

Watershed Treatment Model (WTM) 2013 User's Guide

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Deb Caraco, P.E.
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Step 1. Calculate Pollutant Source Loads



Step 2. Calculate the benefits of Existing Management Practices



Step 3. Calculate the benefits of Future Management Practices



Step 4. Account for Future Growth

**Figure 1. WTM Model Structure****Primary Sources**

This worksheet summarizes the loads from sources that can be determined solely by land use. It requires basic land use information and calculates surface runoff loads. In addition, it requires basic watershed data, such as annual rainfall, stream length, and soils distribution. The loads calculated in this worksheet incorporate data from the “turf management” section of the “existing management practices” tab (see page 6), and model default values reflect typical lawn care practices.

Secondary Sources

Secondary sources are pollutant sources that cannot be calculated based on land use information alone. Many of these sources, such as CSOs and SSOs, are at least partially composed of wastewater.

Existing Management Practices

This sheet reflects programs currently in place to control loads from urban land. Users need to input information about the effectiveness and level of implementation of various programs and practices.

This sheet, and other sheets in the WTM that quantify program implementation, ask the user to input “discount factors” for each practice. “Discount factors” are used to reduce the ideal (i.e., literature value) load reductions for a practice that can rarely be achieved. For example, structural practices may lack space or have poor maintenance that can hamper practice effectiveness over time. For programmatic practices, such as lawn care education, only a fraction of the population may implement the recommendations put forward in the educational program. In both of these cases, specific design features for structural practices, or marketing approaches for education and outreach techniques can make the practice more effective. While some discount factors have default values, the WTM asks the user to input values for others. In each case, the model provides guidance to select appropriate values.

Future Management Practices

This sheet reflects the planned extent of programs to control loads from urban land. By default, the model populates this sheet with values from the “Existing Management Practices” sheet. The user then enters data that describe proposed or “future” management practices given the same existing land use.

Retrofit Worksheet

Stormwater retrofits are BMP put in place after development has occurred. The retrofit worksheet allows the user to input individual stormwater retrofit practices. These are then reported in the “Future Management Practices” sheet.

Future Land Use

In this sheet, the user enters the projected future land use in the watershed. Land use can be determined from comprehensive planning or zoning documents, or forecasted using other methods. If no data are entered in this tab, the model default is to assume no growth in the watershed.

New Development

This sheet calculates the loads from future development, based on future development in the watershed, and proposed future treatment. The sheet calculates new “primary source” loadings based on the increase in area of certain land uses, then asks the user to describe the types of stormwater controls on new development. Next, it adds secondary sources, such as loads from new OSDS customers and wastewater treatment plant loads. Finally, it calculates the loads from active construction as land is developed.

Display Sheets

Three sheets display final loads and runoff volumes: *Existing Loads*, *Loads with Future Practices*, *Loads Including Growth*. These sheets simply sum up the loading from other sheets, and partition them into surface (both storm- and non-storm) and groundwater loads.

SECTION 2. DATA ENTRY OVERVIEW

Although the WTM is a simple model, it requires significant data input. In addition, no part of the spreadsheet is write protected, in order to allow for maximum flexibility. These decisions put a great deal of responsibility on the user, and some guidelines need to be followed to prevent errors in algorithms. This section describes some components of the WTM designed to facilitate the data input process, as well as some tips for tracking down and avoiding errors in the model.

Color Coding

In order to make data entry easier, cells are coded in four colors: green, blue, grey and purple.

BLUE CELLS must be filled out, unless a pollutant source or treatment option is not being considered. For example, the acres of commercial land only need to be filled out only if commercial land is in the watershed.

YELLOW CELLS represent model defaults that a user may want to modify. Examples include pollutant concentrations and practice efficiencies.

GREY CELLS have been calculated, and typically should not be overridden. Examples include practice load reductions.

PURPLE CELLS represent “bottom line” calculations, such as load reductions or final loads.

The worksheets of the WTM are also color coded. Of the ten tabs of the WTM, three are strictly for output, and have a purple tab color, while the remainder are green to indicate that data entry is needed.

“Pop-Up” Guidance and Comments

Many pieces of input data require some judgment on the part of the user. By clicking on many of the green cells (particularly those for discount factors), a “popup” message will appear with guidance for data values (Figure 2).

