CHAPTER 3
STORMWATER

3.1 STORMWATER AND THE HYDROLOGIC CYCLE

The Hydrologic Cycle

The hydrologic cycle, illustrated in Figure 3.1-1, is the movement of water from the atmosphere to the earth's surface. Water moves through one or more components of the cycle including evaporation, transpiration, runoff, precipitation, infiltration, percolation and its eventual return to the atmosphere.

In an undeveloped area, with natural ground cover such as forest or meadow, a significant portion of precipitation infiltrates into the soil. This water is filtered and cooled as it travels underground. Some infiltrated water is subsequently discharged into rivers and streams as *baseflow*. Baseflow provides a steady contribution of high quality water to lakes, streams and rivers. Other infiltrated water descends deeper underground to the water table and recharges aquifers. Groundwater recharge replenishes the supply of underground water that can be extracted for domestic use and irrigation. Another portion of precipitation is returned to the atmosphere through a combination of evaporation and plant transpiration called evapotranspiration. Where there is natural ground cover, all of these processes together serve to minimize the percentage of precipitation that becomes runoff, the water that flows over that land surface into streams and other surface water bodies.

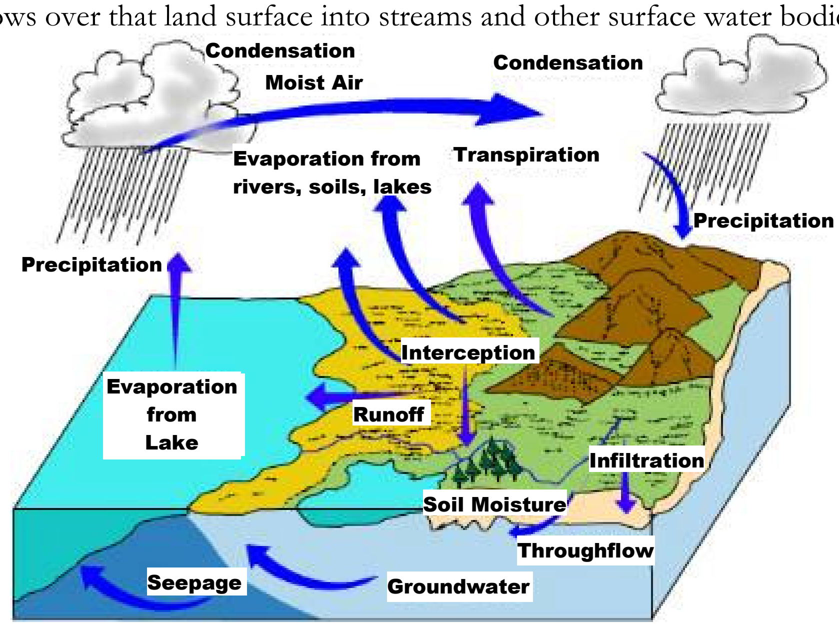

Figure 3.1-1 The Hydrologic Cycle, Adapted from: The Physical Environment: An Introduction to Physical Geography, http://www.uwsp.edu/gEo/faculty/ritter/glossary/h_k/hydrologic_cycle.html

Stormwater and the Hydrologic Cycle

Urbanization dramatically affects the hydrologic cycle by altering the relative percentage of precipitation that contributes to groundwater, evapotranspiration, and runoff relative to the natural ground cover. Specifically, urbanization increases runoff by decreasing the amount of water that infiltrates into the ground and is taken up and transpired by plants. This is because water cannot infiltrate into, and plants cannot grow on, impervious surfaces such as pavement and rooftops. Figure 3.1-2 illustrates how watershed imperviousness affects the magnitude of each of the hydrologic cycle components. Increased stormwater runoff not only decreases baseflow and groundwater recharge, but also increases the amount of water that runs off the surface, picking up and carrying pollutants to lakes, streams, rivers and wetlands. The increased surface runoff increases flooding frequency and severity while the increased input of pollutants degrades water quality and aquatic habitat.

