow values immediately preceding and proceeding the missing values. Alternately, another method of generating missing values can be used provided the method is approved by the TMDL Section Supervisor. Provisional data (i.e., gage flow data available from the NWIS website which USGS has not yet reviewed and is subject to change) may be needed and may be utilized if required, since there must be flow data at the proxy gage on the dates when sampling was performed.

One way to scan for missing data is to convert the given dates to numbers in a new column then subtract the value in each cell from the value in the cell above it. Each value should be one unit larger than the last value, and therefore any result besides 1.0 indicates a data break. An example is provided in column M. Conditional formatting can be used to further increase the ease of spotting data breaks.

Sample_Dates. Clear the contents of the example cells (A2 through D17). Paste the dates samples were taken at the sampling station into column A, starting in cell A2. Enter the associated flows measured during sampling on these dates in column B. press the 'Get Flows' button to activate the visual basic HYSEP routine, which populates columns C and D. Any event with a 50% or greater % Storm Flow represents a possible runoff event. To verify, look at the field sheets, and determine if there was rainfall within the watershed 48 hours prior to the sampling event. If there was rainfall or if there is no data, then determine change in AWF at the stream within the 5-day period around the sampling date in question, and use best professional judgment to determine if any the change in flow instream is great enough to represent a runoff event. For example, in Cane Creek at RM 0.0 (a 13.6 square mile watershed), a change in flow greater than 0.3 cfs was used as the threshold for determining whether a runoff event occurred. Label any such stormflow points using the procedure found in the LDC tab description in Section 4.F.2.1.

The reverse applies as well: On days where HYSEP does not indicate a 50% Storm Flow but the change in flow within the 5-day period around the sampling date was greater than a minimum change (0.3 cfs in the case of Cane Creek) and the field datasheet indicates rainfall in the 48-hour period immediately before the sample was taken, the data point will be labeled as a storm event on the LDC graph. Any decisions made using best professional judgment must be approved by the TMDL Section Supervisor.

4.F.2.3 Allocate Loads. WLAs and LAs are apportioned from the TMDL Target load. As stated, the TMDL Target is set at the WQC minus the MOS, both expressed as a load. Calculate allocations in the following order:

<u>1) KPDES-Permitted Point Sources (e.g., Wastewater Treatment Plants) (WLA)</u>. In the case of KPDES-permitted point sources such as Wastewater Treatment Plants (WWTPs), the WLA for each facility is set at the design flow times the

WQC, expressed in the same units as the TMDL and TMDL Target load. An example, which gives load in units of colonies/day, follows:

$$\text{WLA} = \text{Design Flow (gal/day)} \times \text{TMDL Target (colonies/100ml)} \times 3.875\ \text{L/gal} \times 1000\ \text{ml/L}$$

(Equation 4.)

No MOS is applied to WWTP WLAs, as there is no lack of understanding between effluent limits and their effect on instream pollutant levels.

2) Non-Permitted Sources and Natural Background (LA). The LA is the remainder of the TMDL Target load after subtraction of the MOS load and the WLA load. However, if there is a MS4, it receives a portion of the LA equal to the fraction of the watershed it covers upstream of the end of the impaired segment (see below for procedures to calculate the MS4 area). But even though MS4s receive an allocation computed as a fraction of the LA, they are part of the WLA.

3) MS4s (WLA). If an MS4 is present upstream of or within the impaired segment, the MS4 portion of the WLA is calculated by first determining the percent of the watershed area that MS4 is responsible for. Use the MS4 boundaries available within the Kentucky Singlezone Geographic Information System Portal to determine the percent of MS4 area above the downstream end of the impaired segment. However, not all runoff from within the MS4 boundary transits impervious surfaces and/or is collected by the MS4 infrastructure; some precipitation falls on areas such as forest or farms and the runoff goes directly to creeks instead (e.g., MS4s can contain forest, agriculture, wetlands, etc. which drain directly to creeks). Therefore, the portion of the load allocated to the MS4 is determined by assigning the different landuse categories within the MS4 boundary either to the MS4 or to the LA sources. The landuse categories are assigned as follows:

Table 4.F.2.3 MS4/LA Landuse Assignments Within the MS4 Boundary

Land Use	Load Assignment
Forest (all kinds)	LA
Agriculture (all kinds)	LA
Developed (all kinds)	MS4
Natural Grassland	LA
Wetland (all kinds)	LA
Barren	LA

This calculation is only performed within the MS4 boundary: in non-MS4 areas, 100% of the land area is attributed to LA sources (and WWTPs, if present). Mathematically, the MS4 allocation can be expressed as:

$$\text{MS4 WLA} = (\text{TMDL} - \text{MOS} - \text{KPDES WLA}) \times (\%\ \text{of area that is MS4})$$

(Equation 5)

4.F.3 Mean Annual Flow Method.

When no gage is useful for constructing flow duration curves, and no other method allows a sufficient flow record to be generated at ungaged sites, the MAF method will be used to develop pathogen TMDLs.

4.F.3.1 Calculate Existing Concentration. Calculate the 90th percentile of all pathogen data from one impaired segment (which may include the data from one or more sampling sites, with the concurrence of the TMDL Section Supervisor) to generate an existing concentration. This will be done in Microsoft Excel™ using the percentile function.

4.F.3.2 Determine the Critical Flow. Obtain the MAF for the downstream end of the impaired segment represented by the sampling site(s) from the Hydrology of Kentucky website (http://kygeonet.ky.gov/kyhydro/main.htm). Add any inputs greater than 1% of the MAF (including the design flow of any WWTPs within or upstream of the impaired segment, or flows from other known sources) to the MAF and subtract any withdrawals greater than 1% of the MAF to generate the Critical Flow.

4.F.3.3 Determine Existing Load. Multiply the existing concentration by the Critical Flow and a conversion factor (i.e., flow (cfs) times concentration (colonies/100ml) times 24,405,408 gives load in colonies/day: another appropriate unit is billions of colonies/day) to determine the existing load.

4.F.3.4 Allocate Loads. Calculate the TMDL Target concentration (i.e., the WQC minus the MOS), then multiply the TMDL Target concentration by the Critical Flow and the conversion factor (as in 4.F.3.3) to convert to the TMDL Target load. Calculate the percent reduction using the Equation 3. Assign WLAs and LAs as described in 4.F.2.3.

4.G CRITERIA.

Pathogen TMDLs must meet the following criteria:

1. They must conform to this SOP, with any deviations approved by the TMDL Section Supervisor and documented within the TMDL,
2. They must set the TMDL at the WQC as set forth in 401 KAR 10:031,
3. They must meet the requirements in the latest version of DOW's *Quality Assurance Project Plan for Data Analysis for TMDL Development* (Draft, KDOW, 2008), and
4. They must be approved by the TMDL Section Supervisor. The TMDL Section Supervisor checks the "Approved" box and initials the Coordination Sheet for the Proposed Draft when approving the TMDL. The same procedure is followed for the Proposed Draft and the Final TMDL before it is sent to EPA for final approval.

4.H RECORDS MANAGEMENT. As stated in DOW's *Quality Assurance Project Plan for Data Analysis for TMDL Development* (Draft, KDOW, 2008), the Final TMDL and the TMDL QAPP Checklist are maintained in the Administrative Record indefinitely.

5.0 QUALITY CONTROL AND QUALITY ASSURANCE SECTION. The TMDL Section Supervisor completes the TMDL QAPP Checklist for each pathogen TMDL submittal as required by the *Quality Assurance Project Plan for Data Analysis for TMDL Development* (Draft, KDOW, 2008).

6.0 REFERENCES

33 U.S.C. § 1251, Section 303(d). Clean Water Act. 1972.

40 CFR Part 130. Water Quality Planning and Management Regulations. 1985.

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