Erosion and Sediment Control	
Program Efficiency	70%
Fraction of Building Permits Regulated	
Installation/ Maintenance Discount	
Street Sweeping	
Sweeper Type	Streets Swept Residential
Mechanical	
Regenerative Air	

Accounts for ESC Program
 Few inspectors, no pre-construction meeting! 0.3
 Inspectors visit monthly; pre-construction for larger sites 0.6
 Inspectors visit weekly, contractor education, pre-construction meeting for most sites 0.9

Figure 2. Example Pop-Up Guidance for the Installation/Maintenance Discount for ESC programs

Pull-Down Menus

While many of the data in the WTM require a number value, some of the inputs are multiple choice (e.g., type of practice) or “yes/no” (e.g., Do you have a program for...) questions. The WTM uses “pull down menus” for these questions. For these cells, the user should not (and cannot) select an option that does not appear in the menu.

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SECTION 3. DATA ENTRY DETAILS

This section describes in detail the data entry requirements of each worksheet of the WTM. It separates the discussion by worksheet (for each calculation sheet), but “Existing Management Practices” and “Future Management Practices” are discussed together because of the overlap between the two.

Primary Sources

This worksheet has four major sections: *Land Use*, *Partitioning Coefficients for Rural and Forest Land*, *Watershed Data*, and *Soils Information*. Data Requirements for each are as follows:

Land Use

The user is required to enter the area of each land use category. If there is a land use that is not included in the model but it is present in the watershed, the user should type in the land use category (Figure 4) and enter in appropriate values to characterize the land use in the blue cells listed below. In addition, users may override model defaults for land uses included in the model for the following data (blue cells):

- Impervious Cover %
- Turf %
- Pollutant Concentrations
- Pollutant Loading rates/R1:49:38 PMunoff Rates (lbs/acre, billion/acre or in/year). Note that, for rural and agricultural land uses, loading rates should be entered directly, since they are not determined from concentrations and runoff calculations for these land uses.

PRIMARY SOURCES - Land Use				Concentrations			
Watershed		Area (Acres)	Impervious Cover (%)	Turf Cover (%)	TN (mg/l)	TP (mg/l)	TSS (mg/l)
Category	Detailed Description						
Residential	LDR (<1 du/acre)		12%	70%	2.1	0.31	49
	MDR (1.4 du/acre)		21%	63%	2.1	0.31	49
	HDR (>4 du/acre)		33%	54%	2.1	0.31	49
	Multifamily		44%	45%	2.1	0.31	49
				0%	2.1	0.31	49
				0%	2.1	0.31	49
				0%	2.1	0.31	49
Commercial	Commercial		72%	22%	2.1	0.22	43
				0%	2.1	0.22	43
				0%	2.1	0.22	43
				0%	2.1	0.22	43
				0%	2.1	0.22	43
				0%	2.1	0.22	43
				0%	2.1	0.22	43
Roadway	Roadway		80%	16%	2.3	0.25	134
				0%	2.3	0.25	134
				0%	2.3	0.25	134
				0%	2.3	0.25	134
				0%	2.3	0.25	134
Industrial	Industrial		67%	38%	2.3	0.25	81

Figure 3. Land Use Data in the Primary Sources tab. The user needs to enter land areas (green) and may override turf and impervious cover, and pollutant concentration values.

Partitioning Coefficients for Rural and Forest Land

This section includes model defaults determining the fraction of the load from forest and rural land that occurs during storm events, versus as extended baseflow. These can be overridden if better information is available for your watershed.

Watershed Data

This section requires entry for annual rainfall and total stream length. The WTM will return errors if these values are not entered.

Soils Information

This section asks the user to describe the soils in terms of Hydrologic Soils Group (A, B, C or D) by entering the percent of the watershed soils in each category. It also asks the user to enter the break-down of soil type based on depth to groundwater (again, describing the percent of the watershed in each category).

Model defaults in this section include runoff coefficients for each land cover category (Turf, Forest, and Rural). For other land covers, the user may enter runoff coefficients in the green cells (columns I through M). Note that the runoff coefficient for turf also takes into account information provided in the *Turf Management* practice on the “Existing Management Practices” sheet.

Secondary Sources

The secondary sources worksheet sums the loads from sources that cannot be determined by land use alone, such as channel erosion or illicit discharges. The data sheet is structured so that data are entered in smaller tables, or sections of the sheet. With the exception of the general sewage use data and channel nutrient concentration provided at the top of the sheet, each section corresponds to a specific secondary source. The required data for this sheet is summarized in Table 1.