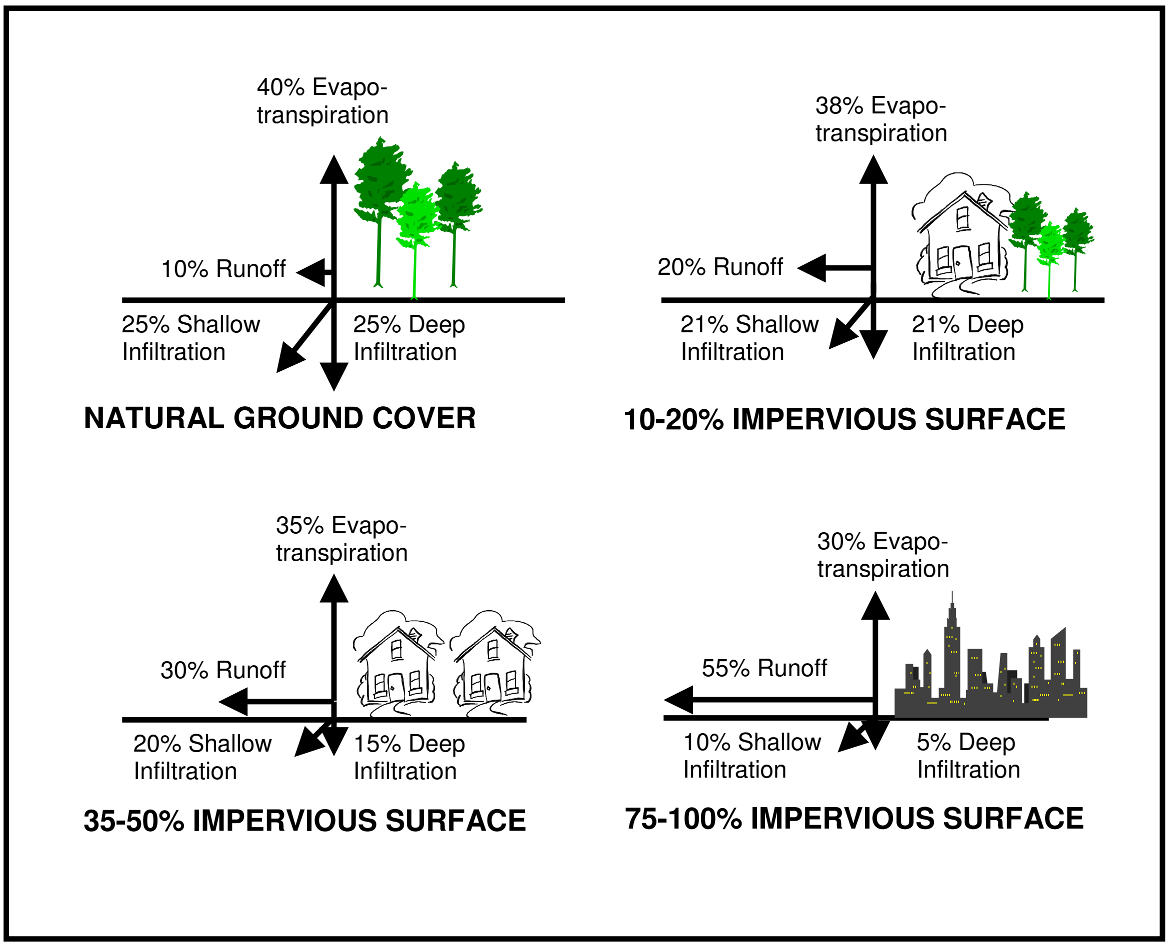

Figure 3.1-2 Impact of Impervious Area on the Hydrologic Cycle Fluxes,
Adapted from: Prince Georges County Department of Environmental Resources Programs and Planning Division. 1999. *Low-Impact Development Design Strategies: An Integrated Design Approach*. Department of Environmental Resources, Prince Georges County, Maryland.

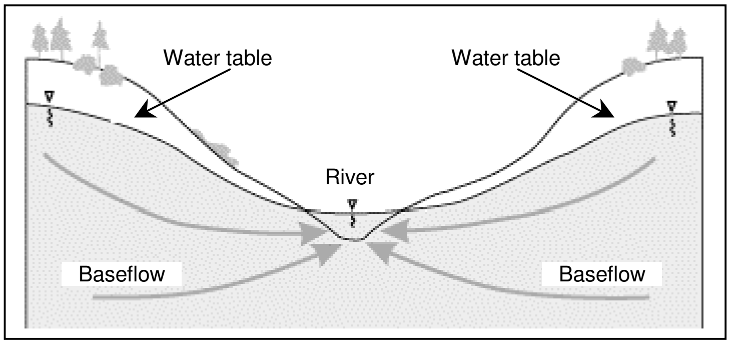

Figure 3.1-3. Baseflow
Baseflow is the groundwater that constantly supplies rivers and streams with high quality water. When imperviousness decreases infiltration to groundwater, baseflow decreases.
Adapted from: *Water Resources Management Practicum, 2000, Dam Repair or Removal: A Decision-making Guide.*

Hydrographs

Stormwater hydrographs are plots of runoff discharge versus time. They illustrate a site's response to a storm event. The highest point on a hydrograph represents the peak flow rate following a storm, and the area under the graph represents the total volume of runoff generated by the storm. Figure 3.1-4 shows the significant difference between a pre- and post- development hydrograph. Specifically, Figure 3.1-4 shows that development increases the volume, peak flow rate and duration of stormwater runoff following a storm event.

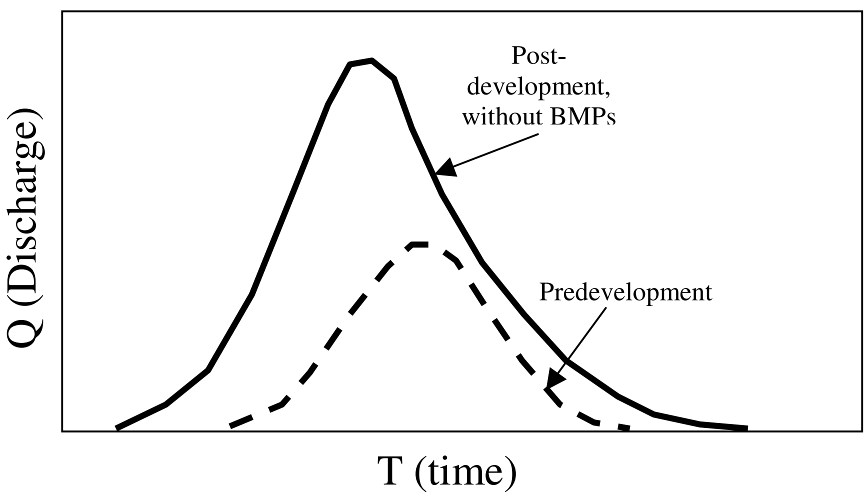

Figure 3.1-4 Pre- and post- development storm hydrograph

The increase in impervious surfaces increases the volume of runoff produced because it reduces infiltration, thus reducing baseflow. The impacts of these changes (Table 3.1-1) include increased flooding, erosion, channel widening, habitat loss, and streambed erosion.

	Flooding	Erosion	Channel Widening	Streambed Alteration	Water Quality Degradation	Habitat Loss
Increased Volume	♦	♦	♦	♦		♦
Increased Peak Flow	♦	♦	♦	♦		♦
Increased Peak Flow Duration	♦	♦	♦	♦		♦
Decreased Base Flow					♦	♦
Changes in Sediment Loading	♦	♦	♦	♦	♦	♦
Increased Pollutant Loading					♦	♦

Table 3.1-1 Effects of Imperviousness
Adapted from: *Urbanization of Streams: Studies of Hydrologic Impacts,* EPA 841-R-97-009, 1997

The Dane County Erosion Control and Stormwater Management Ordinance sets management standards to attenuate the adverse impacts of stormwater. Specifically, stormwater management practices must be designed and installed at new developments to meet ordinance requirements. Management practices must be designed to maintain predevelopment peak flow for the 2- and 10-year, 24-hour storm events, so that the post-development hydrograph is similar to Figure 3.1-5. In order to attenuate the adverse impacts of sediment loading, the ordinance also requires that the stormwater management practices be designed to trap the 5 μm particle for the 1-year, 24-hour storm event.

