Appendix C: Model Development for the Mill Creek TMDL

Overview of model development of the Mill Creek watershed:

Parameter (Condition)	Quantity[1]	Source of: Flow	Source of: Allocation[2]	Watershed	Notes
NH_3-N (Acute)	WLA	TR55 for Scott's runoff	CONSWLA	Crosses Run	WQC is applicable as an hourly maximum; the total maximum load was calculated on an hourly basis Scotts and Nonpoint source major issues
	LA	TR55 for watershed less Scott's area	TMHL-NB-WLA		
	NB	TR55 for watershed under natural, unimpacted conditions	C_{UP} x Q_{NB}		
	TMHL	$Q_{WLA} + Q_{LA} + Q_{NB}$	WQC x Q_{total}		
NH_3-N (Chronic)	WLA	TR55 for Scotts total monthly volume of runoff	WQC x Q_{WLA}	Crosses Run	WQC are applicable as an monthly average; the total maximum load was calculated on an monthly basis Scotts and Nonpoint source major issues
	LA	Q_{TMML}-Q_{NB}-Q_{WLA}	TMML-NB-WLA		
	NB	USGS gage 25th percentile of the average monthly summer flow to reflect baseflow	C_{BWQR} x Q_{UP}		
	TMML	USGS gage 75th percentile of the total average monthly summer flow to estimate a wet weather year	C_{WQC} x Q_{total}		
Total Phosphorus (Chronic)	WLA	TR55 for Scotts for a 2 year, 24 hour design storm adjusted to reflect total summer runoff	1.0 mg/l x Q_{WLA}	Crosses Run	TP target value applicable to a summer period condition; the 1.0 mg/l value for the WLA based on administrative decision; the assumed value for LA is best professional judgment based on implementation actions in place
	LA	TR55 for watershed for a 2 year, 24 hour design storm adjusted to reflect total summer runoff	$C_{assumed}$ x Q_{UP}		
	NB	USGS gage 25th percentile of the average total summer flow	C_{BWQR} x Q_{NB}		
	TMSL	USGS gage 75th percentile of the total average summer flow	C_{target} x Q_{total}		

Overview of model development of the Mill Creek watershed Continued:

Parameter (Condition)	**Quantity**[1]	**Source of:**		**Watershed**	**Notes**
		Flow	**Allocation**[2]		
Pesticides	WLA	No existing point sources of pesticides	0	Crosses Run	Scotts legacy issues reflected in the contaminated sediment
	LA	Criteria dependent critical low flow ($Q_{7,10}$ or Harmonic Mean Flow)	C_{WQC} x Q		
	NB	No existing natural sources of these pesticides	0		
	TMDL	WLA + LA + NB	WLA + LA + NB		
Dissolved Oxygen	WLA	Marysville design flow	QUAL2E	Mill Creek	Marysville WWTP Loading
	NB	Critical low flow ($Q_{7,10}$)	C_{UP} x $Q_{7,10}$		
	LA	Incremental inflow (Q_{incr})	C_{UP} x Q_{incr}		
	TMDL	Q_{WLA} + Q_{LA} + Q_{NB}	WLA + LA + NB		

1 WLA = Wasteload Allocation for Point Sources; LA = Load Allocation for Nonpoint Sources; NB = Natural Background; TMHL = Total Maximum Hourly Load; TMML = Total Maximum Monthly Load; TMSL = Total Maximum Summer Load; TMDL = Total Maximum Daily Load

2 CONSWLA = Conservative Substance Waste Load Allocation Program; C_{UP} = concentration upstream(background); WQC = Water Quality Criteria; C_{BWQR} = statewide background data from the Background Water Quality Report; $C_{assumed}$ = estimated value based on best professional judgment; C_{target} = target value from the "Associations Document"; Q_{NB} = runoff flow under natural conditions; Q_{UP} = stream flow upstream of Scotts; Q_{total} = total flow from the watershed: Q_{WLA} + Q_{LA} + Q_{NB}; Q_{WLA} = total runoff flow from Scotts; Q_{NPS} = flow from the non-point sources; Q = criteria dependent critical flow; Q_{incr} = incremental inflow

Part 1. The Mill Creek Dissolved Oxygen Model

1.0 Introduction

This section describes the methods used in the modeling analysis of dissolved oxygen (D.O.) in the Mill Creek TMDL. It is intended to be used as a supplement to the TMDL report and relies on the report to provide a description of the study area, project objectives and results. The purpose of this section is to document the major steps and decisions made in the modeling process.

1.1 Model Structure and Approach

Dissolved oxygen was modeled using the Enhanced Stream Water Quality Model QUAL2E-UNCAS (QUAL2E) (Brown and Barnwell, 1987). It is a one-dimensional (the D.O. gradient is significant only in the main direction of flow), steady-state (the D.O. profile represents an equilibrium situation where inputs are assumed constant) model which was used to simulate D.O., CBOD, phosphorous, and the nitrogen series. QUAL2E uses a mass balance approach as its basic premise; this approach divides each reach in the study area into computational elements which represent a series of linked completely mixed reactors. Each element is a separate system which has an initial external input and internal interactions that either add to or reduce the dissolved oxygen. The final output is the summation of the input and these interactions and it represents the input into the next element. The major constituent interactions used in the Mill Creek model are depicted in Figure C1.

The Mill Creek study area was divided into 7 reaches; these reaches was further divided into computational elements with a length of 0.1 mile each. The model representation of the stream network showing the computational elements and reaches is presented in Table C2.

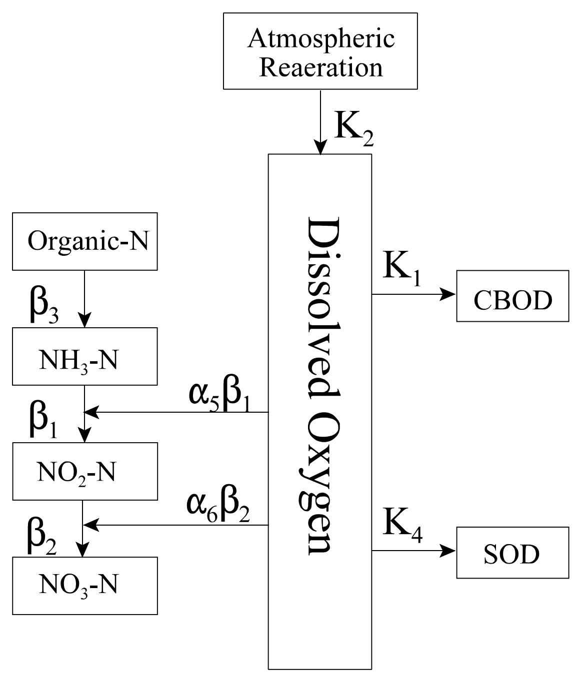


Figure C1. Constituent Interactions for the Mill Creek TMDL

1.2 Calibration and Verification

Calibration and verification of the Mill Creek D.O. model was conducted using data from two stream surveys conducted by the Ohio EPA during the summers of 1986 and 1995 from downstream Town Run (RM 18.4) to Crosses Run (RM 11.9) and calibrated and verified with the appropriate field data.

The calibration began with an initial data set populated only by measured values from the field survey selected for calibration. A range of values for each unknown input was then estimated using the field survey data and literature values. Initial estimates of the unquantified inputs based on the predefined ranges were then incorporated into the data set. The model results were compared to the observed data and the estimated inputs adjusted accordingly. The inputs to adjust were selected by performing a first-order error analysis on the data set to determine which inputs the model was most sensitive to. Then a sensitivity analysis was performed for these inputs and a final value was selected based on the sensitivity analysis results. The model was calibrated in stages for all values simulated by the model. The hydraulic simulations were calibrated first followed by the nitrogen series (organic, ammonia, nitrite and nitrate nitrogens), CBOD and dissolved oxygen. The final dissolved oxygen calibration graph is shown in Figure C2.

After calibration, a simulation representing the current situation under critical conditions was run to estimate the deviation of the current conditions from the desired target (D.O. water quality criteria). Implementation option simulations were then run for selected remediation scenarios under critical conditions to determine TMDLs that would meet the D.O. criteria.

