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Applied Low Impact Development Design with the TSA TOOLS LID Module

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The TSA TOOLS LID Module is a software tool that presents a defined design process and computational methodology to facilitate the application of the Low Impact Development (LID) method of site and stormwater management design.

The TSA TOOLS LID Module builds on LID design techniques originally pioneered by Prince George's County, Maryland. LID continues to gain popularity throughout the United States. It integrates small scale site design and best management practice (BMP) techniques – also referred to as Integrated Management Practices (IMPs) throughout a site. The fundamental premise of LID is to attempt to duplicate a site's pre-development hydrologic characteristics, thus mitigating the loss of groundwater recharge, pollutants, and increased peak discharge rates resulting from impervious areas.

The LID Module provides site and stormwater designers with a simple, effective, and computationally supported tool to facilitate the application of LID.

Much has been published on the application of specific LID site design and BMP techniques. Therefore, the focus of the LID Module is limited to presenting a design process with supporting computational methods in a simple and efficient manner. The purpose of the LID Module is to provide design professionals with a software tool that will reduce time devoted to complex computations and iterations, thereby providing more time to focus on evaluating design alternatives and improving their final design product. A secondary goal is to provide clear, concise output with fully supported equations and references to improve report quality and to facilitate a fair and open review process.

The computational basis for the LID Module is from Urban Hydrology for Small Watersheds TR-55, published by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Conservation Engineering Division Technical Release 55, June 1986, referred to as TR-55. The design goal is to achieve no or minimal increases in peak discharge rates by a combination of impervious area disconnection and volume-based techniques.

INTERPRETATIONS

Several key interpretive elements are introduced with the LID Module that deviate or have not been identified in previous design and computational guidelines. Integrated Management Practices (IMPs) have been divided into two groups: those that have quantifiable storage and those that do not.

The IMPs that have no identifiable storage are considered disconnection practices. The application of these IMPs is computationally reflected by adjusting the Runoff Curve Numbers

(RCNs) per TR-55 criteria. However, TR-55 limits disconnection RCN reduction to sites with a maximum impervious area of 30%. The justification offered is that the pervious areas of more intensely developed sites will reach saturation so quickly that a RCN adjustment is not appropriate. Contemporary practice seems to suggest otherwise, as demonstrated by design manuals published by the Center for Watershed Protection (such as the 2000 Maryland Stormwater Design Manual) that provide unlimited credit for disconnected impervious areas. Therefore, to allow computational analysis of disconnection-based IMPs and to allow more contemporary practices, the LID Module applies the TR-55 numeric methodology without the 30% limit published in TR-55.

The effect of volume-based IMPs is computed and automatically reflected in the peak discharge rates with no reservoir or reach routing routines. This is accomplished using a formula originally developed by the Maryland Department of the Environment (MDE) to reflect the RCN reduction of infiltration practices. This formula is applied even though all of the volume based IMPs are not infiltration devices and will ultimately re-introduce treated runoff. The computational assumption is that these practices (such as bioretention, swales with check dams, etc.) will yield flow attenuation significant enough to have no discernable influence the overall peak discharge rates.

OVERALL FORMAT AND FEATURES

The LID Module is based on a Microsoft Excel and Visual Basic for Applications platform. This is generally a familiar interface that inherently reduces learning curves. The platform is user friendly with integrated design process navigation tools and online help. User input is limited to yellow cells. All other cells are protected and cannot be altered by unauthorized users. Data entry and output is organized into six separate worksheets.

All TSA TOOLS products are distributed in Trial Versions. The Trial Versions can be opened between 5 and 10 times to allow evaluation of the software prior to purchase. Trial Versions are fully functional, although they are not licensed for use on actual design projects. Once the Trial Version has expired, the program must be Registered (purchased) to continue unlimited use.

Each sheet has buttons to assist the designer in several ways. Clicking the Navigator button yields a pop-up dialogue box known as the Navigator. The Navigator has several buttons and brief instructional statements that illustrate the design and data input process. Clicking the buttons switches between sheets. The Navigator also shows the existing and proposed peak discharge rates that are instantly updated with data changes.

Likewise, each sheet has a Summary Data button, which yields a dialogue box showing hydrology, volume, and peak discharge rate results. The Summary Data can also be accessed from the Navigator.

Lastly, each sheet has a Help button that provides online step-by-step instructions.