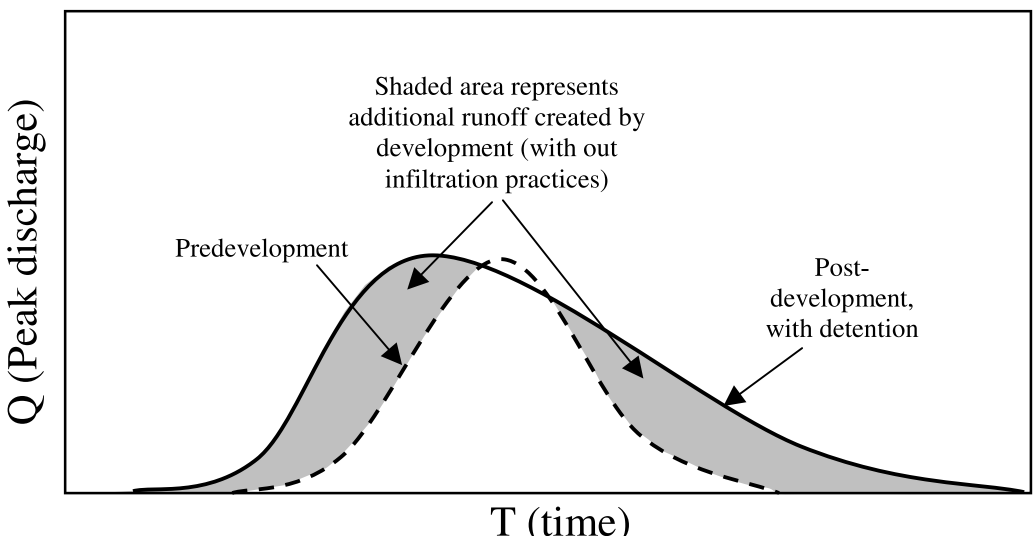

Figure 3.1-5 Hydrograph with stormwater detention practices installed

Note from Figure 3.1-5 that conventional, stormwater detention practices can affect the timing and magnitude of the peak flow rate, but do not equate the volume of pre- and post- development runoff. This is because these management practices retain water and release it at a peak rate equal to predevelopment conditions, but do not facilitate infiltration and evapotranspiration. In order to decrease runoff and partially mitigate the adverse impacts of increased imperviousness, the county ordinance requires that a percentage of the average annual predevelopment infiltration (stay-on) be infiltrated. Residential developments must achieve 90 percent of the average annual predevelopment infiltration (stay-on), while nonresidential development must achieve 60 percent. When more than 1 percent of a residential site, or more than 2 percent of a nonresidential site is needed to meet the stay-on performance standard, a performance standard aimed at meeting a recharge goal may be utilized. The recharge standard requires that a minimum of 7.6 inches of precipitation becomes recharge on an average annual basis. An in-depth explanation of the county infiltration standards and practice modeling is found in Appendix II. The county also strongly recommends infiltration practices be used to meet thermal impact standards, where appropriate, since they have the added benefit of decreasing runoff. Finally, site planners should use techniques that minimize imperviousness and reduce runoff (refer to Section 1.4).

If all of these techniques are utilized, the volume of post-development runoff will approach the volume of predevelopment runoff, reducing the effects of development on lakes and streams.

Dane County stormwater standards should be met through the most effective, economical, and practical combination of management practices. Selection must be site specific and depends on the site conditions (land use, topography, slope, water table elevation, and geology) and applicable standards (rate, volume, sediment, oil and grease and thermal control).

There are three types of management practices that can be used to attenuate stormwater impacts. Dane County recommends utilization of these three methods in the order listed below:

1. Site planning to minimize the volume of runoff originating from the site.
2. Nonstructural techniques, including "good housekeeping" practices, to minimize the amount of pollutants that come into contact with runoff.
3. Construction and maintenance of structural management practices to capture and treat stormwater runoff.

Incorporating these management techniques into the site planning process requires that project proponents identify the site's physical characteristics, use models and other analyses to determine if applicable standards are being met, and consider the cost and feasibility of maintaining the proposed management practices.

Refer to Figure 3.1-6 on the next page for the stormwater planning and permitting process.

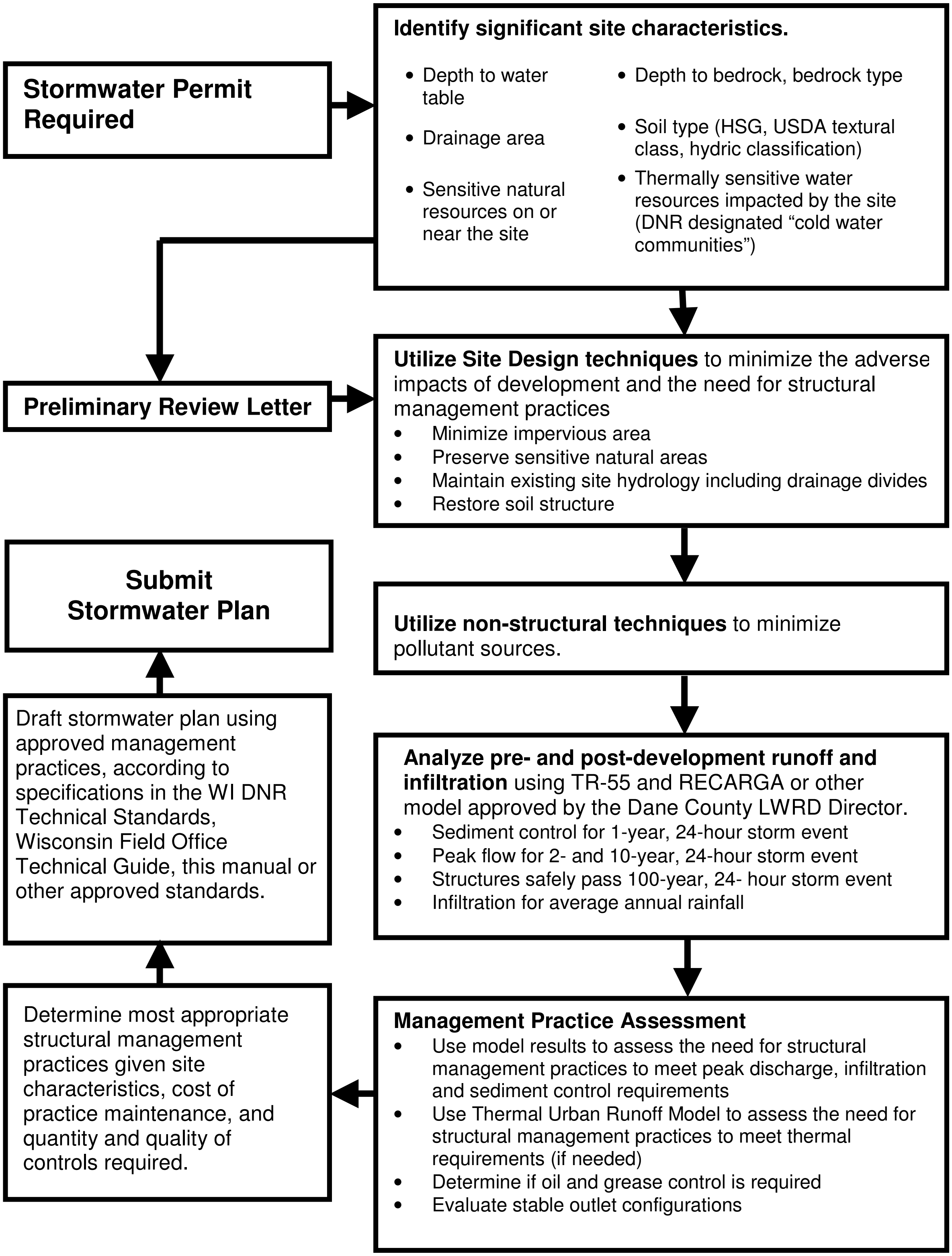

Figure 3.1-6 Dane County Stormwater Site Planning and Permitting Process

3.2 STORMWATER MANAGEMENT STANDARDS AND REQUIREMENTS

The Dane County Erosion Control and Stormwater Management Ordinance requires that all sites needing a stormwater plan and permit install practices that comply with the following standards.