TABLE 1. SECONDARY SOURCE DATA REQUIREMENTS			
Source or Data Area	Required Data (Green Cells)	Model Default Data (Blue Cells)	Notes
General Sewage Use Data	Number of single-family, detached dwelling units	<ul style="list-style-type: none"> • Individuals/unit • Water use/individual • Wastewater pollutant concentrations 	These data are needed to compute loads from OSDSs, SSOs, CSOs, Illicit Connections
Nutrient Concentrations in Stream Channels	Concentrations	Enrichment Factor	Figure 5 provides one source for these data. Used in combination with Channel Erosion data to calculate the nutrient loads from channel erosion.
On-Site Sewage Disposal Systems (OSDSs)	<ul style="list-style-type: none"> • % of Dwelling Units Unsewered • % of OSDSs <100' from waterway • Soils (from pull-down menu) • System type (% of each type of system) • Description of Management (inspection and maintenance) from pull-down menu • Separation distance from groundwater • Density (#/acre) 	<ul style="list-style-type: none"> • Failure rates (calculated from other factors) • Decay of bacteria (% reaching the surface waterway) • Delivery ratio for nutrients • Efficiencies for each OSDS type 	<p>Required data are often available from the health department or other agency responsible for OSDS management.</p> <p>If the user enters "other" for a system type, the efficiency <i>must</i> be entered.</p>

TABLE 1. SECONDARY SOURCE DATA REQUIREMENTS			
Source or Data Area	Required Data (Green Cells)	Model Default Data (Blue Cells)	Notes
SSOs	<ul style="list-style-type: none"> Miles of sanitary sewer 	<ul style="list-style-type: none"> Overflows/1,000 miles Volume per overflow Fraction of load as storm flow (to partition between storm and non-storm loads) 	These sections are a broad estimate of diffuse wastewater sources. If available (e.g., from an SSO/CSO or IDDE study) these data may be directly entered in the Summary table (purple cells) at the bottom of the Secondary Sources worksheet.
CSOs	<ul style="list-style-type: none"> Median storm event (inches) Sewershed area (acres) Sewershed Impervious Cover (%) 	<ul style="list-style-type: none"> # CSOs/year (calculated) Capacity of CS System (rainfall depth in inches) CSO pollutant concentrations. 	
Illicit Connections	<ul style="list-style-type: none"> Fraction of watershed population illicitly connected Number of businesses 	<ul style="list-style-type: none"> Fraction of businesses with illicit connections. Characterization of businesses wash water Business wastewater flow in gpd. 	
Urban Channel Erosion	<p>Method of calculation (Methods 1-3) from pull-down menu. All data inputs described are required data.</p> <p>Method 1. Estimate based on typical estimates: General Assessment of Channel Erosion (Low, Medium, High)</p> <p>Method 2. Back calculate based on known sediment loading. Total watershed loading (lbs TSS/year) based on monitoring data.</p> <p>Method 3. Estimate based on other study results. Sediment Load from Channel Erosion (tons/year)</p>		<p>The WTM offers three options for calculating urban channel erosion. Data required varies depending on the method used.</p> <p>Each method requires progressively more data, and provides a more accurate representation of the watershed.</p>

TABLE 1. SECONDARY SOURCE DATA REQUIREMENTS			
Source or Data Area	Required Data (Green Cells)	Model Default Data (Blue Cells)	Notes
Livestock	# of animals in each category	<ul style="list-style-type: none"> • % of animals exposed to runoff • Load (lbs/animal/year or billion/animal/year) • Delivery ratios of nutrients and bacteria 	
Marinas	<ul style="list-style-type: none"> • Berths • Length of season (days) 	<ul style="list-style-type: none"> • Occupancy (fraction of the season) • Flow rates (gallons/capita/day) • Individuals/boat 	This “untreated” estimate can be significantly lowered by the “marina pumpout station” practice in Existing Management Practices.
Road Sanding	<ul style="list-style-type: none"> • Sand application (lbs/year) • Fraction of roads open section 	<ul style="list-style-type: none"> • Delivery ratio (sand to the receiving water) for closed section roads. • Delivery ratio for open section roads. 	This untreated estimate can be partially remedied by street sweeping.
Non-Stormwater Point Sources	<ul style="list-style-type: none"> • Flow (Millions of gallons/day) • Concentrations (mg/l or MPN/100 ml) 	<ul style="list-style-type: none"> • Loads (lbs/year or billion/year) 	Data can be gathered from Discharge Monitoring Reports (DMRs) for NPDES discharges