1.3 Sources of Data

The majority of the data used in the modeling was field data collected by Ohio EPA. The types of data that were collected include:

- time of travel dye studies to measure stream velocity
- chemical sampling including grab and 24-hr composites samples
- flow measurements of the mainstem and tributaries
- instream D.O., pH, temperature and conductivity hourly recordings for 48 hour intervals
- cross-sectional measurements

Point source effluent were sampled for water quality and flow to quantify their contributions to the Mill Creek for calibration and validation purposes. Other data sources include the effluent data collected by the discharger as required by their NPDES permit. These data are collected over time and are more representative of the effluent quality than the ‘snapshot picture’ that is measured during a field survey. Additionally, flow data collected at the USGS stream gage station (03220000) near Bellpoint (USGS, 2001) were used to define the critical ambient flow values for the simulations.

1.4 Description of Inputs

<u>Forcing Functions</u>

Forcing functions are the user-specified inputs that drive the system being modeled (Brown and Barnwell, 1987). The Mill Creek D.O. model has three applicable types of forcing functions. These functions and a description of the source of the input data are as follows:

1. Headwater Inputs - The average of all the chemical samples taken from the mainstem upstream of the point sources was used as the headwater quality in the critical condition simulation.

2. Point Sources and Withdrawals – Marysville WWTP effluent was sampled during each stream survey and the appropriate water quality was input for the calibration or validation data sets. The critical simulations assumed that the entity was discharging at its design flow and monthly average concentration limit if applicable or at the 50^{th} percentile values as calculated from the discharger's self-reported data if no permit limit applied. The mainstem flow input was the lowest 7-day average flow that has occurred in any 10-year period (the 7Q10).

3. Incremental Inflows – Nonpoint sources such as drains, tiles and groundwater inflows were included as incremental inflows and were assumed to occur uniformly over the entire length of the reaches. Incremental inflow rates were estimated by calculating an incremental flow rate per mile based on differences in the upstream and downstream flow sites. The length of the reach multiplied by the flow rate/mile gave the total inflow per reach. The assumption is that there are some nonpoint (anthropogenic or natural) inflows even during lower flow conditions. The critical simulation used the inflow rates from the data survey conducted to calibrate the model (1986 data). The water quality of the incremental inflows was set to background concentrations.

<u>Hydraulics Data</u>
Hydraulic data includes stream flow, velocity and water depth. Velocity was measured using a Rhodamine dye time of travel survey and the water depths were calculated from cross-sectional data measured at representative sites. These data were used to establish depth and velocity relationships with flow. Flow dependent depth and velocity functions are used to predict the depths and velocities of the stream that would occur under stream flows other than the measured flows. These relationships were established using the following power functions:

$$\text{Depth} = aQ^b$$

$$\text{Velocity} = cQ^d$$

Where: Q = Stream flow
a,c = Stream constants for depth and velocity
b,d = Depth and velocity coefficients

The constants and coefficients were calculated from log-log plots of the stream velocity or depth data where sufficient field data existed to determine such relationships. Where only limited data existed, the coefficients were assumed as follows:

b = 0.6 for free flowing reaches
d = 0.4 for free flowing reaches

QUAL2E uses the following equation to predict width:

$$W = Q / (V * D)$$

Where:	W	=	Width (ft)
	Q	=	Flow (ft^3/s)
	V	=	Velocity (ft/s)
	D	=	Depth (ft)

Dispersion

QUAL2E assumes that complete mixing occurs from side to side and top to bottom in a river. Mixing also occurs as the water travels down the river due mainly to the horizontal and vertical velocity gradients and river channel changes (Thomann and Mueller, 1987). This mixing is referred to as longitudinal dispersion. The time of travel dye studies were used to estimate the longitudinal dispersion using the following equation:

$$E_x = M * (2 A s_p)^{-2} * (\pi t_p)^{-1}$$

Where:	E_x	=	Longitudinal dispersion coefficient for reach x
	M	=	Mass of dye introduced to the stream
	A	=	Average cross-sectional area of reach x
	s_p	=	Peak concentration of the dye in reach x
	t_p	=	Time to peak concentration of the dye for reach x

QUAL2E requires that a value for the longitudinal dispersion *constant* be used. The dispersion constant is a dimensionless value which relates the dispersion coefficient to the depth and shear velocity. The relationship is expressed as:

$$K = E_x / (D * U^*)$$

Where:	K	=	Dispersion constant
	U^*	=	Shear velocity

Model Coefficients and Constants

The constants and coefficients selected during model calibration are shown in Table C1. The coefficients α_5 and α_6 represent the oxygen uptake per unit of oxidized ammonia and nitrite. The values used are recommended by U.S. EPA (1985) and are based on the stoichiometry of the reactions. The Manning's roughness factor used in the model was based on the lowest value recommended in the QUAL2E manual (Brown and Barnwell, 1987) for natural river channels that are winding with pools and shoals.

The measured nitrogen series concentrations exhibited decay in the study area; a first order error analysis of the model indicated that both the predicted ammonia, nitrate, and nitrite concentrations were sensitive to the rate constant for the biological oxidation of ammonia to nitrite (β_1) and to the rate constant for the biological oxidation of nitrite to nitrate (β_2). A sensitivity analysis was conducted on ammonia, nitrite, and nitrate by varying the value of β_1 and β_2 respectively and seeing how the predicted concentrations compared to the observed ones. The values of β_1 and β_2 that gave the best fit and remained in the range of suggested values in the QUAL2E manual (Brown and Barnwell, 1987) were selected. Field measurements of organic nitrogen did exhibit a decay; however, the predicted organic nitrogen and ammonia concentrations did not calibrate well with the observed data when the field estimated value of β_3 was used. Instead, a sensitivity analysis was performed to determine what value gave the best predicted concentrations of ammonia and organic nitrogen when compared with observed values.

An empirical relationship between the CBOD decay rate (K_1) and depth (D) has been observed. The equation, $K_1 = 0.3\,(D/8)^{-0.434}$, gave the best predicted fit for CBOD and D.O. and was used to determine K_1 for the entire study area. The settling constants were assumed to be zero.

The stream reaeration rate was calculated using a predictive equation selected based on stream slope and flow as suggested by Ohio EPA guidance (OEPA, 1984). The recommended predictive equation for the modeled portions of the study area was the Parkhurst-Pomeroy equation.

Sediment oxygen demand (SOD) is a measure of the oxygen consumed by biochemical decompositions of organic matter in stream sediments and is represented by the rate coefficient K_4. No SOD measurements were recorded in the 1986 or 1995 surveys; therefore, following Ohio EPA guidance (Number 6,1998; Rule reference: OAC 3745-2-10 and 3745-2-11), a range of 0.01 to 0.02 $g/ft^2/day$ was determined for advanced treatment plants such as Marysville WWTP. A middle value of 0.014 $g/ft^2/day$ was selected for the model.

Table C1. Summary of Coefficients for D.O. Modeling in the Mill Creek

Coefficient[1]	Description	Units[2]	Value Used
α_5	O_2 uptake per unit NH_3 oxidized	mg O/ mg N	3.43
α_6	O_2 uptake per unit NO_2 oxidized	mg O/ mg N	1.14
n	Manning's roughness	–	0.033
β_1	Rate constant for biological oxidation of NH_3 to NO_2	day^{-1}	0.4
β_2	Rate constant for biological oxidation of NO_2 to NO_3	day^{-1}	0.6
β_3	Rate constant for biological oxidation of Org-N to NH_3	day^{-1}	0.3
K_1	CBOD decay rate	day^{-1}	variable[3]
K_2	Reaeration rate	day^{-1}	variable[4]
K_4	Sediment oxygen demand	$g/ft^2/day$	0.014

[1] Refer to Figure C1 for pictorial representation of the rates.
[2] Presented as the value at 20 degrees C for first-order rate constants β_1, β_2, β_3, K_1, K_2, and K_4.
[3] CBOD decay is variable with average reach depth.
[4] Reaeration is variable with average reach depth and velocity.

Temperature Effects on Coefficients

First-order kinetic coefficients are temperature dependent and the QUAL2E standard is to input the reaction rate value at 20 degrees C. The program then corrects to the actual reaction rate based on the ambient temperature of the receiving water during simulations. The temperature corrections are calculated using the following formula:

$$X_T = X_{20}\, \theta^{(T-20)}$$

Where:

X_T = the value of the coefficient at the ambient temperature (in degrees C)
X_{20} = the value of the coefficient at the standard temperature of 20 degrees C
θ = an empirical constant derived from literature values
T = the ambient temperature (in degrees C)

The temperature correction values used were:

Kinetic Coefficient	Correction Factor
K_1	1.047
K_2	1.024
K_4	1.060
β_1	1.083
β_2	1.047
β_3	1.047

Dam Effects

Dams affect both the upstream and downstream D.O. concentrations. The upstream D.O. concentrations are negatively impacted due to the change in the hydraulics of the stream (decreasing natural stream reaeration, increasing deoxygenation rates of CBOD decay). This impact is captured in the field measurements of the stream hydrology. Oxygen is input to the stream from reaeration over dams so downstream D.O. concentrations are increased. QUAL2E predicts the dam reaeration using the Gameson equation. The inputs required by this equation include:

H = the height through which water falls;
a = an empirical parameter indicating water quality
b = an empirical parameter indicating dam shape

A summary of the dam data is:

Dam Location	H[1] (ft)	a[2]	b[3]
Dam just above WWTP Outfall	3.0	1.6	1.05

[1] Visual observation by Ohio EPA.
[2] The higher the value, the better the water quality. A value of 1.6 indicates slightly polluted water.
[3] A value of 1.05 indicates a weir with free fall.