	Standard	Purpose	Applicability
Runoff Rate	Practices must be designed to maintain pre-development peak runoff rates for the 2-year and 10-year, 24-hour storm event, and safely pass the 100-year storm event. For agricultural land, the maximum runoff curve number that can be used in hydrologic calculations for HSG A, B, C and D is 51, 68, 79 and 84, respectively. On sites that are heavily disturbed, the soil permeability class must be lowered by one.	Prevent and/or minimize stream channel scouring, bank alteration and erosion, and downstream flooding.	All new development requiring a stormwater plan.
Stable Outlet	Discharges from new construction sites must have a stable outlet capable of carrying the designed flows at a non-erosive velocity.	Prevent downstream property damage and erosion.	All sites requiring a stormwater plan.
Sediment Control: new construction	Practices must be designed to retain all soil particles greater than 5 microns, for the 1-year 24-hour storm event.	Reduce total suspended solids in stormwater by 80%, with the expected result being a 50% reduction in phosphorus and heavy metals.	All sites requiring a stormwater plan.
Sediment Control: redevelop-ment	Practices must be designed to retain all soil particles greater than 20 microns for the 1-year 24-hour storm event.	Reduce total suspended solids in stormwater by 40%.	Redevelopment resulting in exposed surface parking lots and associated traffic areas.
Oil and Grease Control	Treat the first 0.5 inch of runoff using the best oil and grease removal technology available.	Prevent oil and grease pollution in lakes and streams.	Commercial and industrial sites, and all other sites where the potential for pollution by oil or grease exists.
Thermal Control	Include provisions and practices to reduce runoff temperature.	Prevent damage to thermally sensitive aquatic habitat.	Sites in thermally sensitive watersheds, (see map, p. 48) unless an approved thermal model indicates that post-development site runoff temperature will not increase.
Infiltration	Practices must be designed to maintain 90 percent of the predevelopment infiltration (residential development) and 60 percent of the predevelopment infiltration (nonresidential). If more than 1 percent of a residential or 2 percent of a nonresidential site is needed to meet the stay-on goal, the practices must be designed to meet the 7.5 inch recharge goal (while dedicating a minimum of 1 percent of the site for residential and 2 percent for nonresidential).	Decrease runoff volume and promote infiltration and groundwater recharge.	All new development requiring a stormwater plan.

Submitted plans must also satisfy the following requirements:

1. A narrative describing the proposed project, as it relates to the implementation of designed practices
2. Proposed schedule for completion and installation of all elements of the stormwater management plan
3. A map showing drainage area(s) for each watershed area showing assumed time of concentration flow path
4. A summary of runoff peak flow rate calculation, by watershed area, including:
   a. pre-existing peak flow rates
   b. post-construction peak flow rates with no detention
   c. post-construction peak flow rates with detention
   d. assumed runoff curve numbers (RCNs)
   e. time of concentration (T_c) used in calculations
5. A complete site plan and specifications, signed by the designer which includes:
   a. property lines and lot dimensions
   b. all buildings and outdoor uses, existing and proposed, including all dimensions and setbacks
   c. all public and private roads, interior roads, driveways and parking lots. Show traffic patterns and type of paving and surfacing material
   d. all natural and artificial water features, including, but not limited to lakes, ponds, streams (including intermittent streams), and ditches. Show ordinary high water marks of all navigable waters, 100-year flood elevations and delineated wetland boundaries, if any. If not available, appropriate flood zone determination or wetland delineation, or both, may be required at the applicant's expense
   e. depth to bedrock
   f. depth to seasonal high water table
   g. the extent and location of all soil types as described in the Dane County Soil Survey, slopes exceeding 12%, and areas of woodland or prairie
   h. existing and proposed elevations (referenced to the North American Vertical Datum of 1988, where available) and existing and proposed contours in the area requiring a shoreland erosion control permit
   i. elevations, cross sections, profiles, and details as needed to describe all natural and artificial features of the project
   j. soil erosion control and overland runoff control measures, including runoff calculations as appropriate
   k. detailed construction schedule
   l. copies of permits or permit applications required by any other governmental entities or agencies
   m. any other information necessary to reasonably determine the location, nature and condition of any physical or environmental features of the site
   n. location of all stormwater management practices
   o. all existing and proposed drainage features
   p. the location and area of all proposed impervious surfaces
   q. the limits and area of the disturbed area
6. Engineered designs for all structural management practices

7. Proof of stable outlet capable of carrying the design flow at a non-erosive velocity

8. For new development, trap 5 micron soil particle (80% reduction in TSS) for the 1-year, 24-hour storm event

9. For redevelopment, trap 20 micron soil particle (40% reduction in TSS) for the 1-year, 24-hour storm event

10. Treat first half inch of runoff for control of oil and brease from commercial or industrial areas

11. For residential development infiltrate 90% of the predevelopment infiltration volume and for non-residential development infiltrate 60% of the predevelopment infiltration volume

12. If the site is located in the watershed of a DNR-designated coldwater community, provisions and practices to reduce the temperature of runoff for sites that drain to a coldwater resource as identified in the ordinance (refer to Thermal Locator, p. 45)

13. Identification of the entity responsible for long-term project maintenance

14. A maintenance plan and schedule for all permanent, privately owned stormwater management practices

15. Copy of recorded affidavit required by s.14.49(3)(d) for privately owned stormwater practices

16. Copy of Preliminary Review Letter (PRL), if applicable

17. Evidence of financial responsibility to complete work proposed in plan – A letter of credit (LOC) is required if the estimated cost of implementing the proposed practices is greater than $5000

18. The local authority may establish off-site stormwater management and associated fees, provided that provisions are made to manage stormwater by an off-site facility, and provided that all of the following conditions for the off-site facility are met:
    a. the facility is in place
    b. the facility is designed and adequately sized to provide a level of stormwater control that meets or exceeds the ordinance standards
    c. the local approval authority is satisfied that the facility has a legally obligated entity responsible for its long-term operation and maintenance

In order to assist in meeting the ordinance requirements, Tables 3.2-2 and 3.2-3 list practices that could be used to achieve the stormwater performance standards. The table briefly describes where management practices should be used along with maintenance requirements, environmental concerns and any special considerations for the practice. A more descriptive explanation of each practice is provided in Appendix I. Other practices may be used to meet erosion control or stormwater management standards if first approved by the Dane County LWRD Director.

