

DEP STORMWATER THERMAL ANALYSIS SPREADSHEET INSTRUCTIONS

DRAFT, October 14, 2025

Introduction

The Department of Environmental Protection (DEP) has developed the Stormwater Thermal Analysis Spreadsheet (Spreadsheet) to facilitate implementation of the requirements of 25 Pa. § 102.8(f)(13). The Spreadsheet was designed using the latest version of Microsoft Excel® and is in Excel macro workbook (XLSM) format.

Completion of a quantitative thermal impact analysis is a requirement of PCSM Module 2 in certain scenarios. The Spreadsheet may be used to satisfy this requirement. If approaches other than the Spreadsheet are used, the applicant should seek approval from DEP's Bureau of Clean Water (BCW) prior to submitting the Notice of Intent (NOI) or application for a Chapter 102 permit. Alternative analyses should be sent to RA-EPChapter102@pa.gov.

The Spreadsheet focuses the thermal analysis on the summer months (June through September) when the likelihood to exceed state water quality standards (WQS) for temperature is greatest.

Users should check DEP's website periodically for updates to the spreadsheet and instructions by visiting www.dep.pa.gov/constructionstormwater and selecting "E&S Resources". In general, DEP/CCD will accept older versions of the spreadsheet no more than 6 months following the revision date of the spreadsheet. DEP/CCD also reserves the right to request completion of the latest version of the spreadsheet for any project.

Questions on the use of the spreadsheet can be directed to BCW (RA-EPCHAPTER102@pa.gov).

General Information

It is important that the user follow these instructions carefully. Omission of data in any cell designed for data entry may result in the failure of important calculations.

If prompted by Excel after opening the spreadsheet, enable editing and macros. *Note that you may need to add additional Trusted Locations in the Trust Center Settings of Excel in order to run the macros.* These locations may include server drives and/or locations where you intend to save the file for use. The following steps may be taken:

1. Excel Options > Trust Center > Trust Center Settings > Trusted Locations
2. Check the box to "Allow Trusted Locations on my network"
3. Select "Add new location"
4. Browse to select the folder (or server) where the file will be saved, check the "Subfolders of this location are also trusted" box, and then OK.

The top of the worksheet contains a "Clear Form" button. The user may click on the "Clear Form" button at any time to delete **all** data from the current worksheet. If the user wants to revise the information in only one cell, the user should select that cell and use the backspace or delete key to remove the current value and then enter the new value into the cell.

All cells available for data entry or selection from a drop-down menu are highlighted. **The user may use the Tab, arrow, or Enter keys to move from cell to cell. Using the mouse to click from cell to cell may result in validation errors.**

Care must be taken to enter the data in the correct order identified in these instructions to avoid potential errors with the calculations and logic. For example, skipping a cell may prevent a calculation or produce an error message. The spreadsheet is protected. Formulas are not visible but are explained in this document. Validation that exists in the spreadsheet is highlighted and explained in this document.

Completing the Spreadsheet

CLEAR FORM

CHAPTER 102
STORMWATER THERMAL ANALYSIS SPREADSHEET

Project Name:

Select the thermal analysis scenario from the dropdown list:

- **Project Name** – Enter the Project (Site) Name that will be or has been identified on NOI or application for a Chapter 102 permit.
- **Thermal Analysis Scenario** – Select from the dropdown list the scenario for thermal analysis (corresponding with PCSM Module 2):
 - **Scenario 1** – One or more peak rate control SCMs are proposed that will receive stormwater from a drainage area containing more than 25% impervious surface. Only the last peak rate control SCM in a series of SCMs, which discharges to a surface water or conveyance to a surface water, should be considered for this scenario.
 - **Scenario 2** – A Wet Basin or Engineered Stormwater Treatment Wetland is proposed that does not include shading and/or a reversed slope outlet pipe and discharges to a surface water or conveyance to a surface water.

NOTE – If both Scenarios 1 and 2 apply to an SCM, select Scenario 1.

 - **Scenario 3** – There will be post-construction undetained areas, within the limit of disturbance, that contain impervious surface.

Scenarios 1 and 2

Scenarios 1 and 2 are handled identically except where indicated below. Note that one stormwater control measure (SCM) should be reported per Spreadsheet. If there are multiple SCMs for a project that meet the Scenario 1 and/or Scenario 2 criteria, Spreadsheets should be completed for each SCM.