Relationship between CBOD5 and Ultimate CBOD
QUAL2E uses ultimate CBOD (CBODU) as its default input and output CBOD measure. Waters dominated by domestic waste effluents and waters that are not strongly influenced by industrial wastes typically have 20-day CBOD values that closely approximate the ultimate values (OEPA, 1998). Therefore, CBOD20 and CBODU will be considered equal for the purposes of this study.

The WLAs based on the model output are expressed as CBODU; however, most municipal treatment works' NPDES permits are expressed as CBOD5. The following equation was used to convert from CBODU to CBOD5:

CBODU = 2.2 * CBOD5 . . . . for municipal plants with advanced treatment

1.5 Quantified Comparison of Observed and Modeled Dissolved Oxygen
A statistical measure of how well a constructed model compares to observed data is relative error. This technique gives an indication of model adequacy and is the absolute value of the difference between the observed and the predicted values divided by the observed value. The median percent relative error for the calibrated Mill Creek model is 3%. A study of 20 different state-of-the-art models was conducted and the median percent relative error in measured versus simulated D.O. was compared. The results (USEPA, 1997) show that 60 percent of the models studied had relative median errors greater than 3%. The Mill Creek TMDL model compares well to those models studied and indicates that the Mill Creek model should give credible results.

1.6 Summary
The Mill Creek watershed was modeled using QUAL2E and field collected data. The predicted dissolved oxygen concentrations compared reasonably well (see figure A-3) with the measured values for all areas and the model can be relied on to give credible results. A set of inputs reflective of critical conditions was used to determine the current critical D.O. profile. The conditions that were considered critical (and not subject to change) are low flow conditions (7Q10) determined from data collected at Mill Creek USGS gage station (#03220000) since 1943. The effects of various loading changes were then estimated to determine what changes were necessary in the current study area to result in attainment of the dissolved oxygen criteria.

Figure C2. Computational Representation of the Mill Creek QUAL2E Model

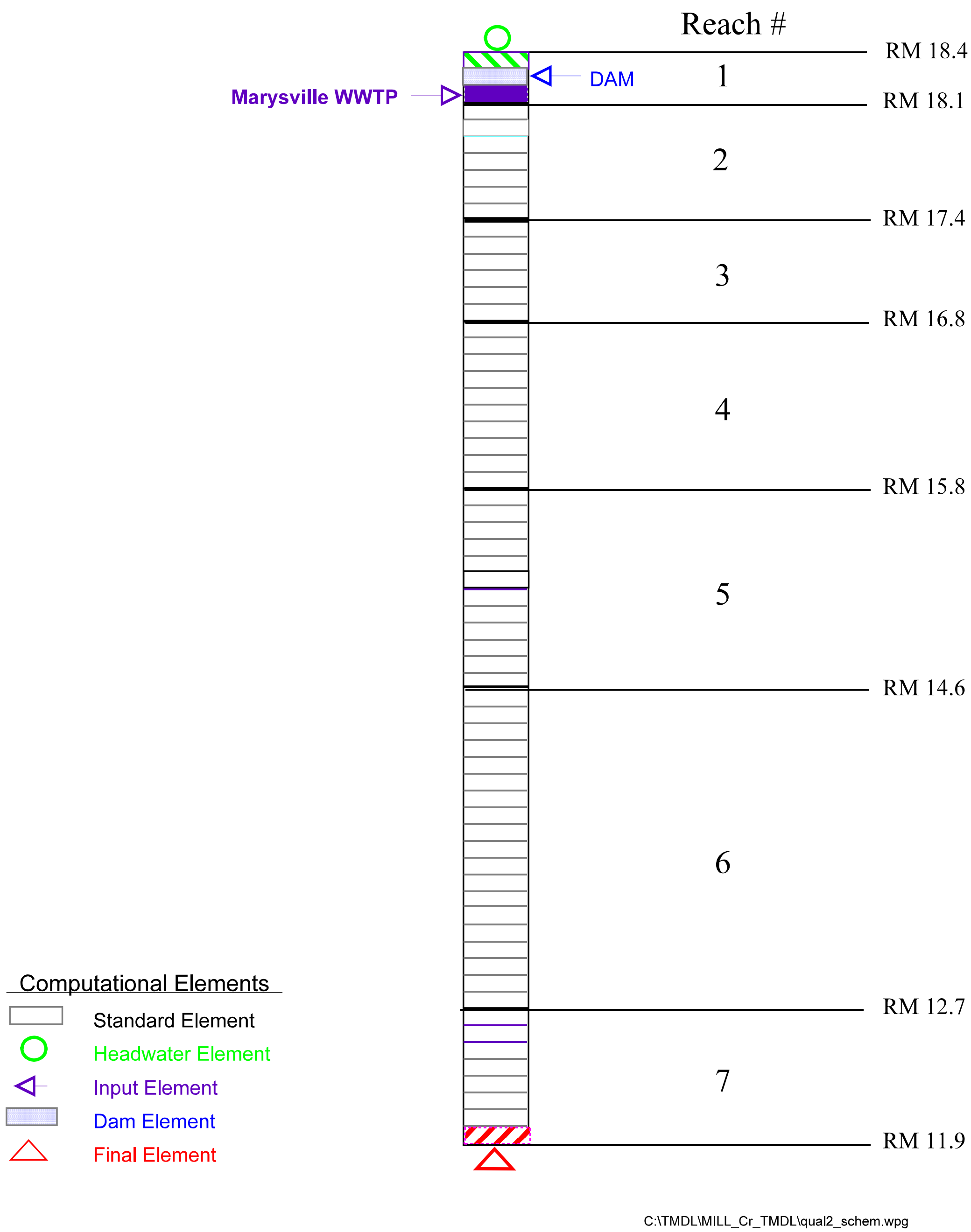
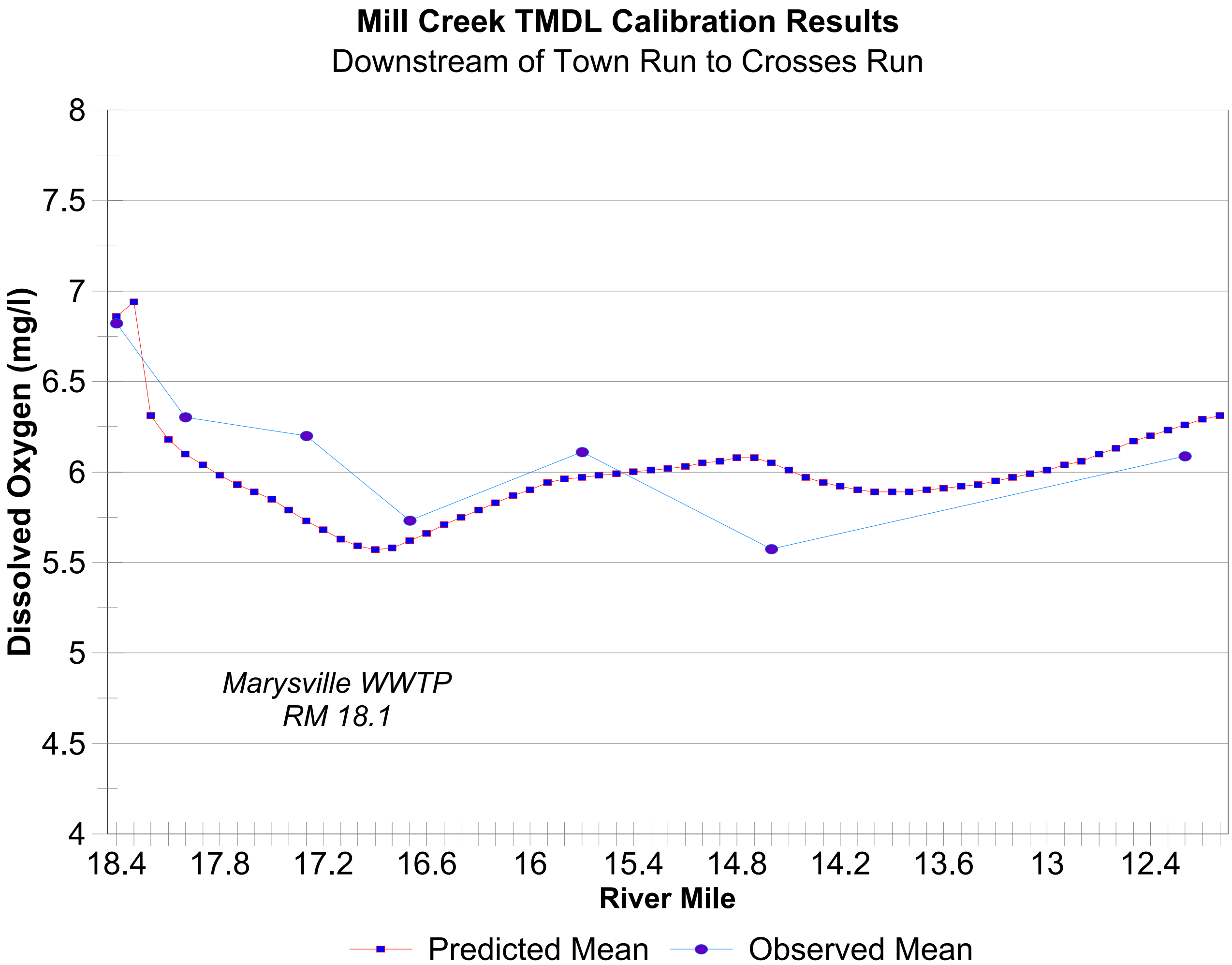