Non-Structural Practices	Applicable Standard	Applicability to Sites	Maintenance Requirement	Environmental Concerns	Special Considerations	Appendix Page Number
Minimizing Impervious Areas	Thermal, Rate Control, Infiltration	Limited application to retrofit sites	Low	None	May reduce improvement costs	I.M-1
Native Plants	Infiltration, Rate Control	Widely applicable	Low	None	Careful selection of native species; Requires a cover crop during establishment	I.N-1
Parking Lot/Street Sweeping	20% TSS Goal	Widely applicable	Moderate	Sediment and debris collected may be contaminated with heavy metals	Hi-Vac trucks are more efficient	I.P-1
Surface Roughening	7.5 Tons/Acre/year	Widely applicable	Low	Erosion may increase if not done on the contour of the slope	Need a specially selected tracked or wheeled vehicle	I.S-15
Tree Planting	Thermal	Widely applicable (excluding berms and streambanks)	Low	Canopy may shade out ground level vegetation	Careful selection of native species; Size; Proper spacing	I.T-1

Table 3.2-2 Non-Structural Stormwater Management Practices, Adapted from Massachusetts Stormwater Technical Handbook (1997)

Structural Practices	Applicable Standard	Applicability to Sites	Maintenance Requirement	Environmental Concerns	Special Considerations	Appendix Page Number
Bioretention	80% TSS; 40% TSS; Infiltration; Oil and Grease; Thermal; Rate Control	Widely applicable	Moderate	Potential for groundwater contamination if not designed, sited, constructed and maintained properly	Cost; Use native plus or root stock; contamination from salt; construction timing	I.B-1
Basin, Dry	80% TSS; 40% TSS; Thermal; Rate Control	Widely applicable, Larger drainage areas needed	Low to Moderate	Provides less water quality improvement than Wet Basins	Sufficient/suitable land area; Design considerations; Sediment forebay	I.B-2
Basin, Wet	80% TSS; 40% TSS; Rate Control	Widely applicable	Low	Possible thermal impacts; low bacteria removal; May attract undesirable wildlife	Sufficient/suitable land area; Design considerations; Sediment forebay	I.B-3
Vegetated Buffer Strip	80% TSS; Rate Reduction	Widely applicable	Low	None	Sufficient/suitable land area; Careful selection of species; Must be used in conjunction with other BMPs	I.V-1
Constructed Wetland	80% TSS	Applicable on sites with medium-fine textured soils; Requires a large drainage area	High	Possible downstream warming, releases nutrients in the fall	Sufficient/suitable land area, Cost; Careful design; Biomass harvesting	I.C-1
Diversion, Permanent	Stable Outlet	Applicable to vegetated ditches and swales	Moderate	Possible erosion of diversion structure if diverted runoff carries a large sediment load	Must be carefully designed to prevent property damage	I.D-3
Gabion	80% TSS; 40% TSS; Stable Outlet	Widely applicable	Low to Moderate	Does not remove smaller suspended solids	Carefully size stone	I.G-1
Grassed Swale	Stable Outlet	Widely applicable	Low to Moderate	Restricted use for areas with high pollution potential	Pretreatment; Check dams; Careful design	I.G-2
Infiltration Basin	Infiltration; Rate Control; Stable Outlet; Thermal	Moderately restricted to sites with suitable soils; Requires a substantial area to meet standards	Low to Moderate	Potential for groundwater contamination; Restricted use for areas with high pollution potential	Sufficient/suitable land area; Proper construction; Compaction avoidance 80% TSS pretreatment	I.1-1
Infiltration Trench or Bed	Infiltration; Rate Control; Thermal	Highly restricted to sites with small drainage areas and proper soils; Depth to water table and bedrock; Slopes	High	Potential for groundwater contamination; Restricted use for areas with high pollution potential	Recommended with careful soils evaluation & 80% TSS pretreatment	I.I-2

Table 3.2-3 Structural Stormwater Practices, Adapted from Massachusetts Stormwater Technical Handbook (1997)

Structural Practices	Applicable Standard	Applicability to Sites	Maintenance Requirement	Environmental Concerns	Special Considerations	Appendix Page Number
Lined Waterway or Outlet	Stable Outlet	Widely applicable	Low to Moderate	Alters natural cover	Sufficient/suitable land area; Runoff velocities	I.L-1
Oil & Grease Filter	Oil and Grease Removal, 1st 1/2 inch of runoff	Applicable on small impervious areas (With less than 1 acre of drainage)	Moderate to High	Limited pollutant removal	Cost and Frequent Maintenance	I.O-1
Oil & Grease Separator	Oil and Grease Removal, 1st 1/2 inch of runoff	Applicable on small impervious areas (With <1 acre of drainage)	Moderate to High	Limited pollutant removal, does not remove soluble pollutants	Proprietary device must be approved	I.O-2
Pervious Pavement	Infiltration; Thermal; Rate Control	Applicable on areas with very low traffic volumes	Moderate	Potential for groundwater contamination	Limited use in cold climates, Durability, Potential to clog	I.P-2
Rain Garden	80% TSS; 40% TSS; Rate Control; Infiltration	Applicable on sites with drainage areas less than 2 acres	Low	Susceptible to clogging	Sufficient/suitable land area, proper soils	I.R-1
Stone Check Dam	80% TSS; 40% TSS; Rate Control; Stable Outlet	Applicable to vegetated ditches and swales	Low to Moderate	Does not remove smaller suspended solids	Use clear or washed stone	I.S-8
Stone Crib	Thermal	Widely applicable, especially in urban areas	Low to Moderate	Limited effectiveness with large storm events	Needs to be properly sited	I.S-9
Stone Outlet Protection	Stable Outlet	Widely applicable	Low	Limited effectiveness with large storm events	Sufficient/suitable land area; Carefully size stone	I.S-10
Stone Weeper	Widely applicable to outlets	Applicable to vegetated ditches and swales	Low to Moderate	Does not remove smaller suspended solids	Carefully sized stone	I.S-12
Subsurface Drain	Thermal; Rate Control	Widely applicable	Low	Provides limited sediment and pollutant removal	Must have stable outlet	I.S-14

Table 3.2-3 Structural Stormwater Practices, Cont., Adapted from Massachusetts Stormwater Technical Handbook (1997)

3.3 SEDIMENT CONTROL REQUIREMENTS

For new development, the ordinance requires stormwater practices be designed to retain all soil particles greater than 5 microns for the 1-year, 24-hour storm event.

For redevelopment resulting in exposed surface parking lots and associated traffic areas, the ordinance requires that stormwater practices be designed to retain soil particles greater than 20 microns for the 1-year, 24-hour storm event.

Although not required by the ordinance, the following goals should be met whenever possible. The design, suggested location, and implementation of proposed practices should be included in the plans.