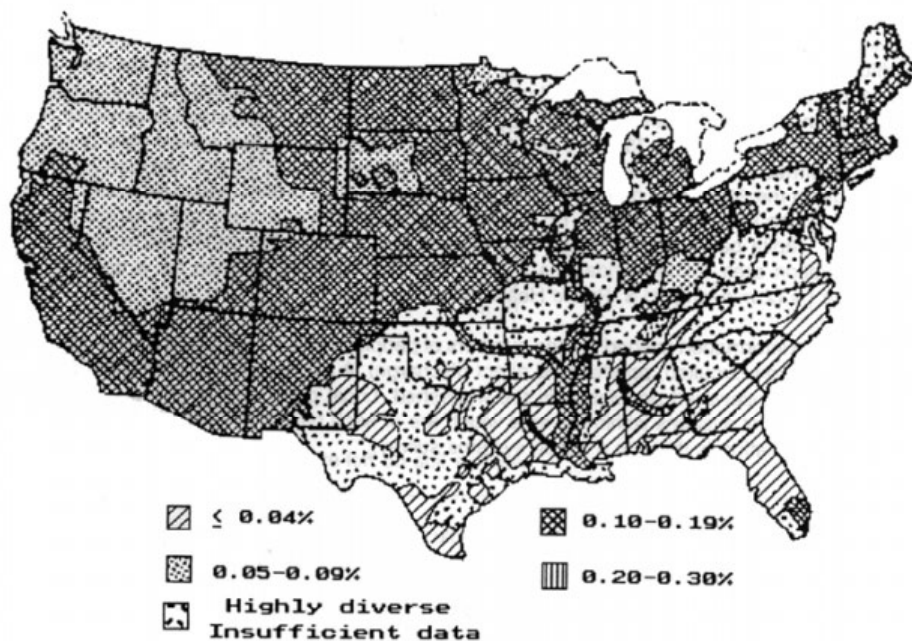


Figure 4. Soil N/P concentrations (by % mass in soil). From Haith et al., 1992

Existing and Future Management Practices

These two worksheets calculate the benefits of practices and programs in the watershed. Current land use conditions are used for the Existing and Future Management Practices worksheet (e.g. does not consider future changes in land use within the watershed). The practices entered into the Existing Management Practices worksheet are carried over to the Future Management Practices. However, additional practices and program options for non-structural practices are included in the “Future Management Practices” section. A description of the practice types and their data input is provided in Table 2. While the specific data for each practice varies, some of the discount factors appear for several practices, including the following:

- **Awareness Factor:** Applied to all educational programs, the awareness factor reflects the % of people who remember an educational message.
- **Maintenance Factor:** Typically applied to structural practices, this factor reflects the maintenance of practices over the long term.
- **Design or Technique Factor:** Reflects the quality of the practice design
- **Implementation.** Reflects the fraction of long-term capitol projects identified (e.g., SSO removal) that are implemented.

By default, the WTM will use the values from the “Existing Management Practices” worksheet for the “Future Management Practices” values. If expanded coverage of a particular practice is proposed, the user should enter values for the future condition. For example, if the watershed currently has 5 miles of riparian buffer, and a management plan proposes is to expand this by one mile, the data on the “Future Management Practices” tab should be edited by the user to include 6 miles of buffer.

TABLE 2. DATA REQUIREMENTS FOR EXISTING/FUTURE MANAGEMENT PRACTICES			
Practice	Required Data (Green Cells)	Model Default Data (Blue Cells)	Notes
<i>Practices on the Existing Management Practices Sheet Only</i>			
Turf Condition and Management Practices - Residential	<ul style="list-style-type: none"> • % of lawns bare/compacted • % of homes <10 years old • % off lawn area “highly managed” (high input) 	<ul style="list-style-type: none"> • Residential turf area (calculated from Primary Sources) • Typical fertilizer applications/year • Fertilizer rate (lbs N/acre) • Distribution of fertilizer type (by %) • N and P analysis of fertilizers 	<p>Data for bare and compacted lawns and “highly managed” lawns can be gathered from field surveys.</p> <p>Fertilizer use and application rates are default values but can be replaced with survey or fertilizer sales data.</p> <p>Fertilizer losses are incorporated as a primary source (in loading rates) and as a secondary groundwater source.</p> <p>The turf runoff coefficient (on the primary sources tab) is modified based on the % if bare/compacted lawns.</p>
Turf Condition and Management Practices – Other	<ul style="list-style-type: none"> • Management compared to residential turf (pull-down menu). Choices are “Same”, “Comparatively High Management/Input”, or “Better management/ nutrient management” 	<ul style="list-style-type: none"> • Turf area calculated from Primary Sources 	<p>The simplified approach for this source “scales” loading compared with residential lawns rather than asking users for a separate assessment.</p>
Structural Stormwater Practices	<ul style="list-style-type: none"> • Drainage areas to each practice • Impervious Area draining to each practice • Capture Discount (annual rainfall captured) • Design Discount • Maintenance Discount 	<ul style="list-style-type: none"> • Turf area draining to each practice • Efficiencies and runoff reduction (%) 	<p>Although structural stormwater practices can be modified or added in the future condition, these practices are considered “Stormwater Retrofits” and accounted for separately.</p> <p>The model includes pop-up guidance for each discount factor.</p>

