BROWN'S CREEK
WATERSHED DISTRICT
Preserving the integrity of the watershed for future generations
www.bcwd.org | 455 Hayward Ave N, Oakdale, MN 55128 | 651-330-8220

Thermal Modeling Guidance for Rule 2.5.3:

Basin in Contributing Area to Groundwater-Dependent Natural Resource

Purpose

This guidance has been developed to provide recommendations on the information and calculations that should be submitted to demonstrate compliance with **Rule 2.5.3**, which states that:

"A stormwater basin within the surface contributing area to a groundwater-dependent natural resource must contain and infiltrate the volume generated by a two-year, 24-hour storm event, if feasible. The basin bottom must be at least three feet above the seasonally high water table, bedrock or other impeding layer. If this infiltration standard is determined infeasible, basin outflow must be non-erosive and routed through a subsurface system, flow spreader or other device that discharges water through or across the ground to lower discharge temperature to that of the ambient soil."

Guidance for Evaluating the Discharge Temperature Rule

Option 1: Demonstrate the feasibility of infiltrating the two-year, 24-hour storm event

If the runoff volume generated by the two-year, 24-hour storm event can be contained and infiltrated, thermal modeling of the system is not required. The following steps describe how to demonstrate that a basin can meet this requirement.

A. Calculate the runoff volume for the two-year, 24-hour storm event using Atlas 14 precipitation depths and the runoff coefficients (C) provided in Table 1, which are based on the SCS curve numbers generated for post-development conditions. For each land use type there is a corresponding curve number (CN) for each of the SCS hydrologic soil types (A, B, C, and D). The hydrologic soil types can be found in the Soil Survey of Washington and Ramsey Counties, Minnesota (SCS, 1977), and the CN can be found in the Hydrology Guide for Minnesota (U.S. Department of Agriculture Soil Conservation Service St. Paul, Minnesota). A composite CN is determined by calculating the weighted average of the CN's based on the area of the subwatershed. To obtain the runoff volume, multiply the runoff coefficient by the area of the subwatershed (in units of square feet) and by the precipitation depth (in units of inches), then divide the result by 12 (this converts the result to units of cubic feet), as shown below.

Runoff Volume = Runoff Coefficient x Subwatershed Area x Precipitation Depth ÷ 12

Table 1. Curve numbers and corresponding runoff coefficients

SCS Curve Number (CN)	Runoff Coefficient (C)	SCS Curve Number (CN)	Runoff Coefficient (C)
40	0	72	0.225
45	0.005	75	0.27
50	0.015	78	0.33
55	0.045	80	0.37
58	0.06	84	0.46
60	0.08	85	0.485
65	0.13	90	0.62
66	0.145	95	0.79
70	0.195	98	0.91

B. Estimate the 24-hour infiltration volume using the infiltration rates shown in Table 2, which are based on the hydrologic soil group of the underlying soil. To obtain the 24-hour infiltration volume, multiply the infiltration rate (given in units of inches per hour) by the area of the bottom of the basin (in units of square feet), then multiply the result by 2 (this converts the result to units of cubic feet), as shown below.

Infiltration Volume = Infiltration Rate x Basin Area x 2

Table 2. Estimated infiltration rates expected for hydrologic soil groups

Hydrologic Soil Group	Infiltration Rate (in/hr)	Soil Textures	Corresponding Unified Soil Classification
A	1.63 – 0.8	Silty gravel, gravelly sand, sand, loamy sand, or sandy loam	**GW** – Well-graded gravel **GP** – Poorly-graded gravel **GM** – Silty gravel **GC** – Clayey gravel **SW** – Well-graded sand **SP** – Poorly-graded sand
B	0.45 – 0.3	Silty sand, loam, or silt loam	**SM** – Silty sand **MH** – Elastic silt
C[1]	0.2	Sandy clay loam or silt	**ML** – Silt
D	0.06	Clay loam, silty clay loam, sandy clay, silty clay, or clay	**SC** – Clayey sand **CL** – Lean clay **OL** – Organic silt **CH** – Fat clay **OH** – Organic clay

C. Calculate the storage volume requirement by subtracting the infiltration volume (calculated in Step B) from the runoff volume (calculated in Step A), as shown below.

Storage Volume = Runoff Volume – Infiltration Volume

D. Compare the estimated storage volume of the basin with the storage volume requirement calculated in Step C. If the basin volume is greater than or equal to the requirement, proceed to Step E; if not, proceed to Option 2.

E. Show that the bottom of the basin is greater than three feet above the seasonally high water, bedrock, or other impeding layer. Options for determining this depth include the Soil Survey, well-monitoring data, or by examination of soil borings.

[1] Soils with infiltration rates <0.2 in/hr NOT recommended for use with stormwater management practices.

Option 2: Demonstrate adequate reduction in discharge temperature

If the steps in Option 1 indicate that the runoff volume generated by the 2-year, 24-hour storm event cannot be contained and infiltrated, modeling of the system is required to show that the temperature of any discharge from the basin can be reduced to the temperature of the ambient soil.

It is recommended that the Minnesota Heat Export Tool (MINUHET) be used to demonstrate this reduction in discharge temperature, as it is freely available and relatively easy to use. Conveniently, the tool has built-in storm events including a 2-year, 24-hour rainfall event of 2.8 inches ("Synthetic03"), which is very close to the Atlas 14 precipitation depths for locations within the district. The tool can be downloaded at https://cse.umn.edu/safl/feature-stories/minuhet-software-tool-available-practitioners-better-assess-temperature. The webpage also contains links to reference materials such as the MINUHET user manual, which includes example modeling scenarios. Users unfamiliar with MINUHET should start by consulting the user manual.