- For existing development, design practices to retain soil particles greater than 40 microns on the site, resulting from a 1-year, 24-hour storm event.
- For street reconstruction, design practices to retain soil practices greater than 20 microns on the site, resulting from a 1-year, 24-hour storm event.

3.4 POLICY FOR OIL AND GREASE CONTROL

The ordinance requires that all stormwater plans for commercial and industrial developments and all other areas where the potential for oil or grease exists must include practices to treat oil and grease in the first 0.5 inches of runoff. The best available oil and grease removal technology must be used.

Oil and grease removal practices are generally combined with other stormwater runoff management practices and are obtained through commercial sources. Information regarding choice, installation and maintenance of these management practices is best obtained from the manufacturer.

Sites that must control the first half-inch of runoff for oil and grease include:

- vehicle fueling and service areas
- commercial buildings with drive-though areas
- parking lots with more than 40 stalls
- convenience stores
- other areas that are determined to have the potential for oil and grease pollution

3.5 RUNOFF RATE

The ordinance requires that all stormwater facilities be designed, installed and maintained to effectively accomplish the following:

- Maintain predevelopment peak runoff rates for the 2-year, 24-hour storm event (2.9 inches over 24 hours)
- Maintain predevelopment peak runoff rates for the 10-year, 24-hour storm event (4.2 inches over 24 hours)
- Safely pass the 100-year, 24-hour storm event (6.0 inches over 24 hours)

The ordinance requirements for water quantity apply to individual sites and not the entire watershed. It is more difficult to control the larger storms with the practices installed on an individual site.

Municipalities may consider large regional facilities, sited as part of municipal and regional stormwater planning, in order to manage stormwater from larger storms.

Determining Runoff Rate Using TR-55

Technical Release 55 (TR-55), or Urban Hydrology for Small Watersheds (NRCS 1986), is a model that calculates storm runoff volume, peak rate of discharge, hydrographs (refer to Section 3.1), and storage volumes for stormwater facilities. This model was developed for small watersheds (10 square miles or less), especially urbanizing watersheds, in the United States. A revision was made in June of 1986 that incorporated results of subsequent research and other changes based on experience with the original edition. TR-55 begins with a rainfall amount distributed uniformly over a watershed over a specified time period. Mass rainfall is converted to mass runoff and runoff travel time routed through segments of a watershed is used to create a runoff hydrograph.

The ordinance requires that TR-55 specified curve numbers for land uses must be used in hydrologic calculations, except for agricultural land subject to stormwater standards. For agricultural land, the maximum runoff curve number used in calculations shall be 51 for Hydrologic Soil Group (HSG) A, 68 for HSG B, 79 for HSG C, and 84 for HSG D.

Calculation of post-development runoff must account for changes in permeability class due to the soil characteristics and site compaction. Areas with high equipment traffic shall be considered heavily disturbed. Areas with limited equipment traffic will be considered lightly disturbed. Developers are required to lower one permeability class for all hydrologic calculations, unless practices such as deep tilling, chisel plowing, and incorporating organic matter into the upper soil surface have successfully restored soil structure.

The TR-55 Program with additional documentation and a presentation can be found on NRCS's web site at: http://www.wcc.nrcs.usda.gov/hydro/hydro-tools-models-tr55.html.

3.6 Stable Outlets

The ordinance requires that discharges from new construction sites have a stable outlet capable of carrying designed flow at a non-erosive velocity. Outlet design must consider both flow capacity and duration. This requirement applies to both the site outlet and the ultimate outlet to stormwater conveyance or water body.

Stable outlets are an integral part of well-designed erosion control and stormwater management practices. Stable outlets allow stormwater and erosion control structures to function properly and provide a way for runoff to be discharged without causing damage to downstream properties or water bodies. A stable outlet can be a grassed waterway, vegetated or paved area, grade stabilization structure, underground outlet, rock chute, rock lined channel or stable watercourse.

Stable outlets must have the capacity to handle the designed outflow from the stormwater or erosion control structures they serve. If the outlet is to be vegetated, it should be constructed and established before installation of other stormwater or erosion control structures. Verify that the channel lining is adequate to carry the design to velocity and volume.

Channel Lining

To prevent channels from eroding, an analysis of the channel velocity must be performed to determine the required control practice(s). Where velocities are higher than 5 feet per second or where the channel must carry prolonged flow, the channel should be lined with riprap or other armoring material. Channel linings shall be designed based on the expected channel velocity from the 10-year, 24-hour storm event.

3.7 INFILTRATION

Infiltration reduces runoff volumes and depends on rainfall intensity, slope of the infiltrating surface, the permeability of soils and subsoils, soil moisture, content, vegetation and temperature. During infiltration, water enters from surface storage into soils via the combined effects of gravity and capillary forces. The capillary forces are inversely proportional to the diameter of pores. As the process continues, the pore space becomes filled and the capillary tension decreases. Under saturated conditions, flow is mostly due to gravity.

The ordinance requires that a percentage of the average annual rainfall be infiltrated unless the applicant can demonstrate that the practice is likely to result in groundwater contamination. Infiltration is all precipitation that does not leave the site as surface runoff, and is referred to as "stay-on." For residential developments, 90 percent of what infiltrated in the predevelopment condition (predevelopment infiltration) must be infiltrated. For nonresidential development, 60 percent of predevelopment infiltration must be infiltrated. If more than one percent of a residential development or two percent of a nonresidential development is needed to meet the infiltration standard, infiltration practices may be alternatively designed to meet an average annual recharge goal of 7.6 inches. If the ordinance requirement is met with the recharge methodology, a minimum of one percent or two percent of the site (for residential or nonresidential development respectively) must be dedicated to the infiltration practices.

3.8 THERMAL CONTROL

Thermal Standards

The ordinance requires that the increase in runoff temperature originating from sites in cold-water community watersheds must be reduced, unless results of a thermal impact model approved by the Dane County LWRD Director show that the temperature increase of post-development runoff from the site will be zero.