SUMMARY SHEET

The LID Module opens to the Summary Sheet. Project and company information is entered, which is then automatically shown on all other sheets. Rainfall depths for various storm events are entered. Pull down list boxes are provided to select the intended design storm event and storm type for the project region. The design storm may be changed at any time by returning to this sheet. Once a design is complete, the LID Module allows a designer to evaluate the results of other storms instantly.

TSA Tools	LID MODULE	STUDY AREA:	1
LID Module Version 1.0	SUMMARY	Project #:	PN
	PROJECT:	Date:	Date
	Test project	Designer:	Design
		Checked:	Checked

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RAINFALL & DESIGN STORM DATA

Frequency	Rainfall Depth
1-Year	2.60 inches
2-Year	3.20 inches
10-Year	5.10 inches
25-Year	5.50 inches
50-Year	6.30 inches
100-Year	7.20 inches
Other	6.00 inches

DESIGN STORM: 1-Year

STORM TYPE: II

DESIGN RAINFALL DEPTH: 2.60 inches

SUMMARY DATA

	Existing	Initial Proposed	Proposed w/ Disconnects	Proposed w/ Disconnects & Volume
	Hydrology			
Area	3.000 ac	3.000 ac	3.000 ac	3.000 ac
RCN	**55**	64	59	**55**
T_C	**0.38 hrs**	0.38 hrs	0.38 hrs	**0.38 hrs**
	Volumes			
Runoff Depth	**0.10 inches**	0.30 inches	0.18 inches	**0.10 inches**
Runoff Volume	1106 cf	3213 cf	1955 cf	1105 cf

VOLUME REQUIRED	**849 cf**	VOLUME PROVIDED	**850 cf**

Peak Discharge Rates	**0.12 cfs**	0.48 cfs	0.22 cfs	**0.12 cfs**

This sheet also includes overall summary data information for reference and report purposes. The summary data is presented in four columns:

- Existing Conditions – reflects pre-development results for either wooded or grassed condition, as discussed further below.
- Initial Proposed – results that do not include any RCN adjustments for disconnection or volume provided.
- Proposed with disconnects – reflects the RCN reduction for disconnected impervious areas.
- Proposed with disconnects and volume – reflects results that include RCN reductions for by disconnected impervious areas and the volume provided in volume-based IMPs.

Presenting the data in this manner allows the designer to evaluate the effect of each type of IMP and allows very quick computational iterations to be performed in conjunction with site design alternatives.

In the event that the existing and proposed areas differ, a red flag appears to warn the user of the discrepancy.

EXISTING SITE CONDITIONS

Pull-down list boxes are provided to select the existing land use and unit of measure for input. Either woods (good hydrologic condition) or grass (meadow) can be used for the existing, or baseline, hydrologic conditions. Previous LID references have suggested the use of woods. Area data can be entered in either acres or square feet.