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General Section

SCM ID:

SCM Drainage Area: acres

Total Drainage Area of Surface Water at SCM's DP: acres

Ratio of SCM Drainage Area : Surface Water Drainage Area: %

A thermal analysis is required because the ratio exceeds 10%.

- **SCM ID** – Enter the SCM ID number from PCSM Module 2 and PCSM Plan Drawings.
- **SCM Drainage Area** – Report the drainage area for the SCM, in acres. Note that this information is not required for Scenario 2.
- **Total Drainage Area of Surface Water at SCM's DP** – Enter the total drainage area, including the SCM drainage area, of the surface water (i.e., watershed area) at the SCM's discharge point (DP). Note that this information is not required for Scenario 2. [USGS StreamStats](#) or other services may be used to determine this value.
- **Ratio of SCM Drainage Area: Surface Water Drainage Area** – The ratio between SCM Drainage Area and Surface Water Drainage Area is calculated and displayed. A message is shown below the ratio in red if a thermal analysis is required or in green if an analysis is not required. Note that this information is not required for Scenario 2.

SCM Information

Click on the checkbox to display information related to the SCM.

☒ **SCM Information**

2-Year/24-Hour Storm Precipitation Depth: inches

SCM Discharge Period: hours

Total Volume Discharged During SCM Discharge Period: CF

Average SCM Discharge Rate: cfs

Average SCM Discharge Temperature: °F

- **2-Year/24-Hour Storm Precipitation Depth** – DEP recommends that applicants utilize the [NOAA Atlas 14 online service](#) to locate the weather station closest to the project site and select the 2-year / 24-hour storm event total, in inches.

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- **SCM Discharge Period** – Enter the number of hours, up to 24, that the SCM is expected to discharge during the 2-year/24-hour storm, following the start of the 24-hour storm event, through modeling. For example, if the storm event begins at 8 AM and the SCM begins discharging at 12 PM and continues discharging until the end of the storm event, enter 20 hours. The modeler can assume that there has been no precipitation in the prior week leading up to the storm.
- **Total Volume Discharged During SCM Discharge Period** – Report the total volume discharged from the SCM, in cubic feet (CF), during the discharge period by developing an outflow hydrograph.
- **Average SCM Discharge Rate** – The average SCM discharge rate is calculated by dividing the Total Volume Discharged During SCM Discharge Period by the SCM Discharge Period, in seconds.
- **Average SCM Discharge Temperature** – Enter the average SCM discharge temperature expected for the month of July. The default average SCM discharge temperature is 82°F, which is the median effluent temperature determined by Jones and Hunt (2010)¹ from a wet pond receiving urban runoff during July 2006. The following lists the median effluent temperatures for all summer months:

Month	Median Effluent Temperature (MET)	Difference from July MET
June	76.9°F	- 5.1°F
July	82°F	-
August	79.1°F	- 2.9°F
September	73.9°F	- 8.1°F

As discussed further below, the projected downstream temperatures (following mixing with SCM discharges) apply the Difference from July MET values for the months of June, August, and September.

Users may enter a value other than 82°F for the average SCM discharge temperature during July if supported by data and/or published research that is provided as an attachment to the Spreadsheet. However, the minimum allowable temperature is 76°F.

Surface Water Information

☒ **Surface Water Information**

Surface Water Name:

Chapter 93 Classification:

Surface Water Q₇₋₁₀ Flow: cfs

Site-Specific Ambient Temperature Data are Available:

- **Surface Water Name** – Enter the name of the surface water that will receive SCM discharges.
- **Chapter 93 Classification** – Select the Chapter 93 classification from the dropdown list. If the surface water has an [existing use](#), select the existing use, otherwise select the designated use in [Chapter 93](#). For discharges

¹ Jones, M. P., Hunt, W. F. 2010. Effect of Stormwater Wetlands and Wet Ponds on Runoff Temperature in Trout Sensitive Waters. *Journal of Irrigation and Drainage Engineering*. American Society of Civil Engineers. Volume 136, Number 9.

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directly to the Ohio River, select “ORSANCO”. If “ORSANCO” is selected, the more stringent of Warm Water Fishes (WWF) and ORSANCO temperature criteria will be used.