Figure C3. Mill Creek modeling results



Part 2. The TR-55 Storm Water Runoff Model[1]

2.0 Introduction
This section describes the methods used in the runoff analysis. A method was needed to establish storm flows since the source of the load in the Crosses Run sub-watershed was wet weather driven. It is intended to be used as a supplement to the TMDL report and relies on the report to provide a description of the study area, project objectives and results. The purpose of this section is to document the steps and decisions made in the modeling process.

2.1 Model Structure and Approach
The loading of ammonia and phosphorus was estimated by determining the storm water runoff in the Crosses Run sub-watershed using Technical Release-55 (TR-55). TR-55 is a single event rainfall-runoff hydrologic model designed for small watersheds and developed by the USDA, Natural Resources Conservation Service (NRCS).

Hydrologic studies to determine runoff and peak discharge of rain events should ideally be based on long-term stationary streamflow records for the area. Such records are seldom available for small drainage areas. Even where they are available, accurate statistical analysis of them is usually impossible because of the conversion of land to urban uses during the period of record. Therefore it is necessary to estimate peak discharges with hydrologic models based on measurable watershed characteristics.

Changes to the land use can dramatically effect a watershed's response to precipitation. The most common effects are reduced infiltration and decreased travel time, which significantly increase peak discharges and runoff. Runoff is determined primarily by the amount of precipitation and by infiltration characteristics related to soil type, soil moisture, antecedent rainfall, cover type, impervious surfaces, and surface retention. Travel time is determined primarily by slope, length of flow path, depth of flow, and roughness of flow surfaces. Peak discharges are based on the relationship of these parameters and on the total drainage area of the watershed, the location of the development, the effect of any flood control works or other natural or man-made storage, and the time distribution of rainfall during a given storm event.

The model described in TR-55 begins with a rainfall amount uniformly imposed on the watershed over a specified time distribution. Mass rainfall is converted to mass runoff by using a runoff curve number (CN). CN is based on soils, plant cover, amount of impervious areas, interception, and surface storage. Runoff is then transformed into a hydrograph by using unit hydrograph theory and routing procedures that depend on runoff travel time through segments of the watershed. For a description of the hydrograph development method used by NRCS in TR-55, see chapter 16 of the NRCS National Engineering Handbook, Section 4 - Hydrology (NEH-4)(NRCS 1985). The routing method (Modified Att-Kin) is explained in appendices G and H of Technical Release 20 (TR-20, NRCS 1983).

[1] Discussion of TR-55 principles from NRCS Technical Release 55, version date 3/01, beta version.

2.2 Description of Inputs

Synthetic rainfall distributions

The highest peak discharges from small watersheds in the United States are usually caused by intense, brief rainfalls that may occur as distinct events or as part of a longer storm. These intense rainstorms do not usually extend over a large area and intensities vary greatly. One common practice in rainfall-runoff analysis is to develop a synthetic rainfall distribution to use in lieu of actual storm events. This distribution includes maximum rainfall intensities for the selected design frequency arranged in a sequence that is critical for producing peak runoff.

The length of the most intense rainfall period contributing to the peak runoff rate is related to the time of concentration (Tc) for the watershed. The Tc represents the time it takes for runoff to travel to a point of interest from the hydraulically most distant point. In a hydrograph created with NRCS procedures, the duration of rainfall that directly contributes to the peak is about 170 percent of the Tc. For example, the most intense 8.5-minute rainfall period would contribute to the peak discharge for a watershed with a Tc of 5 minutes. The most intense 8.5-hour period would contribute to the peak for a watershed with a 5-hour Tc. TR-55 includes four regional rainfall time distributions. But different rainfall distributions can be developed for each of these watersheds to emphasize the critical rainfall duration for the peak discharges. However, to avoid the use of a different set of rainfall intensities for each drainage area size, a set of synthetic rainfall distributions having “nested” rainfall intensities was developed. The set “maximizes” the rainfall intensities by incorporating selected short duration intensities within those needed for longer durations at the same probability level. For the size of the drainage areas for which NRCS usually provides assistance, a storm period of 24 hours was chosen for the synthetic rainfall distributions. The 24-hour storm, while longer than that needed to determine peaks for these drainage areas, is appropriate for determining runoff volumes in small drainage areas like the Crosses Run sub-watershed. Therefore, a single storm duration and associated synthetic rainfall distribution can be used to represent not only the peak discharges but also the runoff volumes for a range of drainage area sizes.

The intensity of rainfall varies considerably during a storm as well as geographic regions. To represent various regions of the United States, NRCS developed these four synthetic 24-hour rainfall distributions (I, IA, II, and III) from National Weather Service (NWS) duration-frequency data (Hershfield 1061; Frederick et al.,1977) or local storm data. Type IA is the least intense and type II the most intense short duration rainfall. Type II represents the most of the country including the region encompassing the Mill Creek basin. All four distributions are for a 24-hour period and this period was chosen because of the general availability of daily rainfall data that were used to estimate 24-hour rainfall amounts. The 24-hour duration spans most of the applications of TR-55.

The Tc is a critical parameter in the model. Normally a rainfall duration equal to or greater than Tc is used. Therefore, the rainfall distributions were designed to contain the intensity of any duration of rainfall for the frequency of the event chosen. That is, if the 10-year frequency, 24-hour rainfall is used, the most intense hour will approximate the 10-year,1-hour rainfall volume.

Runoff

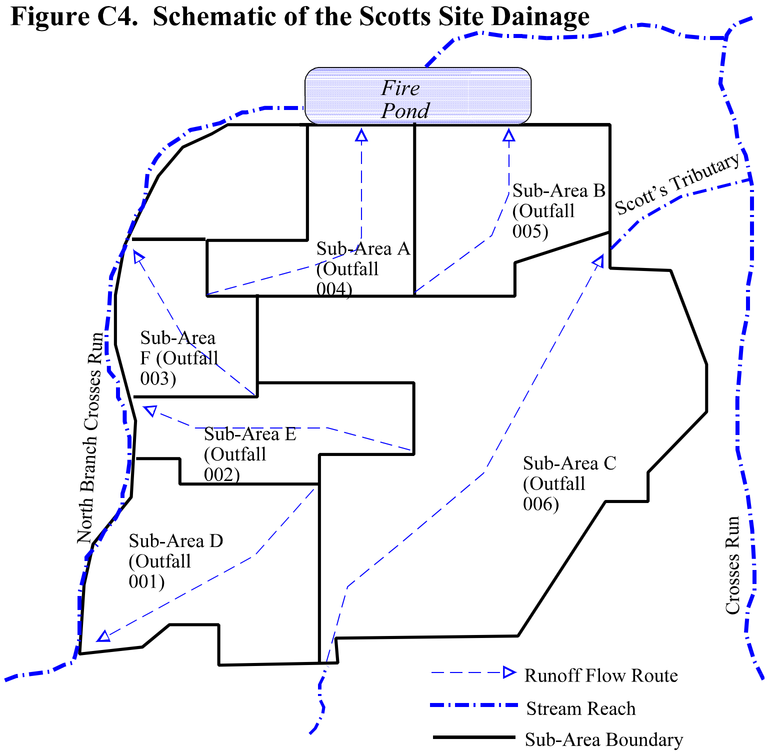
To estimate runoff from storm rainfall, TR-55 uses the runoff curve number (CN) method. Determination of CN depends on the watershed soil and cover conditions, which the model represents as hydrologic soil group, cover type, treatment, and hydrologic condition (refer to table C3 for the list of model inputs). Another factor considered is whether impervious areas outlet directly to the drainage system (connected) or whether the flow spreads over pervious areas before entering the drainage system (unconnected).