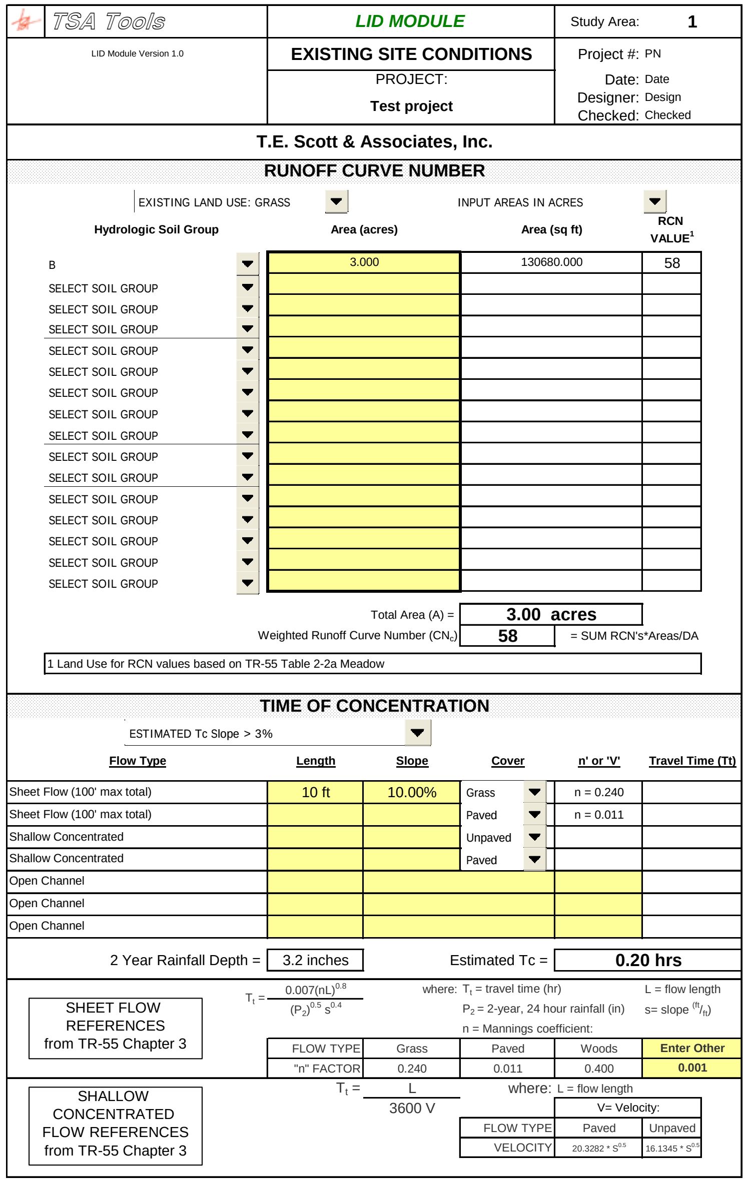
The Study Area to be evaluated may vary, depending upon site characteristics and municipal requirements. In some cases, the Study Area will be the entire site, including areas proposed to be disturbed and those not to be disturbed. In the event that separate natural drainage areas exist on a site, separate Study Areas to individual discharge points may be most appropriate.

The LID Module applies to a single Study Area, so separate files must be used for multiple drainage areas.

Area of hydrologic soil groups are entered in the Runoff Curve Number Section.

A pull down list box is provided to choose a method of performing time of concentration calculations. Time of concentration may be calculated in accordance with TR-55 calculations or estimated. Estimation is provided for convenience of quick “what-if” scenarios and is not recommended because time of concentration calculations can vary significantly based on specific site attributes. If estimates are used, the time is based on the slope of the sheet flow segment, with an assumed grass land use. Additional time is estimated for the balance of the flow path, although it will vary significantly from this estimate on small or large sites. An “Estimated Tc Info – Must Read” button is provided that yields a dialogue box with warnings and instructions.

If detailed computations method is selected, lengths and slopes for each segment are entered and all time calculations are automatically performed. Although only grass, woods and paved surface options are included for sheet flow, space is provided under “Enter Other” to allow user preferred input.



TSA Tools | LID MODULE | Study Area: 1

LID Module Version 1.0

EXISTING SITE CONDITIONS

PROJECT: Test project

Project #: PN
Date: Date
Designer: Design
Checked: Checked

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RUNOFF CURVE NUMBER

EXISTING LAND USE: GRASS — INPUT AREAS IN ACRES

Hydrologic Soil Group	Area (acres)	Area (sq ft)	RCN VALUE[1]
B	3.000	130680.000	58
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			
SELECT SOIL GROUP			

Total Area (A) = 3.00 acres

Weighted Runoff Curve Number (CN_c) 58 = SUM RCN's*Areas/DA

1 Land Use for RCN values based on TR-55 Table 2-2a Meadow

TIME OF CONCENTRATION

ESTIMATED Tc Slope > 3%

Flow Type	Length	Slope	Cover	n' or 'V'	Travel Time (Tt)
Sheet Flow (100' max total)	10 ft	10.00%	Grass	n = 0.240	
Sheet Flow (100' max total)			Paved	n = 0.011	
Shallow Concentrated			Unpaved		
Shallow Concentrated			Paved		
Open Channel					
Open Channel					
Open Channel					

2 Year Rainfall Depth = 3.2 inches — Estimated Tc = 0.20 hrs

SHEET FLOW REFERENCES from TR-55 Chapter 3

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

where: T_t = travel time (hr); L = flow length; P_2 = 2-year, 24 hour rainfall (in); s= slope ($^{ft}/_{ft}$); n = Mannings coefficient:

FLOW TYPE	Grass	Paved	Woods	Enter Other
"n" FACTOR	0.240	0.011	0.400	0.001

SHALLOW CONCENTRATED FLOW REFERENCES from TR-55 Chapter 3

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

where: L = flow length; V= Velocity:

FLOW TYPE	Paved	Unpaved
VELOCITY	$20.3282 * S^{0.5}$	$16.1345 * S^{0.5}$

PROPOSED SITE CONDITIONS

As with existing conditions, pull-down list boxes are provided to select the unit of measure for input. Likewise, pull-down list boxes are provided to select hydrologic soils groups and proposed conditions land uses and/or integrated management practices (IMPs). The proposed land uses and IMPs available are discussed below:

- Connected impervious area – any impervious area that is conveyed directly to receiving waters by an efficient drainage system, most often an enclosed storm drain system.
- Disconnected impervious area – any impervious area that is not directly connected to a drainage system, as discussed above. THIS LAND USE IS FOR DISCONNECTED

IMPERVIOUS AREAS THAT DO NOT APPLY TO THE BELOW IMPS. Enter only the impervious area that is disconnected.

- IMP - Impervious to filter strips - bands of dense vegetation planted downstream of a runoff source. Input the impervious area that contributes to the filter strip.
- IMP - Impervious to grass swales – grass swales are shallow grass-covered hydraulic conveyances that help to slow runoff and facilitate infiltration. In this case, these are free flowing swales with no direct means of capturing or storing runoff volumes (such as check dams). Enter the impervious area that contributes to the swale.
- IMP - Permeable surfaces (no storage) – grass pavers, integrated block systems, porous paving systems, etc. with NO discernable storage volume specified. If storage is proposed – such as gravel voids beneath porous paving, it should be entered as a volume-based IMP on the Volume Provided Sheet. Enter the total area of the permeable surface.
- IMP - Impervious area to vegetated buffer - Buffer areas along natural resource areas such as wetlands or floodplains that trap and filter sediments, nutrients, and chemicals from surface runoff and shallow groundwater. Enter impervious area that discharges to the buffer in sheet flow.
- IMP – Green roof –Green roofs are structural components that help to mitigate the effects of urbanization on water quality by filtering, absorbing or detaining rainfall through vegetation and shallow, lightweight growing medium. Enter the area of the proposed green roof. An Open Space (Grass) land use will be applied.
- Grass – any grassed or landscaped area
- Woods, good condition – any wooded area, typically existing woods to be preserved.
- IMP – Grass w/ soil amendments - Soil amendments, which include organic soil conditioners and fertilizers, make the soil more suitable for the growth of plants and increase water retention capabilities. When this IMP is

TSA Tools	LID MODULE	Study Area: 1
LID Module Version 1.0	PROPOSED SITE CONDITIONS	Project #: PN
	PROJECT: Test project	Date: Date Designer: Design Checked: Checked

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RUNOFF CURVE NUMBER

INPUT AREAS IN ACRES — Page 1 of 2

PROPOSED Land Use or Intergrated Management Practice	Hydrologic Soil Group	Area (acres)	Area (sq ft)	IMPERVIOUS Area[1]	RCN VALUE[2]
DISCONNECTED Impervious	B	0.60	26136.00	0.60 ac.	98
Woods, Good Condition	B	2.40	104544.00		55
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
SELECT LAND USE	NO ENTRY				
IMP - Green Roof	D				

Total Area (A) = 3.000 acres
Impervious Area (A_i) = 0.600 acres
% IMPERVIOUS (I) = 20.00 — $I = A_i / A$
Weighted Runoff Curve Number (RCN) 64 — = SUM RCN's*Areas/DA

[1] Impervious Areas from TR-55 Table 2-2a "Average percent impervious areas"
[2] RCN Values from TR-55 Table 2-2a - Impervious areas to Filter Strips, Grass Swales, Vegetated Buffers, Permeable Pavers, & Green Roofs considered Disconnected Impervious Area

IMPERVIOUS & PERVIOUS AREA SUMMARY

IMPERVIOUS AREA SUMMARY

HYDROLOGIC SOIL GROUP	A	B	C	D	TOTAL
CONNECTED IMPERVIOUS AREA					
UNCONNECTED IMPERVIOUS AREA		0.600 acres			0.600 acres