- **Surface Water Q_{7-10} Flow** – Report the 7-day, 10-year low flow statistic (Q_{7-10}) for the surface water at the point of SCM discharge. DEP recommends use of [USGS StreamStats](#). Identify the study area and click on “Delineate”. Click on the stream at the location of the discharge. Click on “Continue”, then “Low-Flow Statistics”, then “Continue”, and “Open Report.” An example report is shown below. In this example the Q_{7-10} flow is 2.13 cfs. In the event the drainage area is too small, StreamStats may not be able to compute low flow statistics. In such cases the user should select the first point downstream where low flow statistics can be computed by StreamStats and use the Q_{7-10} flow at that point. For assistance contact DEP (RA-EPChapter102@pa.gov).

Low-Flow Statistics Flow Report [Low Flow Region 2]		
Statistic	Value	Unit
7 Day 2 Year Low Flow	3.05	ft ³ /s
30 Day 2 Year Low Flow	3.28	ft ³ /s
7 Day 10 Year Low Flow	2.13	ft ³ /s
30 Day 10 Year Low Flow	2.28	ft ³ /s
90 Day 10 Year Low Flow	2.58	ft ³ /s

- **Site-Specific Ambient Temperature Data are Available** – Select “Yes” or “No” from the dropdown list to indicate whether site-specific ambient (upstream) temperature data are available for the surface water. If “No” is selected, default ambient data are used when the Chapter 93 classification is WWF, Cold Water Fishes (CWF), or Trout Stocking Fishery (TSF). These ambient data are shown on the Reference worksheet and are contained in DEP guidance ([Implementation Guidance for Temperature Criteria](#)). Default ambient data for High Quality WWF (HQ-WWF) and ORSANCO classifications are the same as WWF. Default ambient data for HQ-CWF and Exceptional Value (EV) classifications are the same as CWF.

If site-specific ambient temperature data are available, select “Yes” from the dropdown list and attach the data to the Spreadsheet. Applicants planning to collect site-specific ambient temperature data for this purpose should contact DEP (RA-EPChapter102@pa.gov) for guidance.

Temperature Period	Ambient Temperature (°F)
Jun 1-15	
Jun 16-30	
Jul 1-31	
Aug 1-15	
Aug 16-31	
Sep 1-15	
Sep 16-30	

Contributing Flow from Watershed

Runoff from the contributing watershed is added to the surface water’s Q_{7-10} flow and the SCM’s discharge to determine the downstream surface water temperature, for comparison with the allowable temperature.

☒ **Contributing Flow from Watershed**

Watershed Area (Outside SCM Drainage Area):		acres
% Impervious in Watershed Area:		%
Total Volume of Runoff During 2-Year/24-Hour Storm:		CF
Average Watershed Runoff Rate:		cfs
Average Watershed Runoff Temperature:		°F

- **Watershed Area (Outside SCM Drainage Area)** – Enter the total drainage area of the surface water minus the SCM drainage area. If the analysis is evaluating Scenario 1, the value entered should be the difference between the SCM Drainage Area and the Total Drainage Area of Surface Water at SCM's DP, entered earlier (note that neither the SCM Drainage Area nor the Total Drainage Area is requested for Scenario 2).
- **% Impervious in Watershed Area** – Select the percentage of impervious area within the watershed area (outside of the SCM Drainage Area) from the dropdown list. [USGS StreamStats](#) can provide an estimate of % impervious in the watershed area through the use of the National Land Cover Database (NLCD). After delineating the watershed, click on "Basin Characteristics", "Select All Basin Characteristics", "Continue" and "Open Report." The % impervious from the NLCD 2001 or later data set will be shown in the report.