Affected sites are those located within the watershed of a river or stream identified by the Wisconsin Department of Natural Resources as:

- A Cold Water Community as identified through NR 102.04(3)(a), NR 104, Wisconsin Administrative Code, and Class I, Class II, and Class III Trout Streams identified in "Wisconsin Trout Streams," DNR publication PUB-FH-806-2002 or its successor
- Rivers or streams proposed by the Wisconsin Department of Natural Resources as Cold Water Communities and Class I, II, and III Trout Streams

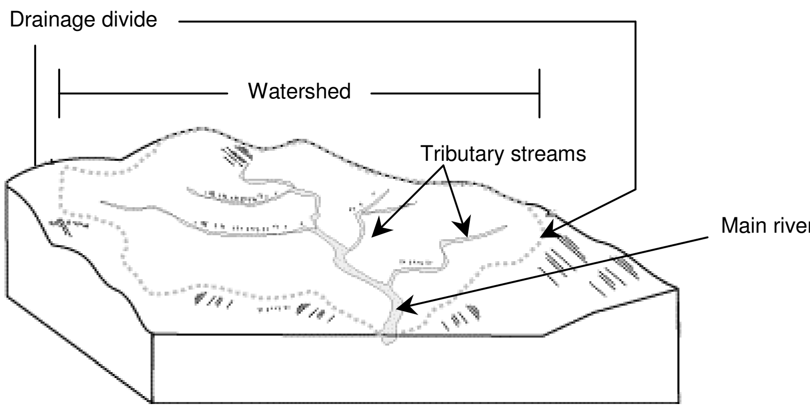

Figure 3.8-1 Watersheds A watershed is the land area that drains to a common location (typically a water body and its tributaries). For this reason, watershed boundaries are also called drainage divides. Practices to reduce the temperature of runoff must be installed if a site is located anywhere within the watershed of a thermally sensitive water body. Figure 3.8-2 shows these water bodies and the boundaries of their watersheds.

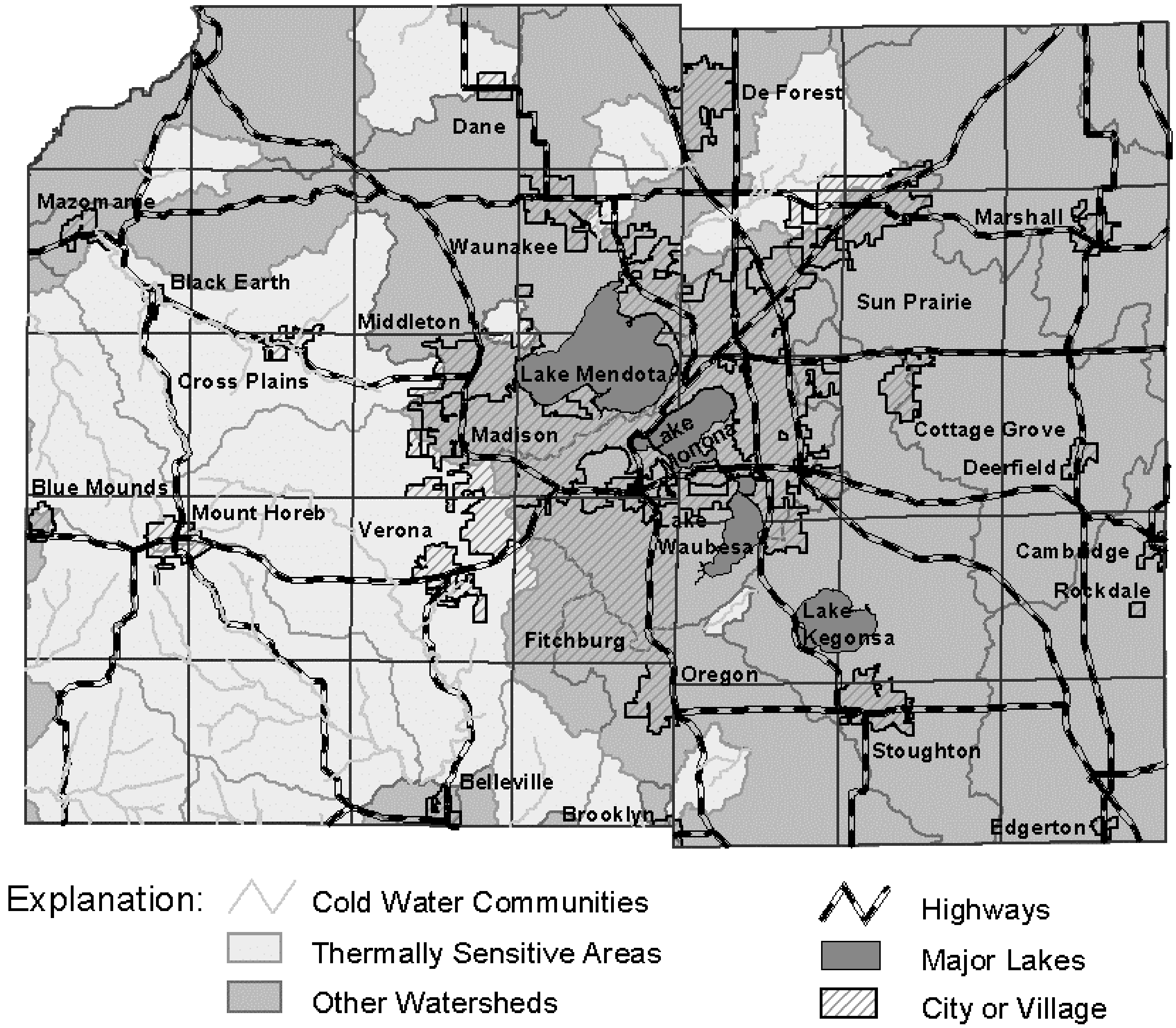

Figure 3.8-2 Stream Segments Requiring Thermal Control. The proposed and existing cold-water watersheds in Dane County, current as of July 9, 2002, are subject to change. The WDNR may change stream classifications as they are warranted. A current list and map of affected watersheds is available for reference at the Dane County Land Conservation Division or at: http://www.co.dane.wi.us/landconservation/cws/cwmap.html.

Locator

To determine whether a parcel of land is located within the watershed of a cold-water stream, Dane County has developed a user-friendly locator available at: http://www.co.dane.wi.us/landconservation/cws/index3.html, under "data and technology" (Arrington, Kathleen. 2002. GIS Application to Thermal Impact in Urban Areas. MS Thesis, UW-Madison Soil Science Department)

The locator performs a preliminary assessment to determine whether the property is located within a cold-water watershed using the unique parcel number of the property or other locating information.

(Parcel numbers are available from Access Dane at: http://accessdane.co.dane.wi.us/). As a result of this assessment, the web site will inform the user if thermal practices are required in the storm water management plan.

Thermal Considerations

The increase of impervious surfaces in urban areas is a major source of thermal pollution in cold climates and threatens the health of cold-water ecosystems (Galli, J. 1990. Thermal Impacts Associated with Urbanization and Storm Water Best Management Practices. Maryland Department of Environment). Research shows that the average stream temperature increases directly with the percentage of impervious cover in the watershed. Impervious areas absorb energy from the sun, which causes them to become warmer. As water runs over these areas, it absorbs some of that heat energy and is warmed, causing thermal pollution in lakes, rivers, and streams. Impervious areas also compound the problem by reducing infiltration, which in turn increases the volume of runoff that is created, leading to higher permanent stream temperatures in the summer months.