Both Crosses Run and it's major tributary, North Fork Crosses Run (NFCR) drains predominately agricultural land and identical soil groups. The CN, therefore, was reflective of permeable conditions consisting of straight planted row crops and residue cover with good hydrologic soil conditions. The Scotts facility consists of predominantly impermeable surfaces. The CN number here falls under an urban area category of paved parking lots, roofs, and driveways.

During the time which passes between storm events, pollutants from the Scott facility operations accumulate on these impermeable surfaces through product spillage, aerial deposition, etc. Generally, the greater the length of time which elapse the greater the risk of adverse effects to the receiving stream by the runoff from a storm event. The index of this runoff potential before a storm event is the antecedent runoff condition (ARC). ARC is an attempt to account for the variation in CN at a site from storm to storm over time. The CN's used for the sub-catchment areas are for the median ARC taken from representative sample rainfall and runoff data.

The schematic below (Figure C4) shows the Scotts facility catchment area with defined flow paths though the catchment area to the outlet. The accumulated runoff from all sub-areas routed through the watershed reach system, by definition, is the flow at the watershed outlet.

Figure C4. Schematic of the Scotts Site Dainage



Runoff Equation
The NRCS Runoff Curve number (CN) equation is

$$Q = \frac{(P-Ia)^2}{(P-Ia)+S}$$

where:

Q = runoff (in)
P = rainfall (in)
S = potential maximum retention after runoff begins (in) and
Ia = initial abstraction (in)

Time parameters - Time of Concentration and Travel Time
The method used to distribute the runoff into a hydrograph is based on velocities of flow through segments of the watershed. Two major parameters are time of concentration (Tc) and travel time (Tt) of flow through the segments. These and other parameters are used in accepted hydraulic analyses of open channels. Many methods are empirically derived from actual runoff hydrographs and watershed characteristics. This method was chosen because it is basic; however, other methods may be used. The peak discharge and hydrographs describes a method for approximating peak rates of discharge, and a method for obtaining or routing hydrographs. Both methods were derived from hydrographs prepared by procedures outlined in chapter 16 of NEH-4 (NRCS 1985). The computations were made with a computerized NRCS hydrologic methodologies contained in TR-55 (NRCS 1983).

Tt is a component of Tc and is the time it takes water to travel from one location to another in a watershed. Tc is computed by summing all the travel times for consecutive components of the drainage conveyance system. The Tc influences the shape and peak of the runoff hydrograph. Urbanization usually decreases Tc, thereby increasing the peak discharge.

Factors affecting Tc and Tt include surface roughness, channel shape and slope. The effects of the impervious surfaces from the Scotts facility, increases flow velocity from storm runoff due to the decreased flow retardants. The travel time through these types of modified watersheds is greatly decreased as soil infiltration is restricted or eliminated and flow is diverted along gutters or storm sewers. Typically, such facilities reduce the overland flow lengths by conveying storm runoff into a channel as soon as possible. Since channel designs have efficient hydraulic characteristics, runoff flow velocity increases and travel time decreases. Slopes are usually modified as well depending on the extent of site grading. Slope will tend to increase when channels are straightened and decrease when overland flow is directed through storm sewers and other diversions.

Travel time (Tt) is the ratio of flow length to flow velocity:

$$T_t = \frac{L}{3600V}$$

where:

Tt = travel time (hr)
L = flow length (ft)
V = average velocity (ft/sec)
3600 = conversion factor from seconds to hours.

Time of concentration is the sum of Tt values for the various consecutive flow segments:

$$Tc = Tt_1 + Tt_2 + ... Tt_m$$

where:

Tc = time of concentration (hr)
m = number of flow segments

Water moves though a watershed as sheet flow, shallow concentrated flow, open channel flow, or some combination of these. The maximum length TR-55 allows for sheet flow is 300 feet. However, sheet flow for 300 feet is very unusual because the surface and the corresponding flow would need to be extremely uniform. Generally, beyond 100 feet the flow becomes concentrated flow. Therefore, for the Crosses Run sub-watershed, the maximum recommended distance of 100 feet was assumed for sheet flow. With sheet flow calculation, a friction value (Manning's n) is used and is an effective roughness coefficient that includes the effect of raindrop impact, drag over the plane surfaces, obstacles such as litter, crop ridges and rocks, and erosion and transportation of sediment where applicable.

For sheet flow of less then 300 feet the following Manning's kinematic solution was used:

$$T_t = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5}\, s^{0.4}}$$

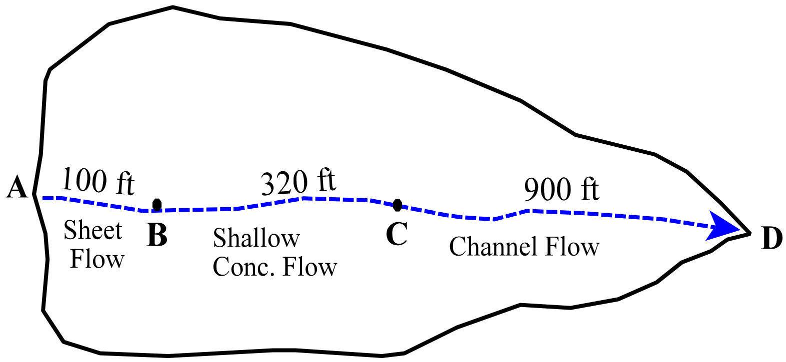
where:

T_t = travel time (hr)
n = Manning's roughness coefficient
L = flow length (ft)
P_2 = 2-year, 24-hour rainfall (in)
s = slope of hydraulic grade line (land slope, ft/ft)

Any remaining distance was routed as shallow concentrated flow until a receiving channel or storm sewer was reached. In the case of the Scotts facility, the channel is the storm sewer which conveys the runoff via underground pipes which discharge directly to ether North Branch or Crosses Run. These flow distances vary with each sub-catchment area (see table C3) and were estimated by measurements derived from a site drainage map provided by the Scotts Company.

The figure below represents a typical Scotts sub-catchment area with the runoff flow segment types. To compute Tc at the outlet of the watershed (D) from the hydraulically distant point of the watershed (A), the Tt for each segment is first determined and then these values are summed.

Figure C5.



<u>TR-55 capabilities and limitations</u>
Table C2 lists TR-55 capacity to analyze watersheds which meet the following criteria:

Table C2 TR-55 Capabilities & Limitations

Variable	**Limits**
Maximum area	25 square miles (16,062 acres)
Number of sub-watersheds	1-10
Time of concentration (T_C) for any sub-area	0.1 hour $\leq T_C \leq$ 10 hour
Number of reaches	0-10
Type of reaches	Channel or structure
Reach routing	Muskingum-Cunge
Structure routing	Storage-Indication
Structure types	Pipe or weir
Structure trail sizes	1-3
Rainfall depth	24-hour
Rainfall distribution	NRCS type I, IA, II, III,NM60, NM65,NM70, NM75, or user-defined (e.g. Huff 3rd quartile)
Rainfall duration	24-hour
Dimensionless unit hydrograph	Standard peak rate factor 484, or user defined (e.g. Delmarva)
Antecedent moisture condition	2 (average)

Table C3. Summary of Inputs for the TR-55 Model.