IMPNLCD01	Percentage of impervious area determined from NLCD 2001 impervious dataset	3.7623	percent
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- **Total Volume of Runoff During 2-Year/24-Hour Storm** – The NRCS Curve Number (CN) method is used to estimate the volume of runoff from the watershed area during the 2-year/24-hour storm, in CF, at the 2-year/24-hour storm precipitation depth. A CN of 98 is assigned to impervious areas. For pervious areas a CN of 65 is used, which is an average of forested and open space land covers for B and C soils.
- **Average Watershed Runoff Rate** – The Total Volume of Runoff During 2-Year/24-Hour is divided by 86,400 seconds (one day) to determine the Average Watershed Runoff Rate, in cfs.
- **Average Watershed Runoff Temperature** – The average runoff temperature from the watershed outside of the SCM drainage area is calculated by combining the estimated thermal loads from impervious and pervious areas, as follows:
 - For pervious areas, it is assumed that the runoff temperature is the same as the default ambient surface water temperature for July (see References worksheet) or the site-specific ambient surface water temperature for July that is entered by the user.
 - For impervious areas, the following regression equation determined by James and Verspagen (1997)² is used to simulate heat transfer between asphalt and stormwater:

$$\Delta T_{sr} = A(\ln(t)) + B$$

² James, W. and Verspagen, B. 1997. Advances in Modeling the Management of Stormwater Impacts: Chapter 8, Thermal Enrichment of Stormwater by Urban Pavement.

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Where:

ΔT_{sr} = change in surface runoff temperature ($^{\circ}\text{C}$);
 A = temperature decay characterized by: $0.0047i - 5.18ks - 0.13T_{is} + 0.15T_{ir} - 1.55$;
 B = y intercept (starting temperature) characterized by: $-0.0294i - 2.26ks + 0.52T_{is} + 0.07T_{ir} - 14.62$;
 t = time (minutes, corresponding to the SCM Discharge Period);
 i = rainfall intensity (mm/hr, e.g., 3.2 mm/hr for a 3-inch/24-hour storm event);
 ks = thermal conductivity of asphalt (assumed $0.00145 \text{ kW}/(\text{m}\cdot^{\circ}\text{C})$);
 T_{is} = initial temperature of the asphalt (assumed 140°F or 60°C);
 T_{ir} = initial temperature of the runoff (assumed 80°F or 26.7°C).

The equation above is used to determine temperature changes in comparison to the initial temperature of the runoff (80°F) each consecutive minute during the SCM Discharge Period. The average runoff temperature is then calculated and used as the runoff temperature for impervious areas.

Downstream Results

☒ **Downstream Results**

Temperature Period	Allowable Temperature ($^{\circ}\text{F}$)	Projected Temperature ($^{\circ}\text{F}$)
Jun 1-15	60	
Jun 16-30	64	
Jul 1-31	66	
Aug 1-15	66	
Aug 16-31	66	
Sep 1-15	64	
Sep 16-30	60	

- **Allowable Temperature ($^{\circ}\text{F}$)** – For surface waters with a classification of WWF, CWF, TSF, and ORSANCO, the allowable temperature for each period is the Chapter 93 temperature criterion for the period, as shown on the Reference worksheet, unless the user-entered ambient surface water temperature exceeds the Chapter 93 criterion. If this is the case, the user-entered ambient temperature plus 1°F becomes the allowable temperature. A 1°F increase is allowed as per [DEP's temperature guidance](#) relating to measurement precision.

For surface waters with a classification of HQ or EV, the standard is no measurable degradation in existing water quality (temperature). The allowable temperature for each period is the user-entered ambient surface water temperature (if applicable) plus 1°F or the default ambient surface water temperature plus 1°F .

- **Projected Temperature ($^{\circ}\text{F}$)** – The projected downstream temperature, assuming complete mix between surface water flow, discharge flow, and contributing watershed flow, is calculated by the following formula:

$$\frac{[(\text{Average SCM Discharge Rate} \times \text{Average SCM Discharge Temperature}) + (\text{Surface Water } Q_{7-10} \text{ Flow} \times \text{Ambient Surface Water Temperature}) + (\text{Average Watershed Runoff Rate} \times \text{Average Watershed Runoff Temperature})]}{(\text{Average SCM Discharge Rate} + \text{Surface Water } Q_{7-10} \text{ Flow} + \text{Average Watershed Runoff Rate})}$$

If the Projected Temperature is less than or equal to the Allowable Temperature a green checkmark is displayed; otherwise, a red "x" is displayed.

✓ **Downstream Results**

Temperature Period	Allowable Temperature (°F)	Projected Temperature (°F)
Jun 1-15	80	80
Jun 16-30	84	80
Jul 1-31	87	81
Aug 1-15	87	81
Aug 16-31	87	81
Sep 1-15	84	79
Sep 16-30	78	79



Compliance



Exceedance

Scenario 3

Scenario 3 evaluates the impacts of stormwater from proposed undetained impervious surfaces (i.e., runoff from impervious that is not captured and treated by an SCM) on surface water temperatures.