RATIO OF UNCONNECTED TO TOTAL IMPERVIOUS AREA (R) = 1.000

PERVIOUS AREA SUMMARY

HYDROLOGIC SOIL GROUP	A	B	C	D
GRASS				
Woods, Good Condition		2.400 acres		

WEIGHTED PERVIOUS RCN (CN_p) = 55.00

RCN REDUCTION FOR IMPERVIOUS DISCONNECTION

Page 2 of 2

Disconnection RCN reduction methodology from TR-55 Chapter 2
Except RCN Reduction allowed for any Impervious Area %

$CN_c = CN_p+(P_{imp}/100)*(1-0.5R)$

where: CN_p = 55.00
R = 1.000
P_{imp} = 20.00

CN_c = 59.30

USE 59

selected, the entire vegetated area to be treated is included and the hydrologic soil group from published soil survey data should be adjusted to the next group (ie, D adjusted to C, C adjusted to B, B adjusted to A).

Computationally, all of the above IMPs are considered disconnected impervious areas. If supporting information exists than can quantify a volume provided by any of these IMPs, the designer should enter them on the Volume Provided sheet instead of in the Land Use data.

Next a summary of pervious and impervious areas is provided to support the following RCN Reduction calculations for disconnected impervious areas. The RCN Reduction calculations are from TR-55:

$$CN_c = CN_p+(P_{imp}/100)*(1-0.5R)$$

where:

CN_c= RCN adjusted for impervious disconnection
CN_p = weighted pervious RCN
P_{imp} = proposed impervious area (%)
R = ratio of unconnected to total impervious area

The LID Module places no limit on the imperviousness of the site for this reduction. TR-55 limits its use to sites that are less than 30% impervious "because the absorptive capacity of the remaining pervious areas will not significantly affect runoff." Contemporary practice does not seem to adhere to this criteria. In fact, disconnected impervious areas can even be considered to be woods - with no impervious area restrictions - in some states, such as Maryland. It seems reasonable to deviate from published guidance, especially considering the evolution of stormwater management practice toward more micro-scale practices that were not recognized when the latest version of the TR-55 manual was authored.

Proposed time of concentration data is then entered. The existing time is shown for reference purposes, as the design should strive to meet that time in the proposed conditions.

As with existing conditions, a pull down list box is provided to choose a method of performing time of concentration calculations. Time of concentration may be calculated in accordance with TR-55 calculations or estimated. Estimation is provided for convenience of quick "what-if" scenarios and is not recommended because time of concentration calculations can vary significantly based on specific site attributes. If estimates are used, the time is based on the assumed change in drainage characteristics from existing conditions. An "Estimated Tc Info – Must Read" button is provided that yields a dialogue box with warnings and instructions.

If detailed computations method is selected, lengths and slopes for each segment are entered and all time calculations are automatically performed. Although only grass, woods and paved surface options are included for sheet flow, space is provided under "Enter Other" to allow user preferred input.

VOLUME REQUIREMENTS

This sheet is provided for reference and computational support only, as no user input is required. Runoff volumes are computed for existing and proposed conditions in accordance with TR-55 methodology:

$$Q_a = (P-I_a)2/(P-I_a)+(^{1000}/_{RCN})-10$$

where:

Q_a = runoff depth (watershed inches)
P = rainfall depth
I_a = Initial Abstraction (200/RCN)-2
RCN = runoff curve number adjusted for impervious area disconnection (CN_c)

The resulting Distributed Storage Required is simply the difference between the existing and proposed runoff volumes for the site.

It is important to note that one of the principles of LID methodology is to distribute storage throughout a site. Therefore, even though the required volume could possibly be provided in a few facilities, the location of IMPs and distribution of storage volumes must be throughout the site, with an emphasis on areas with more pervious soil characteristics.

In the Distributed Storage Required section, the depth of IMPs can be selected to determine the required area for IMPs distributed throughout the site.