TABLE 2. DATA REQUIREMENTS FOR EXISTING/FUTURE MANAGEMENT PRACTICES			
Practice	Required Data (Green Cells)	Model Default Data (Blue Cells)	Notes
<i>Practices on Both Sheets</i>			
Pet Waste Education*	<ul style="list-style-type: none"> Program in Place (yes/no pull-down) Number of dwelling units (unless already entered on the "Secondary Sources" worksheet) Awareness of the Message 	<ul style="list-style-type: none"> Characteristics of the population (dog owners, fraction who clean up) Fraction of the population willing to change their behavior. Dog waste characteristics (waste production and pollutant concentrations) Delivery factors (fraction of pollutants that reach the receiving water) 	Concentrations in the "Primary Sources" tab include loads from pets. Consequently, the benefits of these programs will be subtracted from the "base loads" calculated in the primary and secondary sources tabs.
Erosion and Sediment Control	<ul style="list-style-type: none"> Fraction of building permits regulated Installation/ Maintenance discount 	<ul style="list-style-type: none"> Program efficiency 	The model defaults and the recommended discounts can be refined based on field experience of ESC inspectors.
Street Sweeping	<ul style="list-style-type: none"> Area Swept for residential streets, other streets, and parking lots. Type of sweeper used Sweeping frequency Technique discount 	<ul style="list-style-type: none"> Sweeper efficiencies for TSS and nutrients 	
Riparian Buffers	<ul style="list-style-type: none"> Buffer length (miles) Buffer width (feet) Maintenance factor 	<ul style="list-style-type: none"> Buffer efficiencies Treatability (fraction of the watershed captured). Calculated from other values. 	Collect original buffer data from aerial photographs and field surveys. For the future condition, consider proposals to reforest the buffer, or to expand buffer protection.
Catch basin cleanouts	<ul style="list-style-type: none"> Area captured (imperious cover) Cleaning frequency Disposal discount 	<ul style="list-style-type: none"> Efficiencies 	
Marina Pumpouts	<ul style="list-style-type: none"> Number of pumpouts 	<ul style="list-style-type: none"> Total number of berths (same as the value from "marinas" on the secondary source sheet) Boats served per station Fraction of owners willing to use 	

Note: Cells in red font will show an "Enter Value" message if data entry is needed. If no data are entered, an error will result.

TABLE 2. DATA REQUIREMENTS FOR EXISTING/FUTURE MANAGEMENT PRACTICES			
Practice	Required Data (Green Cells)	Model Default Data (Blue Cells)	Notes
<i>Practices on the Future Management Practices Sheet Only</i>			
Residential Lawn Care Education	<ul style="list-style-type: none"> Awareness of the Message Yes/No pull-down menus to ask if several specific lawn care education programs are in place 	<ul style="list-style-type: none"> Turf area Additional forest area (from turf conversion) Revised fertilizer application rate Distribution of fertilizer type (by %) N and P analysis of fertilizers Ease of implementation for each education program type 	<p>The WTM uses the same calculations to calculate Nitrogen and Phosphorus loss, but uses the forecasted results of a future education program to revise fertilizer application rates.</p> <p>One program goal (Add soil amendments to lawn) is actually recorded on the "Retrofit Worksheet" described on the following pages.</p>
Residential Impervious Cover Disconnection	<ul style="list-style-type: none"> Program in place (yes/no from pull down menu) Fraction of land where applicable Fraction of population reached by the message 	<ul style="list-style-type: none"> Roof area (square feet) Fraction willing to participate 	The area of disconnection produced from this program is recorded as a stormwater retrofit, and appears in the stormwater retrofit worksheet.
Urban Downsizing	<ul style="list-style-type: none"> Fraction Implemented (i.e., % of planned land conversion that happens) Acres of urban land (in each land category) converted to another use Acres of other land use created 	<ul style="list-style-type: none"> Loading and runoff rates for each land use 	<p>This practice applies only to a planned urban downsizing.</p> <p>If another land use is created or converted, the user will need to override the land use categories and loading rates.</p>
Redevelopment with Improvements	<ul style="list-style-type: none"> Land to be redeveloped (acres) Impervious cover reduction (%) Turf reduction (%) 	N/A	
Stormwater Retrofits	N/A	N/A	Retrofit benefits are summarized on the Future Management Practices Worksheet, but data entry are in the Retrofit Worksheet