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's n	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
Area A (outfall 104)							
Sheet	100	0.0050	0.011				0.039
Shallow	201	0.0050	0.025				0.039
Channel	1320	0.0006	0.013	7.07	9.42	2.32	0.158
					Time of Concentration:		0.236
Area B (outfall 105)							
Sheet	100	0.0050	0.011				0.039
Shallow	201	0.0050	0.025				0.039
Channel	636	0.0015	0.009	1.77	4.71	3.33	0.053
					Time of Concentration:		0.131
Area C (outfall 106)							
Sheet	100	0.0060	0.011				0.036
Shallow	81	0.0060	0.025				0.014
Channel	2260	0.0003	0.014	19.63	15.71	2.14	0.294
					Time of Concentration:		0.344
Area D (outfall 101)							
Sheet	100	0.0060	0.011				0.122
Shallow	741	0.0060	0.050				0.165
Channel	540	0.0100	0.014	60.0	17.0	25.0	0.006
					Time of Concentration:		0.292
Area E (outfall 102)							
Sheet	100	0.0130	0.011				0.089
Shallow	141	0.0130	0.050				0.021
Channel	265	0.0100	0.022	3.14	6.28	4.33	0.017
					Time of Concentration:		0.127
Area F (outfall 103)							
Sheet	100	0.0070	0.011				0.034
Shallow	201	0.0070	2.6				0.041
Channel	900	0.0010	0.013	3.14	6.28	2.29	0.109
					Time of Concentration:		0.184
North Branch							
Sheet	100	0.0075	0.170			0.262	
Shallow	3500	0.0075	0.050			0.696	
Channel	5808	0.0040	0.042	85.00	14.70	7.24	0.223
					Time of Concentration:		1.215

Table C3. Summary of Inputs for the TR-55 Model - Continued.

Sub-Area Identifier/	Flow Length (ft)	Slope (ft/ft)	Mannings's (n)	End Area (sq ft)	Wetted Perimeter (ft)	Velocity (ft/sec)	Travel Time (hr)
Crosses Run							
Sheet	100	0.0075	0.170				0.262
Shallow	4000	0.0075	0.050				0.795
Channel	6340	0.0060	0.042	82.30	12.30	9.76	0.180
					Time of Concentration:		1.271

2.3 Allocation Inputs

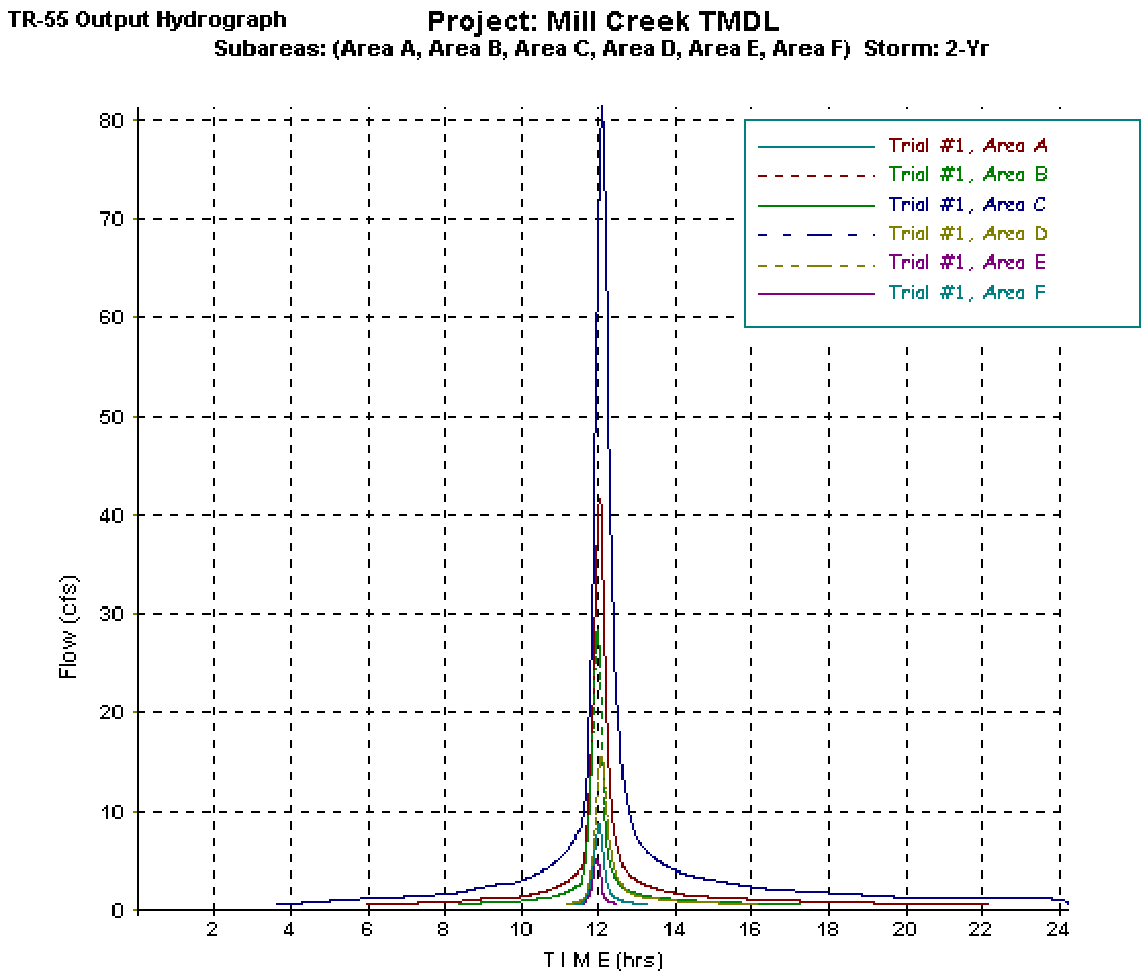
Model estimated runoff

The results of the TR-55 model produces peak runoff values at the combined average time of 12 hours after the start of a storm (see figure C6) for the Scotts catchment area. Therefore, for the purpose of uniformity, all the model estimated runoff flows used in the point-source load calculations were taken at the corresponding 12 hour time period for each outfall. Similarly, the receiving stream runoff flows were set at 12 hours. For the situations where the model predicted flow value didn't correlate exactly to the 12th hour, the flow value was interpolated. Table C4 lists the resulting flow and times from the TR-55 design storm and Figure C6 shows this graphically.

Table C4. Sub-Area Peak Flow and Peak Time by 2-Yr Rainfall Return Period.

Scotts Co. Sub-Area	Flow at 12 hrs (cfs)	Time to Peak Flow (hr)
Area A	40.8	12.02
Area B	27.5	11.95
Area C	69.8	12.09
Area D	14.1	12.06
Area E	4.7	11.96
Area F	8.6	12.00
NFCR	86.6	12.56
Crosses Run	82.0	12.51

Figure C6.



<u>Gage estimated runoff</u>
There are conditions for which the TR-55 estimated runoff are not appropriate. Such as when the criteria of a pollutant is based on a chronic or summer long condition. For this situation, flow and rain data collected at the USGS gage (03220000) on the Mill Creek at the village of Bellpoint was used to get a statistical estimation of the typical flow which might occur in the Crosses Run sub-watershed during the summer months (June1 to September 30). The flow values from this gage were yield adjusted to Crosses Run and the rain data were assumed to be uniformly distributed over the entire watershed.

Part 3. TR-55 Application

3.1 Ammonia-nitrogen: Acute Condition
The NH_3-N runoff load produces a toxic effect in the Crosses Run sub-watershed. The acute WQC is based on a 1-hour average condition so the runoff flows predicted by TR-55 are appropriate for the load calculation. TR-55 was used for all the allocations under the acute condition including upstream runoff to the receiving stream. Refer to Table C5 and C6 for specific values used for the acute condition.

Total Maximum Hourly Load

For this acute 1-hour average condition, a Total Maximum *Hourly* Load (TMHL) was needed. To determine the runoff flows for the WLA, the appropriate watershed information was entered into TR-55 (see section 2.2) for the land area included both Crosses Run and NFCR sub-watersheds. The flow from the Scotts area was estimated in a separate model run then added to the runoff flow of the adjacent watershed, which was estimated in Crosses Run just below the confluence of the North Fork Crosses Run (NFCR) at river mile 2.0. The flow for the non-point source load was calculated for the entire watershed. These runoff flows were then added to the total runoff from the sub-watershed to determine the TMHL (Crosses Run + NFCR + Scotts). See Table C4 for the list of flow used in the NH_3-N acute condition load allocations.