TSA Tools	LID MODULE	Study Area: 1
LID Module Version 1.0	VOLUME REQUIREMENTS	Project #: PN
	PROJECT: Test project	Date: Date Designer: Design Checked: Checked

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STORM EVENT

Design Storm:	100-Year	Rainfall Depth (P) =	7.20 inches

EXISTING RUNOFF VOLUMES

RCN =	58	from Existing Conditions Input
Initial Abstraction (I_a) =	1.45 inches	I_a = (200 / RCN)-2
Runoff Depth (Q_a) =	2.55 inches 0.212 feet	$Q_a = (P-I_a)^2/(P-I_a)+(1000/RCN)-10$
Site Area (A) =	3.000 acres	
Runoff Volume Q_{EXIST} =	**0.637 ac/ft** **27728 cf**	$Q_{EXIST} = A*Q_a$

PROPOSED RUNOFF VOLUMES

RCN =	59	from RCN Reduction Calculations
Initial Abstraction (I_a) =	1.39 inches	I_a = (200 / RCN)-2
Runoff Depth (Q_a) =	2.65 inches 0.220 feet	$Q_a = (P-I_a)^2/(P-I_a)+(1000/RCN)-10$
Site Area (A) =	3.000 acres	
Runoff Volume Q_{PROP} =	**0.661 ac/ft** **28812 cf**	$Q_{PROP} = A*Q_a$

DISTRIBUTED STORAGE REQUIRED

Q_{EXIST} =	0.637 ac/ft	
Q_{PROP} =	0.661 ac/ft	
Storage Volume Required (V_S) =	**0.025 ac/ft** **1085 cf**	$V_S = Q_{PROP}-Q_{EXIST}$
Average IMP Depth (D):	12 Inches	
Required IMP Area distributed over site =	**1085 sf** **0.025 ac**	V_S * D

VOLUME PROVIDED

The volumes of up to twenty volume-based IMPs may be entered to satisfy the volume requirements. Pull-down list boxes are provided that list the volume-based IMPs. Selection of a particular IMP is for reference purposes only and does not affect calculations. Other IMP or BMP types may be added to the pull-down by clicking the "Add IMP" button. Volume calculations must be performed separately, and then entered in the provided cells. A field for comment is provided.

Volumes are totaled and a red flag indicates if volume requirements have been met for the selected design storm event.
Methodology for adjusting the RCN to account for the provided storage is taken from "Modeling Infiltration Practices Using TR-20", published by the Maryland Department of the Environment in October, 1983:

TSA Tools	LID MODULE	Study Area: 1
LID Module Version 1.0	VOLUME PROVIDED PROJECT: Test project	Project #: PN Date: Date Designer: Design Checked: Checked

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DISTRIBUTED STORAGE REQUIRED

Storage Volume Required (VS) = **0.025 ac/ft** / **1085 cf**

IMP VOLUMES PROVIDED

IMP	IMP TYPE	Volume Provided	Comment
1	Bioretention		
2	Select IMP Type		
3	Select IMP Type		
4	Select IMP Type		
5	Select IMP Type		
6	Select IMP Type		
7	Select IMP Type		
8	Select IMP Type		
9	Select IMP Type		
10	Select IMP Type		
11	Select IMP Type		
12	Select IMP Type		
13	Select IMP Type		
14	Select IMP Type		
15	Select IMP Type		
16	Select IMP Type		
17	Select IMP Type		
18	Select IMP Type		
19	Select IMP Type		
20	Select IMP Type		

Total Volume Provided (V_P)=

ADDITIONAL VOLUME OR SUPPLEMENTAL MEASURES MAY BE REQUIRED

Remaining Volume Required = **1085 cf**

RCN ADUSTMENT WITH VOLUME PROVIDED

$$\text{Adjusted RCN} = \frac{200}{(P+2Q+2)-(5PQ+4Q^2)^{.5}}$$

from: "Modeling Infiltration Practices Using TR-20", October, 1983 Maryland Department of the Environment

where: P = Rainfall Depth
Q = Runoff Depth - Volume Provided

P = 7.20 inches
Q = 2.65 inches
Runoff Depth = 2.65 inches
Site Area (A) = 3.000 acres
Volume Provided (Watershed Inches) = $=V_P/A$

Adjusted RCN = 59

$$\text{Final Adjusted RCN} = \frac{200}{(P+2Q+2)-(5PQ+4Q^2)^{.5}}$$

This formula was originally developed by the Maryland Department of the Environment (MDE) to reflect the RCN reduction of infiltration practices. It is applied even though all of the volume-based IMPs are not infiltration devices and many will ultimately re-introduce treated runoff, which has the potential of contributing to the peak discharge rates. The computational assumption is that these practices (such as bioretention, swales with check dams, rain barrels, etc.) will yield flow attenuation significant enough to have no discernable affect the overall peak discharge rates of the site.