TABLE 2. DATA REQUIREMENTS FOR EXISTING/FUTURE MANAGEMENT PRACTICES			
Practice	Required Data (Green Cells)	Model Default Data (Blue Cells)	Notes
Channel Protection	<ul style="list-style-type: none"> Assessment option (from pull-down menu) <p>No Channel Protection</p> <p>Option 1: Estimate based on miles of stream stabilized</p> <ul style="list-style-type: none"> Portion of stream channel unstable Miles of stream channel stabilized Fraction of watershed with flow control for the 1-year storm event. <p>Option 2: Enter Total Anticipated Removal</p> <ul style="list-style-type: none"> Sediment removal (tons/year) Phosphorus and Nitrogen Removal (lbs/year) 	<ul style="list-style-type: none"> For option 1, miles of unstable channel is calculated 	Channel protection refers to in-stream channel protection measures. The model allows separate options to allow the user to input local values from a detailed stream study that may have resulted in estimated removals that may differ from the model default. The model default values are considered conservative,
Illicit connection removal	<ul style="list-style-type: none"> Fraction of system surveyed Fraction of repairs made 	N/A	These wastewater source reduction measures all calculated reductions by multiplying the user defined fraction or reduction in events by the fraction completed over the planning horizon timeline times the load from the original secondary source load.
CSO Repair/Abatement	<ul style="list-style-type: none"> CSO Events after Repairs Fraction complete 		
SSO Repair/Abatement	<ul style="list-style-type: none"> Goal (% reduction) Fraction complete 		
OSDS Education	<ul style="list-style-type: none"> Program (yes/no pull down menu) Awareness of the message Fraction willing to change behavior 		OSDS education and repair measures are combined to change the characteristics of the "OSDS" load.
OSDS Repair	<ul style="list-style-type: none"> Program (yes/no pull down menu) Fraction inspected Percent willing to repair 		The WWTP load resulting from retiring OSDSs is subtracted from the "point source reduction" benefit. If the retired systems are directed to a

TABLE 2. DATA REQUIREMENTS FOR EXISTING/FUTURE MANAGEMENT PRACTICES			
Practice	Required Data (Green Cells)	Model Default Data (Blue Cells)	Notes
OSDS Upgrade	<ul style="list-style-type: none"> • Program (yes/no pull down menu) • Fraction inspected • Fraction willing to upgrade • Type of upgrade system • System efficiencies (if “other” selected as system type) 	<ul style="list-style-type: none"> • System efficiencies (except for “other”) 	treatment plant in another watershed, override the WWTP loads and change them to 0.
OSDS Retirement (convert to WWTP)	<ul style="list-style-type: none"> • Fraction of systems inspected • % failing among retired systems • % w/in 100' of a waterway among retired systems • WWTP Efficiencies 	<ul style="list-style-type: none"> • WWTP loads 	
Point Source Reduction	<ul style="list-style-type: none"> • Reduction (lbs/year of billion/year) 	<ul style="list-style-type: none"> • WWTP load (negative) from OSDS retirement 	

Retrofit Worksheet

The retrofit worksheet is a worksheet to enter individual stormwater retrofit practices. Stormwater retrofits are a type of future management practice. The Retrofit Worksheet allows the user to enter detailed design information for each practice. The worksheet asks for general practice information (and data entry options) at the top of the sheet, and then asks for individual practice information in the main section of the worksheet in the “Basic Site Information” table. (Figure 6)

Design Storm (inches)	1.0
Water Quality Volumes	Provide Full WQv 100%
Discount Factors	
Design	See for all (Enter at the right) Value:
Maintenance	See for all (Enter at the right) Value:

Practice from Education Program	Basic Site Information. Make sure to Enter Data in Green Cells						Effectiveness and WQv of Retrofits								Discounts for Retrofit		
	Area Captured (acres)	Impervious Percentage	Is this a Retrofit of an Existing Facility?	What Practice Was the Original Facility?	Dominant Soil Type in Drainage Area	Depth to Groundwater (from Practice Bottom)	WQv (cf)		Effectiveness (%)						Design	Treatment	
							Target WQv	WQv Provided	TN	TP	TSS	Bacteria	Reflow Reduction				
Practice from Education Program	0.000	00%	No	PA	A Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0%	50%	100	0
Practice from Education Program	0.000	0%	No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0%	75%	100	0
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	60%	50%	50%	50%	40%	0.00	0	0	
Practice Type			No	PA	A Soil	15 Feet	0.0	0.0	40%	75%	85%	70%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	
Practice Type			No	PA	C Soil	15 Feet	0.0	0.0	0%	0%	0%	0%	0%	0.00	0	0	

Figure 5. The Retrofit Worksheet, showing the generalized information at the top and individual practice data at the bottom (main section).

Design Storm:

The top of the retrofit worksheet asks the user for the design storm (in inches). This value should reflect the water quality design storm (typically about 1”). This is a critical value that needs to be entered.

Water Quality Volume (WQv)

The target WQv for each practice is the runoff volume from the design storm. Ideally, practices would be sized to capture this volume, but in some cases (particularly for retrofits) the practice cannot be sized to capture the entire volume. In the upper portion of the retrofit worksheet, the user selects from a pull-down menu to determine how to enter the water quality volume, among three choices:

Option 1. Provide the full water quality volume at all practices
If the user chooses this option, no further data entry is required.