Stream water temperature is a major limiting factor for cold-water fisheries, as all biological activity is related to temperature. Temperature is a characteristic of water quality and is very important in chemical and biochemical processes, particularly those involving biochemical activity. Higher stream temperatures result in lower dissolved oxygen (DO) concentrations and may cause biological oxygen demand (BOD) to increase. Temperature increases in streams can also result in behavioral changes of fish and macro invertebrate communities (aquatic insects), as these species have specific water temperature preferences and tolerance limits.

Over time, the cumulative impact of individual development sites will increase water temperature, permanently affecting habitat in the stream. By mitigating runoff and water temperature impacts, the stream community will benefit not only from maintained stream temperature, but also from a decline in the amount of sediment, nutrients, and pollution that reaches receiving waters.

Thermal Model Description

One model that can be used to estimate thermal impacts is the Thermal Urban Runoff Model (TURM) (Norman, J.M. and A. Roa. 2000. Effects of the Natural Environment and Urban Runoff on Stream Temperatures). The University of Wisconsin and the Dane County Land Conservation Division developed the model to estimate runoff temperature from urban watersheds. The thermal impact from impervious areas was documented in a study at Token Creek subwatershed, where collected data was compared to the results calculated by TURM. This model accounts for the fact that storm water not only absorbs heat from impervious surfaces, but that it also cools these surfaces, reducing the ability of the impervious surfaces to heat runoff from additional rainfall. However, TURM does not account for the inherent variability of rainfall due to changes in intensity and the type of storm, as the model assumes that the rainfall is uniform over the entire duration of the event. Field data collected at Token Creek subwatershed indicates that storm water runoff from highly urbanized areas has the potential to increase the temperature of receiving waters by as much as 23° F (Roa, A., J.M. Norman, T.B. Wilson, and K. Johnson. 2002. Thermal Impact Analysis of Token Creek Subwatershed and Validation of Temperature Urban Model (TURM)).

Other model considerations include:
(1) the amount and temperature of impervious area;

(2) the ambient air temperature;
(3) the gain or loss of heat through the passage of water through management practices;
(4) the net change in heat due to tree canopy;
(5) the heat loss through evaporation;
(6) the time and duration of storm events, and;
(7) the difference in the time of concentration of vegetated areas and impervious surfaces.

Other thermal impact models may be used if they are approved by the Dane County LWRD Director.

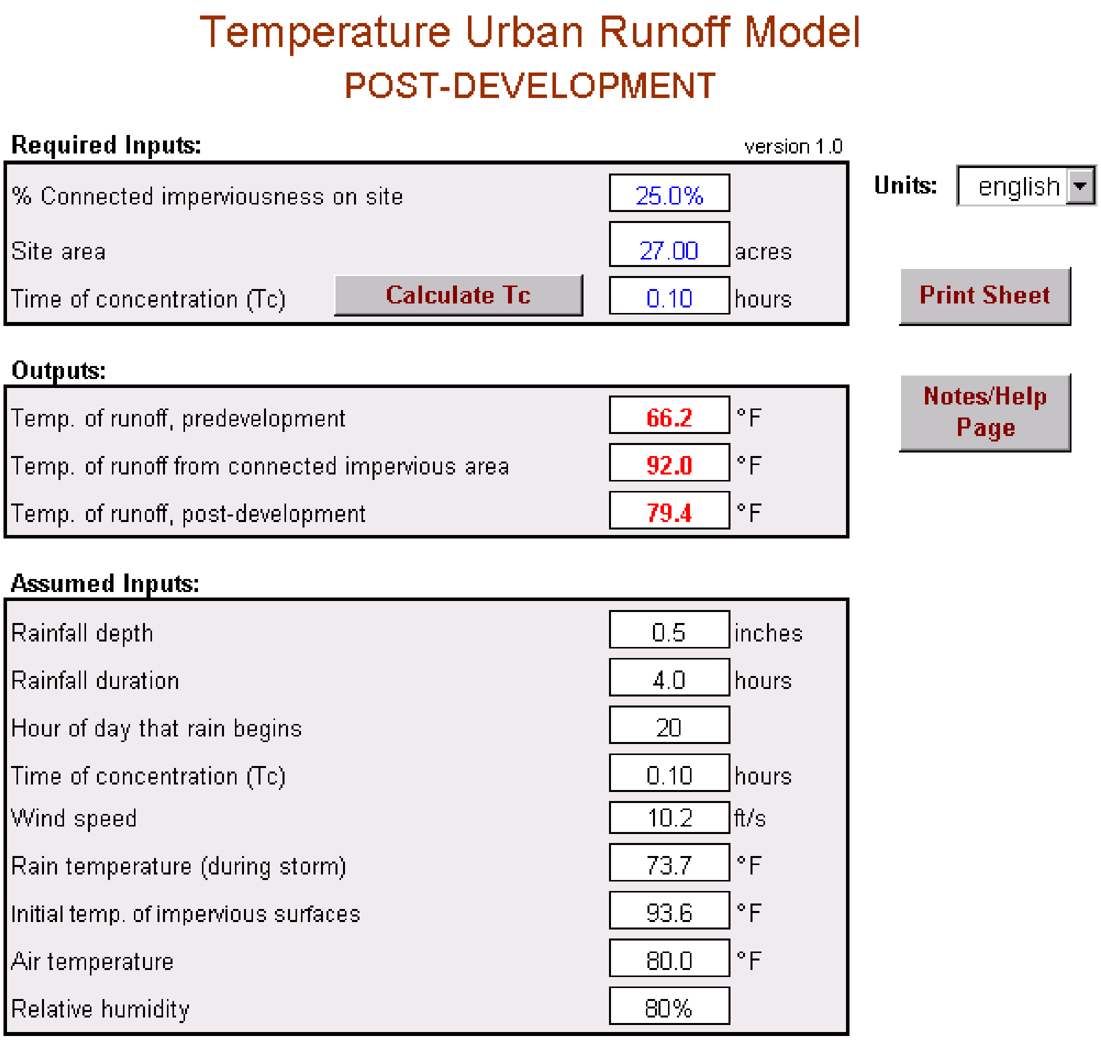

Figure 3.8-3 Example Screen from TURM

3.9 MAINTENANCE REQUIREMENTS

All stormwater management practices must include a maintenance plan, which describes the entity responsible for long-term upkeep of the practice and the type of maintenance required. The maintenance plan must be deed recorded prior to permit issuance. The plan should also include accessibility to the site and the level of maintenance required. Long-term maintenance costs should be considered when selecting a practice. Some practices may be inexpensive to implement, but long-term maintenance activities of the practice may be costly. As part of an approved erosion control or stormwater permit, maintenance requirements are enforceable per Section 14.49(8) of the Dane County Erosion Control and Stormwater Management Ordinance.

The county will maintain a database of permitted stormwater practices and will periodically perform inspections to assure the maintenance requirements set forth in the approved plan are being met.