The recommended method for demonstrating an adequate reduction in discharge temperature is to approximate "ambient soil temperature" by building a model for a site's pre-settlement condition and comparing the discharge temperature with that from the post-development condition. Pre-settlement conditions will vary within the District, and can be estimated from historical land-cover and soil conditions. If historical conditions are not known, recommended settings representing a conservative estimate are shown in Table 3.

Table 3. Suggested settings for pre-settlement conditions in an old-growth forest

Parameter	Recommended Setting
Sheltering	75%
Shading	100%
Soil Type	Soil survey undrained condition (e.g., if soil is B/D, then Soil Type = “D”)
Soil Moisture	“nor”
Vegetation Density	100%
Land Use	“forest”

To facilitate a direct comparison between the pre-settlement and post-development simulations, the delineation of the subwatersheds in each scenario should be equivalent. An example scenario is shown in Figure 1, where four subwatersheds are shown in both the pre-settlement and post-development conditions.

In the scenario shown, a comparison would be reported for the heat export from the entire site post-development (for which the outlet would be the pond "3P") and pre-settlement. A summary of the results is shown in Table 4. It can be seen in Table 4 that the post-development heat export is less than that for the pre-settlement condition, indicating that this design meets the requirements of the rule.

Figure 1. Screenshot of an example simulation setup in the MINUHET interface.

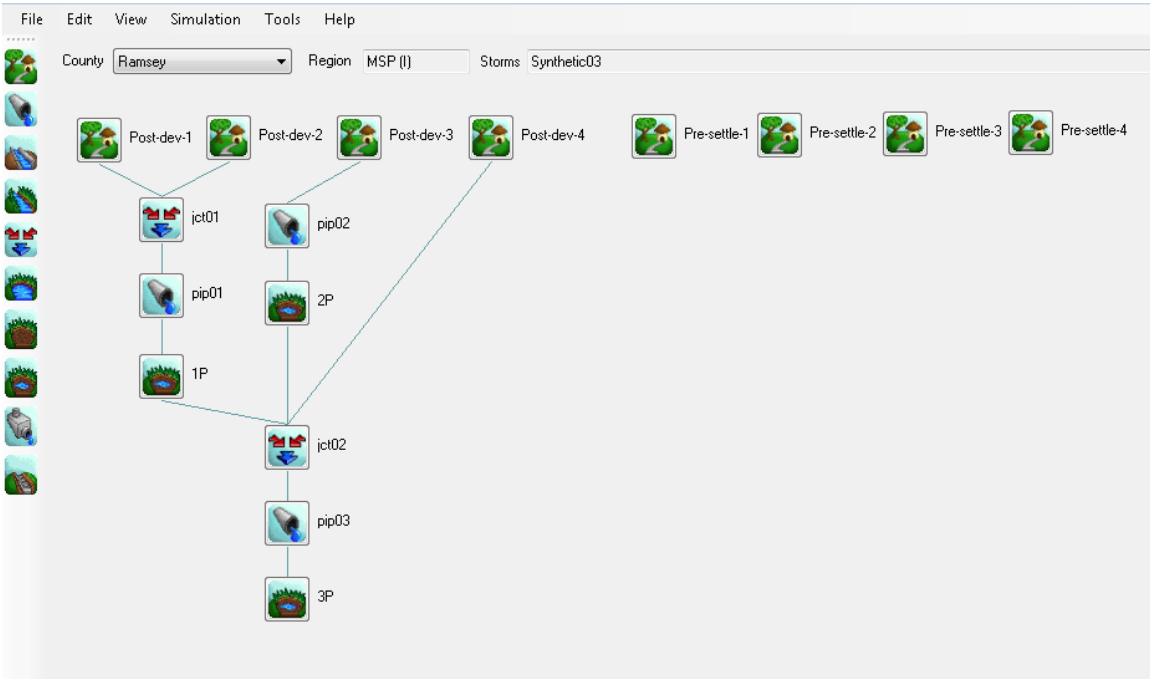

Table 4. Example scenario results and heat export comparison, showing that post-development heat export is less than pre-settlement heat export.

Element	Total Runoff Volume (m^3)	Average Runoff Temperature (C)	Total Heat Export (J)
Pre-settle -1	67.20	21.11	8.72E+08
Pre-settle -2	147.20	21.11	1.91E+09
Pre-settle -3	41.29	21.17	5.46E+08
Pre-settle -4	72.32	21.11	9.38E+08
Pre-settlement subtotal	-	-	4.72E+09
3P	112.9	21.58	1.73E+09
Post-development subtotal	-	-	1.73E+09

It should be noted that certain restrictions exist related to the routing of flow in MINUHET, which are not necessarily clear in the supporting documentation (e.g. the user manual). These include:

A. Two or more flows cannot be routed to certain devices (e.g. pipes) – a Junction must be used;

B. Certain devices (e.g. ponds) cannot be routed in series – an intermediate Junction must be used;

C. The use of Junctions is limited in two ways:

  1. Junctions cannot be routed to other Junctions, and
  2. Junctions can have a maximum of five inflow connections.