Option 2. Provide a consistent fraction of the water quality volume (e.g., 80% of the Target WQv for all practices)

For this option, the user needs to enter the % of the WQv provided in all sites. The value will be entered in cell E5. When this data entry option is selected, an "Enter Value" value appears in this cell.

Option 3. Provide a different water quality volume at each site.

If this option is selected, the user needs to enter the WQv for each practice (in Column J) under the "WQv Provided" heading.

The third option provides the most flexibility, so it is the best choice when a detailed retrofit inventory has been conducted and design information is available. The other options presented represented a way to evaluate "what if" scenarios across a wide range of practices.

Discount Factors

For the design and maintenance factors, the user may either select a single value for all practices (entered in Column F), or to enter a different value for each practice. Note that, if the "Varies" option is selected, the discount factors need to be entered for each practice, in columns P and R. (Scroll over to enter these data).

Basic Site Information

For each practice, select the practice type from the pull-down menu. For each practice, the basic required data includes the following:

- Area captured (acres)
- Impervious Percentage
- Soil in the drainage area
- Depth to groundwater (from practice bottom)

This section also asks the user if this is a "new" retrofit or a retrofit of an existing facility. If the practice is a retrofit of an existing facility, such as a conversion of a dry pond to a wet pond, the user selects the type of *original* practice from a pull-down list.

Effectiveness and WQv of Retrofits

This section of the retrofit worksheet provides the target water quality volume. If the WQv needs to be input, an "Enter Value" will appear in the cells in Column J. Effectiveness (%) will be derived from a look-up table, depending on the practice type, but the user will need to input values if "Other" is selected as a practice option.

Effects of the Original Practice

The WTM reports the pollutant removal of the original practice (if this practice is a retrofit of an existing practice). In general, these cells should not be modified, but may be overridden if the user has detailed data about the effectiveness of a particular existing practice.

Practices from Education Programs

Data for rooftop disconnection and soil amendments are imported into the retrofit worksheet from the "Future Management Practices" sheet. The user does not need to enter data in these sections, although the soil type or other practice features can be modified as needed.

Future Land Use

This tab is simply a forecast of future land use or land cover in the watershed. The only caveat for this portion of the WTM is that the land use categories **must be the same** as those reported in the Primary Sources tab, or errors will occur. Another potential error on this sheet results when total land area either exceeds or is less than the original watershed area. The value under "Total Acres" will report an error if the areas are not the same.

New Development

This sheet includes four sections of data input: New Development, Controls on New Development, Data to Quantify Wastewater Loads, and Active Construction. Data requirements for each section are as follows:

New Development

This section sums the uncontrolled pollutant loads from new development. No data entry is needed, but the user can modify the characteristics of each land use category by adjusting pollutant concentrations, impervious cover and turf cover for each land use type.

Stormwater Controls on New Development

This section describes and quantifies the benefits of stormwater controls to be implemented on new development. The WTM allows three different program options. Each of these options reflects stormwater regulations that are used throughout the United States.

Option 1: Meet a specific pollutant removal target

If this option is selected, the user needs to enter the removal efficiencies in cells marked "Enter Value" next to the "Target % Removal" row.

Option 2: Meet a target load

If this option is selected, the user needs to enter the target load in lbs/acre/year, billion/acre/year inches/year (for runoff volume).

Option 3: Show no net increase in load on each parcel

If this option is selected, no further data are needed.

Discount Factors

Four discount factors (% regulated, capture discount, design discount, and maintenance discount) are applied to the target removals. By default, the data in these cells is derived from data in the “Existing Management Practices” and “Future Management Practices” sheets. While no data are required in this section, the user may override these default values to reflect different levels of program implementation in the future.

Channel Protection

Enter “yes” to answer the question, “Is channel protection required?” if there is some requirement in place to control small (1-year) storms either through detention or runoff reduction, in order to protect stream channels.

Data to Quantify Wastewater Loads

This section requires data to quantify the loads from future wastewater sources, including OSDSs, SSOs, CSOs, Illicit Connections, and WWTP Dischargers. This section uses simplified calculations to forecast loads from these sources. Data required are summarized in Table 3.