The NH_3-N target for this condition is the summer acute criteria for a warm water habitat use designation. To determined the appropriate criteria value, downstream pH and temperature was determined for each receiving stream. For the NFCR, downstream datasonde values were used because the other dataset (STORET) was too limited and not as current. Crosses Run STORET data were more representative in this reach as more data was collected over a longer time period. See Table C5 for the specific values.

Table C5. Ammonia-nitrogen and total phosphorus target values.

Parameter	Stream	Condition	pH (units)	Temp (°C)	Target (mg/l)
Ammonia-nitrogen	NFCR	Acute	7.6	16	13
		Chronic			2.2[A]
	Crosses Run	Acute	8.3	22	4.7
		Chronic			0.6
Total Phosphorus	Crosses Run	Acute	NA	NA	NA
		Chronic	NA	NA	0.08

[A] For the chronic condition, the pH and temp. were from Crosses Run - downstream of NFCR
NA - Not applicable

Table C6. Storm Water Runoff Flow (Q) and Concentration (C) Values.

Parameter	Units	Value	Basis
Ammonia-nitrogen			
Acute Condition			
Q_{TMHL}	ft^3/hour	334.	TR-55 results: Crosses Run + NFCR + Scotts
Q_{NL}	ft^3/hour	18.	TR-55 results: as above but at natural conditions
Q_{WLA}	ft^3/hour	166.	TR-55 results: total Scotts runoff at 12 hours
Q_{NPS}	ft^3/hour	--	Calculated load: TMHL - NL - WLA
C_{TMHL}	mg/l	4.7	Maximum WQC (see Table C5)
C_{NL}	mg/l	0.025	BWQR
C_{WLA}	mg/l	8.53	CONSWLA results
C_{NPS}	mg/l	--	Calculated load: TMHL - NL - WLA
Chronic Condition			
Q_{TMML}	ft^3/month	43339680.	Yield adjusted summer 75^{th} pctl gage data
Q_{NL}	ft^3/month	648582.	Yield adjusted summer 25^{th} pctl gage data
Q_{WLA}	ft^3/month	692771.	TR-55 results: multiplied by ratio of 1.26[A]
Q_{NPS}	ft^3/month	41998326.	Calculated: TMML - NL - WLA
C_{TMHL}	mg/l	0.6	Average WQC (see Table C5)
C_{NL}	mg/l	0.025	BWQR
C_{WLA}	mg/l	8.53	CONSWLA results for acute conditions
C_{NPS}	mg/l	0.478	Calculated: TMML - NL - WLA
Total Phosphorus			
Chronic Condition			
Q_{TMSL}	ft^3/summer	62365274.	Yield adjusted summer 75^{th} pctl gage data
Q_{NL}	ft^3/summer	2594330.	Yield adjusted summer 25^{th} pctl gage data
Q_{WLA}	ft^3/summer	2749090.	TR-55 results: multiplied by ratio of 5.0[B]
Q_{NPS}	ft^3/summer	57021854.	Calculated: TMSL - NL - WLA
C_{TMHL}	mg/l	0.08	Target value from Associations Report
C_{NL}	mg/l	0.039	BWQR
C_{WLA}	mg/l	1.0	Assumed value
C_{NPS}	mg/l	0.039	Calculated mass balance result

[A] ratio = total monthly summer precipitation in Crosses Run divided by the TR-55 design storm depth results
[B] ratio = average summer precipitation in Crosses Run divided by the TR-55 design storm depth results
BWQR - Background Water Quality Report (Analysis of Unimpacted Stream Data for the State of Ohio, OEPA, 1988)
Associations report - (Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Stream, OEPA,1999)
TMHL - Total Maximum Hourly Load
TMML - Total Maximum Monthly Load
TMSL - Total Maximum Summer Load
NL - Natural Load, WLA - Waste Load Allocation, NPS - Non-point Source

Point Source Load
For the acute condition, the flow used for the load calculation is not necessarily the exact peak flow value. The TR-55 output lists the runoff flows at specific times over the duration of the design storm. Most of the runoff values used for the allocations were interpolated from this data set to determine the flow from the contributing area at 12 hours after the start of the storm. The average time of the peak runoff from the six Storm water outfalls at the Scotts facility was 12 hours. The runoff flows for the two receiving streams were also taken at this average peak time. These runoff values were used in the CONSWLA model (see part 3 of this appendix) along with the appropriate WQC and background values to determine the WLA concentration.

Background Load
Similar to the above allocation, the background or natural load (NL) used the TR-55 results to determine runoff flow. The model was set with the drainage basin in "natural" or pre-development conditions. The CN values were changed to that which reflected a watershed in a natural, forested state.

No reliable unimpacted data for NH_3-N exist within the Crosses Run sub-watershed. The concentration used is an empirical value from unimpacted reference sites within the Scioto River watershed (from the BWQR).

Non-point Source Load
The non-point source (NPS) load, was calculated using the above allocations such that: LA = TMHL - WLA - NL

3.2 Ammonia-nitrogen: Chronic Condition

Total Maximum Monthly Load
The chronic WQC for NH_3-N in Ohio is based on a 30-day average condition. So, in order to protect for the chronic (or the 30-day average) WQC for this pollutant, a Total Maximum *Monthly* Load (TMML) was determined. Therefore, the runoff flows for a monthly time period were calculated. To determine this, the total amount of flow, yield adjusted to the mouth of Crosses Run, was summed for each of the summer months (June to September) of each year for the ten year period of record from the Mill Creek gage flow data. The 75th percentile of each months total flow over this 10 year period was then summed to get the total flow over a typical summer period.

The 75th percentile range was chosen because the source of impairment in this watershed is storm runoff; the 75th percentile range tends to more closely correlate to the higher rainfall years. For example, when the drought years (1994, 1997 and 1999) were removed from the dataset, the median flow from the remaining 8 year period of record fell into this 75th percentile range. Additionally, the majority of the chemical samples collected within the watershed was in the summer of 1995; median flows during this summer also fell in this range.

The summer chronic WQC for NH_3-N was selected using the appropriate pH and temperature data as measured by Ohio EPA in 1990 and 1995. This data were collected downstream of the NFCR at river mile 2.0 and 0.8 of Crosses Run.

Point Source Load
Runoff flows for Scotts, as estimated by TR-55, were not reflective of a monthly condition as was needed for a monthly average based WQC. A ratio between the total monthly precipitation (recorded at the Mill Creek gage) during a typical summer in the Crosses Run sub-watershed, which was 13.17 inches for an average four month summer period, was divided by four to get the estimated monthly value of 3.29 inches. This value was then divided by the TR-55 predicted precipitation depth of 2.6 inches. This yielded a ratio of 1.26 which was used as a multiplier to adjust the total hydrograph derived runoff volume of 549,818 ft^3 to an estimated monthly runoff of 692,771 ft^3/month.

The toxic effects of NH_3-N runoff from the Scotts facility is the primary limiting factor in Crosses Run. Accordingly, the acute or maximum WQC must be met at all times to protect aquatic life. Therefore, to protect for this toxic condition and maintain the WQC, the maximum water quality criteria was used for the point source allocation instead of the higher, less protective chronic or average criteria. See Table C6 for the specific value.

Background Load
For the natural background allocation, the yield adjusted Mill Creek gage flow was used to estimate the monthly runoff conditions over a typical summer period. The 25^{th} percentile range of this flow data was based on best professional judgement and was chosen because it provides a reasonable estimation of baseflow.

No reliable, site specific background data exist for NH_3-N in the Crosses Run watershed. Therefore, an empirical value was used which is based on NH_3-N data collected at multiple reference stations within the Scioto River watershed.