The accuracy of results when applying this methodology is contingent upon:

- Designing IMP's with adequate storage for the intended design storm and drainage area contributing the that IMP

- Distribution of the IMPs throughout the site
- Treatment of all impervious areas not disconnected or adequately treated with disconnection-based IMPs

PEAK DISCHARGE RATES

Detailed data and computations references for peak discharge rate computations are provided for comparative and review purposes for the selected design storm. Formulae are from TR-55 Chapter 4, Graphical Peak Discharge Method. Data for four different conditions or scenarios is provided:

- Existing conditions – Existing RCN and time of concentration as inputted. The resulting value is shown on the Navigator.
- Proposed conditions, No Disconnection or Volume Provided – Provides a traditional direct comparison between existing and proposed conditions with no adjustment to the proposed conditions RCN.
- Proposed conditions, With Disconnection No Volume Provided – Reflects the proposed RCN being adjusted for the disconnection of impervious areas and disconnection-based IMPs.
- Proposed conditions, With Disconnection and Volume Provided – Reflects the disconnection RCN adjustment and the final RCN adjustment for volume provided as discussed above. This is the proposed volume shown on the Navigator.

TSA Tools | **LID MODULE** | Study Area: **1**

LID Module Version 1.0

PEAK DISCHARGE RATES

PROJECT: **Test project**

Project #: PN
Date: Date
Designer: Design
Checked: Checked

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STORM EVENT

Design Storm: 100-Year   Rainfall Depth (P) = 7.20 inches

PEAK DISCHARGE RATES

Type II Storm	Existing Conditions	Proposed Conditions: No Disconnection or Volume Provided	Proposed Conditions: With Disconnection No Volume Provided	Proposed Conditions: With Disconnection and Volume Provided	Formula References
Area (A) =	3.000 ac	3.000 ac	3.000 ac	3.000 ac	
RCN =	58	64	59	59	
Time of Concentration =	0.12 hrs	0.12 hrs	0.12 hrs	0.12 hrs	
Rainfall Depth (P) =	7.20 inches	7.20 inches	7.20 inches	7.20 inches	
Initial Abstraction (I_a) =	1.45 inches	1.14 inches	1.39 inches	1.39 inches	1
I_a / P =	0.20 inches	0.16 inches	0.19 inches	0.19 inches	2
Runoff Depth (Q_a) =	2.55 inches	3.11 inches	2.65 inches	2.65 inches	3
Unit Peak Discharge (q_u) =	899 csm/in	917 csm/in	902 csm/in	902 csm/in	4
Peak Discharge Rate (Q) (cfs) =	**10.72 cfs**	**13.39 cfs**	**11.19 cfs**	**11.19 cfs**	5

FORMULA REFERENCES

All references from TR-55 Chapter 4, Graphical Peak Discharge Method

Reference	Formula
1	$I_a = (200 / RCN)-2$
2	Ia/P
3	$Q_a = (P-I_a)^2/(P-I_a)+(1000/RCN)-10$
4	from TR-55 Exhibit 4-11 Equations
5	$Q = q_u(A/640)Q_a$

CONCLUSION

Although the practice of Low Impact Development has been gaining popularity throughout the United States with research and regulation oriented organizations, the mainstream land planning, landscape architecture, and civil engineering community has been hesitant to fully embrace it.

The lack of an efficient design-based methodology and automated tools have – in part – prevented or delayed these practitioners from integrating LID into their daily practice.

The TSA TOOLS LID Module responds to this need by helping designers understand the goals and effects of LID. The LID Module can be used to efficiently apply LID methodology and techniques to a wide range of projects – from low density residential to infill or ultra-urban re-development - in a manner that can be computationally supported, referenced, and fairly reviewed.

BIO

Theodore E. Scott, PE, CPESC, LEED AP has over 20 years experience in site and stormwater management design and is the owner of T.E. Scott & Associates, Inc. (www.mdswm.com). His experience with most aspects of land improvement design coupled with specialization in stormwater management provides unique insight into the current trends in stormwater management design, maintenance, and construction. He is also the owner of Stormwater Maintenance, LLC (www.swmaintenance.com), a construction firm dedicated to maintaining, repairing, and constructing stormwater management systems. Mr. Scott's firms provide services throughout the Mid-Atlantic with clients ranging from small "Mom & Pop" businesses to Fortune 50 Corporations.