TABLE 3. DATA REQUIRED TO CALCULATE FUTURE WASTEWATER LOADS	
Source	Data Required
OSDS	<ul style="list-style-type: none"> • New OSDS customers • OSDS failure rate • OSDS efficiency (High/medium low) compared to the current systems.
SSOs	<ul style="list-style-type: none"> • Miles of sewer constructed • SSOs/mile
Illicit Connections	<ul style="list-style-type: none"> • Percent of population illicitly connected
WWTP Discharges	<ul style="list-style-type: none"> • New wastewater customers (households) • WWTP Efficiency

Active Construction

The WTM calculates loads from active construction based on three user inputs: the program efficiency, % of new development regulated, and the “Maintenance Discount.” By default the WTM imports data from the “Future Management Practices” worksheet, but these data may be adjusted by the user.

SECTION 4. INTERPRETING OUTPUT DATA

Final model results are reported in three summary sheets: Loads with Existing Practices, Loads with Future Practices, and Loads with New Growth. Each of these sheets uses exactly the same format (See Figure 6). The summary output sheets divide the load into two categories: Loads to Surface Waters, and Loads to Groundwater. The loads to Surface Waters are then further subdivided into Storm Loads (e.g., urban runoff) and Non-Storm Loads (e.g., Illicit Discharges).

Existing Loads to Surface Waters					
	TN lb/year	TP lb/year	TSS lb/year	Fecal Coliform billion/year	Runoff Volume (acre-feet/year)
Urban Land	-	-	-	-	-
Active Construction	-	-	-	-	-
SSOs	-	-	-	-	-
CSOs	-	-	-	-	-
Channel Erosion	-	-	-	-	-
Road Sanding	-	-	-	-	-
Forest	-	-	-	-	-
Rural Land	-	-	-	-	-
Livestock	-	-	-	-	-
Illicit Connections	-	-	-	-	-
Marinas	-	-	-	-	-
Point Sources	-	-	-	-	-
Septic Systems	-	-	-	-	-
Open Water	-	-	-	-	-
Total Storm Load	-	-	-	-	-
Total Non-Storm Load	-	-	-	-	-
Total Load to Surface Waters	-	-	-	-	-

Existing Loads to Groundwater (Contributed from Urbanization). Note. Model does not deliver to receiving surface waters.			
	TN lb/year	TP lb/year	Fecal Coliform billion/year
Urban Land	0	-	-
Septic Systems	-	-	-
Total	0	-	-

Figure 6. Output from the “Loads with Existing Practices” Worksheet

Surface Loads

While the WTM is not a continuous model, some users find it useful to separate “storm loads” from “non-storm loads.” This is particularly true for bacteria loads, where violations typically occur during storm events.

Loads to Groundwater

Although the WTM is not a groundwater model, it does estimate the loads (from urban land and OSDs) delivered to the groundwater. It is important to note that the WTM *does not* estimate the amount of this load that is ultimately delivered to the surface water. However, it *does* account for soil infiltration, so it reflects expected delivery to the groundwater system, rather than the entire mass of pollutants infiltrated.

Summaries on Other Sheets

Many of the calculation sheets also offer some summary data that may be useful for comparing practice options. These data are summarized in Table 4.

TABLE 4. DATA REQUIRED TO CALCULATE FUTURE WASTEWATER LOADS		
Sheet	Summary Data	Notes
Primary Sources	Annual Surface Loads (pre-BMP) for each land use and summed in Columns P through U Total loads are divided into <i>storm</i> and <i>non-storm</i> components	The summary data on this sheet are coded grey because they are not highly useful. Although these summaries compare the contributions from each land use, the data can be deceptive because they do not include BMP implementation.
Secondary Sources	The purple cells at the bottom of the sheet report pollutant loads from each secondary source. These loads are then summed and divided into storm load, non-storm load, and loads to groundwater.	These data can be useful, but also do not include BMP implementation.
Existing Management Practices	The summary sheet at the bottom of the page (purple cells) tabulates the load reduction (or runoff reduction), from each practice The summary the divides the total load into storm, non-storm and groundwater components.	Some load reductions may be negative. This <i>negative reduction</i> actually represents an <i>increased load</i> resulting from a management practice. One example of this is the load from infiltration practices to the groundwater.
Future Management Practices	These load reductions are summarized in two sections. Grey cells reflect the load reductions from <i>all practices</i> (both existing and future). Purple cells reflect the <i>net reduction</i> from future management practices.	The purple cells in the Future Management Practices sheet are the most useful, since they reflect the benefit of the proposed practices.
Retrofit Worksheet	The benefits, and loads to groundwater, of each practice are summed in the purple cells to the right. In addition, the model sums the total benefits from each practice.	All of these data are transferred to the Future Management Practices sheet, and aggregated by practice type.
New Development	The net additional load from each source is summed at the bottom of this sheet in purple cells.	

REFERENCES

Haith, D., R. Mandel and R. Wu. 1992. *Generalized Watershed Loading Functions, Users's Manual*. Daprtment of Agricultural and Biological Engineering. Cornell University. Ithaca, NY