Non-point Source Load
No actual data were available to quantify the non-point source (NPS) runoff flow. Therefore, it was calculated as follows:

$$Q_{NPS} = Q_{TMML} - Q_{WLA} - Q_{NL}$$

No data was available for the non-point loading within the Crosses Run sub-watershed. It was possible to calculate the concentration from what was known. Therefore, the NPS concentration was calculated:

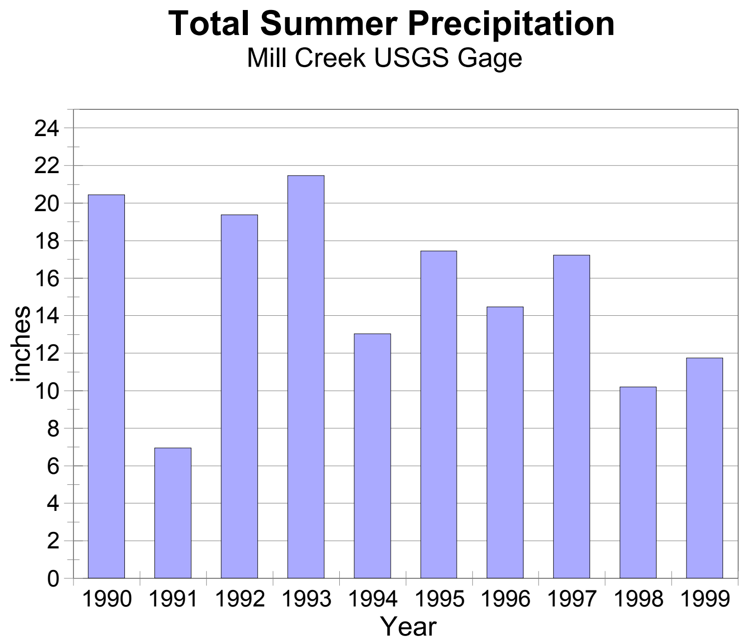
$$C_{LA} = (TMML - NL - WLA) / Q_{NPS}$$

3.3 Total Phosphorus: Chronic Condition
The Crosses Run enriched by phosphorus resulting from storm runoff. To determine a permissible load, the average flow in Crosses Run needed to be estimated for a typical summer period to meet the recommended target value. Therefore, a Total Maximum Summer Load (TMSL) was developed. Refer to Table C5 and C6 for specific values used for the TMSL.

Total Maximum Summer Load
Determination of the runoff flows used for the TMSL were estimated in a similar fashion as the chronic NH_3-N TMML. However, the 75^{th} percentile gage data for the remaining 8 year period of record, with the drought years eliminated, was taken for the entire four month summer period then yield adjusted to Crosses Run. This value (see table C6) represents an estimate of the total collection of runoff at the mouth of Crosses Run over a typical summer period.

The concentration used in the TMSL calculation was the target value from the “Associations” document (OEPA, 1999).

Point Source Load



Runoff flows for Scotts, as estimated by TR-55, represent a single rain event and are not reflective of runoff flows which may occur over a typical summer long period of time. A way to approximate this typical summer runoff flow was needed. Therefore, a precipitation ratio was calculated from rain data collected at the Mill Creek gage where a total average rainfall of 13.17 inches (which fell during the 4 month summer period of the 10 year period of record), was divided by the TR-55 predicted precipitation depth of 2.6 inches. This yielded a ratio of 5.7 but based on the typical wet weather runoff flows observed within the sub-watershed, this ratio would result in a greater amount of flow then what the total summer storms have shown to produce. Therefore, the ratio was reduced to 5.0 (which still over estimates the typical runoff condition, but the excess flow could be considered an implicit safety factor) and was used as a multiplier to adjust the hydrograph derived runoff volume from the TR-55 design storm of 549,818 ft^3 to the estimated summer runoff flow of 2,749,090 ft^3/summer.

The point source TP WLA used an assumed concentration of 1.0 mg/l because of a administrative decision that this value is as low as what is economically possible under current technology.

Background Load

For the natural background allocation, the same yield adjusted gage flow was used to estimate the typical summer runoff conditions. Similar to the background condition for NH_3-N, the 25th percentile range of the gage data was chosen.

No reliable, site specific background data exists for TP in the Crosses Run watershed. Therefore, an empirical value was used which is based on TP data collected at multiple reference stations within the Scioto River watershed (OEPA, 1988).

Non-point Source Load

The non-point source runoff flow is a calculated value,

where: $Q_{NPS} = Q_{TMSL} - Q_{WLA} - Q_{NL}$

There was no data available on the non-point loading within the Crosses Run sub-watershed. Consequently, the assumed value of 1.0 mg/l was used which is based on administrative decision regarding the current technological and economical unlikelihood of maintaining a lower concentration.

Part 4. The CONSWLA Model

4.1 Model Structure and Approach

The Conservative Substance Wasteload Allocation (CONSWLA) program was developed by the Ohio Environmental Protection Agency to predict the instream chemical concentration response by automating the allocation of conservative pollutants for multiple-discharger/multiple-stream systems. The CONSWLA model duplicates the hand written procedure by distributing the available assimilative capacity for each conservative among various discharges along the receiving stream according to defined set of proportioning factors. Proportioning factors are numeric values used to divide the available assimilative capacity among the discharges of the modeled system. For each discharge, the available capacity is multiplied by the ratio of that discharges proportioning factor. The result is the portion of the available load to which that discharge is entitled. This can produce local water quality criteria violations which then must be corrected by reducing the individual allocations. CONSWLA locates the critical point of the violation, the point instream below which the degree of violation decreases. The discharges upstream of this point would have contributed to the violation. CONSWLA then recalculates the allocations for all the discharge points upstream of the critical point based on the available capacity at that point. In this way all the discharge points that contributed to the violation share in the reduction. When allocations are reduced the meet the WQC, the relinquished capacity should be distributed among the other discharge points. After reallocating to these discharges above a critical point, CONSWLA fixes those discharges at their reduced allocations then subtracts the allocations from the available assimilative capacity. CONSWLA then restarts the allocation beginning with the distribution of the capacity. By excluding the fixed discharges (any unallocated flows into the system), the other discharges receive the relinquished capacity as part of the distribution. The new allocations are also checked for WQC violations and corrected by the same process. CONSWLA repeats this allocation loop until all the WQC are maintained.

CONSWLA can handle a wide range of stream/discharger situations and is expandable. The model is setup with the following limitations:

Table C7. CONSWLA model limitations.

Function	Minimum	Maximum
Stream Sections	1	20
Flow sources per section	2	17
Intakes per section[A]	0	1
Discharges per system	1	50
Fixed-Sources per system	0	50
Section levels per system[B]	1	4

[A] Maximum number of intakes per system is dependant on intake locations and the number of section levels.
[B] Smaller stream sections connected to the system.

4.2 Sources of Data

The Storm water runoff flows derived from the TR-55 model was used in CONSWLA for the discharge design flow. The stream flows are similarly derived from the TR-55 model and are used in the CONSWLA model as the upstream flow. This higher flow (relative to a summer low flow drought situation which is more typically associated with instream critical conditions) represents the high loading conditions that exist in the Crosses Run sub-watershed under these wet weather-driven situations and are also coupled with the high stream flow associated with these events. The upstream water quality used in the model were the average of all the ammonia samples taken from the North Branch upstream of the point sources. The Upstream water quality for phosphorus was a statewide value derived from reference sites and sited in the Association Document (OEPA Technical Bulletin, 1999). Table C-6 summaries the inputs used in the CONSWLA model.

Table C8. Summery of the CONSWLA Model Data and Results for Ammonia-N

Variable	Description	Units	Value
Upstream Flow	Flow in stream above the most upstream discharge point to be modeled. Based on TR-55 model design-storm derived runoff.	cubic feet per second (cfs)	NFCR: 86.6
			Crosses Run: 82
Discharge Flow	Flow from each of the Scotts Co. sub-catchment areas at their discharge point. Based on TR-55 model design-storm derived runoff.	Cubic Feet per Second (cfs)	*Area A (outfall 104)*: 40.8
			Area B (outfall 105): 27.5
			Area C (outfall 106): 69.8
			Area D (outfall 101): 14.1
			Area E (outfall 102) : 4.7
			Area F (outfall 103): 8.6
Upstream Water Quality	Instream concentration for each allocated substance above the most upstream discharge point in the receiving stream.	Milligrams per Liter (mg/l)	1.07 (NFCR)
			0.8 (Crosses Run)
Water Quality Criteria	Max. Instream criteria concentration as applicable to the receiving stream.	Milligrams per Liter (mg/l)	13 (NFCR)
			4.7 (Crosses Run)
Wasteload Allocation	The portion of the receiving water's loading capacity that is allocated to ammonia-N to ensure that the level of water quality to be achieved at this point source complies with the applicable WQC.	Milligrams per Liter (mg/l)	**8.53**

The CONSWLA model was developed to predict the instream results of conservative pollutants, such as heavy metals, which do not rapidly leave the water column. These substances are eventually removed through processes such as absorption, settling and chemical reaction but over a considerable time period. For this reason, conservative substances are generally assumed for allocation purposes to be affected only by dilution and in the case of the Scotts Company, NH_3-N is considered a conservative parameter. The large loading rates for this pollutant has a detrimental effect within the receiving stream and has an immediate toxic effect on the aquatic life during the critical wet weather periods. Due to the short instream travel times, little opportunity is available for these substances to be removed though natural processes. Therefore, they are assumed to be affected only by dilution.