General

Undetained Impervious Area:	1.5	acres
Total Drainage Area of Surface Water at Undetained Impervious:	10	acres
Ratio of Undetained Impervious Area : Surface Water Drainage Area:	15.0	%

A thermal analysis is required because the ratio exceeds 10%.

- **Undetained Impervious Area** – Enter the area of proposed undetained impervious surface, in acres.
- **Total Drainage Area of Surface Water at Undetained Impervious** – Report the total drainage area, including the undetained impervious area, of the surface water (i.e., watershed area) at the location where runoff from the impervious area is expected to flow into the surface water. If runoff is expected to flow by sheet flow into the surface water, the mid-point of the sheet flow discharge should be used to determine the total drainage area.
- **Ratio of Undetained Impervious Area: Surface Water Drainage Area** – The ratio between Undetained Impervious Area and Surface Water Drainage Area is calculated and displayed. A message is shown below the ratio in red if a thermal analysis is required or in green if an analysis is not required.

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Impervious Information

☒ **Impervious Information**

2-Year/24-Hour Storm Precipitation Depth:		inches
Total Volume of Runoff During 2-Year/24-Hour Storm:		CF
Average Impervious Area Runoff Rate:		cfs
Average Impervious Runoff Temperature During Storm:	80.3	°F

- **2-Year-/24-Hour Storm Precipitation Depth** – DEP recommends that applicants utilize the [NOAA Atlas 14 online service](#) to locate the weather station closest to the project site and select the 2-year / 24-hour storm event total, in inches.
- **Total Volume of Runoff During 2-Year/24-Hour Storm** – The total volume of runoff from the undetained impervious area is calculated using the NRCS Curve Number method and a CN of 98.
- **Average Impervious Runoff Rate** – The average impervious runoff rate is calculated by dividing the Total Volume of Runoff During 2-Year/24-Hour Storm by 86,400 seconds (1 day).
- **Average Impervious Runoff Temperature During Storm** – The average temperature over the 24-hour storm event is calculated using the James and Verspagen (1997) method explained above for Scenarios 1 and 2.

Surface Water Information

The information requested and calculations for Scenario 3 are the same as Scenarios 1 and 2, described above.

Contributing Flow from Watershed

The information requested and calculations for Scenario 3 are the same as Scenarios 1 and 2, described above, except the Average Runoff Temperature During Storm is calculated using the full duration of the 24-hour storm instead of the average temperature during the SCM Discharge Period (as is done for Scenarios 1 and 2).

Downstream Results

The calculations for allowable and projected temperatures for Scenario 3 are the same as Scenarios 1 and 2, described above.

Mitigation

In the event one or more projected temperatures exceed allowable temperatures, DEP recommends the following mitigation measures:

- **Scenario 1** – One or more peak rate control SCMs are proposed that will receive stormwater from a drainage area containing more than 25% impervious surface.
 - *Recommended Mitigation Measures* – Reduce impervious area in the SCM drainage area; make modifications to the SCM design to reduce the SCM discharge period and/or total volume discharged; maximize the use of vegetated SCMs and tree plantings in the SCM drainage area; and/or direct the

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discharge from the rate control SCM to a riparian buffer or riparian forest buffer (as sheet flow) to reduce temperatures.

- **Scenario 2** – A Wet Basin or Engineered Stormwater Treatment Wetland is proposed that does not include shading and/or a reversed slope outlet pipe.
 - *Recommended Mitigation Measures* – Provide shading through the planting of trees around the perimeter of the SCM and a reversed slope outlet pipe to draw cooler water from the bottom of the SCM.
- **Scenario 3** – There will be post-construction undetained areas, within the limit of disturbance, that contain impervious surface.
 - *Recommended Mitigation Measures* – Reduce the area of undetained impervious.

Site-specific ambient surface water temperature data and/or SCM discharge temperature data may also be collected. It is recommended that applicants contact DEP (RA-EPChapter102@pa.gov) for guidance prior to initiating these efforts.

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Revision History

Date	Version	Revision Reason
10/14/2025	1.0	Draft