EPA SWMM5 for Novice/Advanced Users
EWRI2025 Pre-Conference Workshop, May 17, 2025 (Anchorage AK)

Exercise 3-3: Investigate LID Improvements

This is the third in a series of exercises that addresses flooding due to redevelopment within a residential neighborhood. This exercise uses the U.S. Environmental Protection Agency's Storm Water Management Model (SWMM5, 64-bit version of build 5.2.4) and is in U.S. customary units. It is assumed that you are sufficiently familiar with the SWMM5 user interface, so that only the key commands and input values are highlighted in bold.

This exercise set is intended to build skills in working with a neighborhood-scale pipe network model, comprised of the following exercises:

- ANC3-1: Update an existing system model to account for new development;
- ANC3-2: Investigate conveyance improvements; and
- ANC3-3: Investigate LID improvements.

Key Learning Objectives

1. Identify alternative Low Impact Development (LID) controls in a capital improvement project.
2. Optimize proposed capital projects to provide the desired level of service for stormwater management.

---

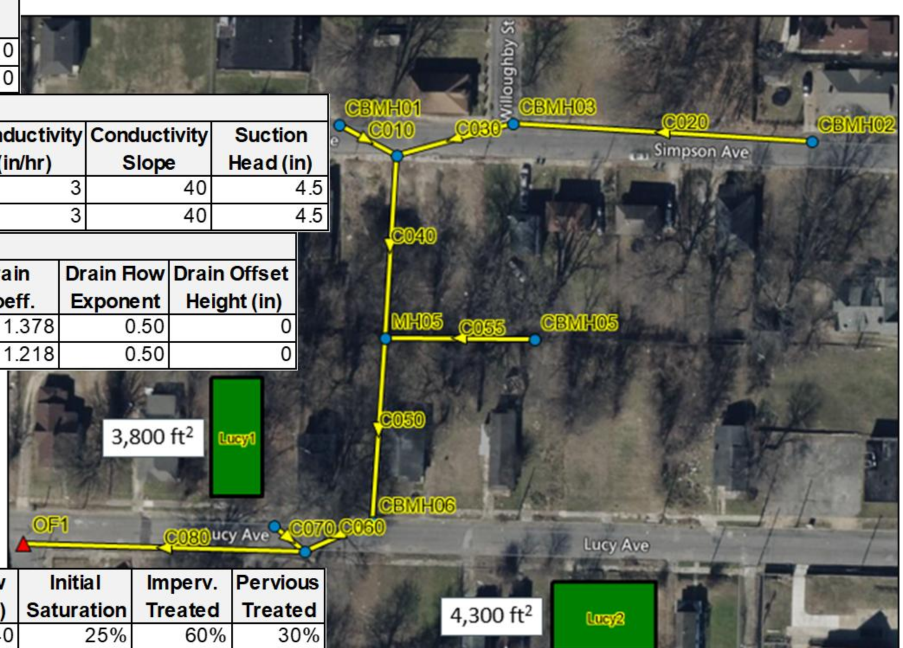
1 Set Up and Evaluate Option A: Bioretention

In this exercise, a series of green infrastructure improvements (referred to as LID controls in SWMM5) are represented throughout the study area. The first option reflects two bioretention cells, with sizes and layout shown below along with the various design parameters.

	Surface Layer			
LID Control	Berm Height (in)	Veg. Volume (fraction)	Roughness Factor	Slope (%)
Lucy1	12	0.1	0	0
Lucy2	12	0.1	0	0

	Soil Layer						
LID Control	Thickness (in)	Porosity (fraction)	Field Capacity	Wilting Point	Conductivity (in/hr)	Conductivity Slope	Suction Head (in)
Lucy1	24	0.42	0.18	0.07	3	40	4.5
Lucy2	24	0.42	0.18	0.07	3	40	4.5

	Storage Layer						
LID Control	Thickness (in)	Void Ratio	Seepage (in/hr)	Clogging Factor	Drain Coeff.	Drain Flow Exponent	Drain Offset Height (in)
Lucy1	24	0.35	0	0	1.378	0.50	0
Lucy2	24	0.35	0	0	1.218	0.50	0



Subcatchment	LID Control	Subcatch. Area (ac)	Footprint Area (sf)	Overflow Width (ft)	Initial Saturation	Imperv. Treated	Pervious Treated
S07	Lucy1	1.0165	3,800	40	25%	60%	30%
S08	Lucy2	1.3674	4,300	80	25%	50%	10%

In a real-world application, proposed facilities that are not located on municipally-owned land could be part of a public–private partnership agreement. Otherwise, the City would need to consider the additional cost of land acquisition in the corresponding cost-benefit analysis.

1-1 **Unzip** the contents of the file "**ANC3-1_Uncontrolled_SW52.zip**" into an empty folder and **launch SWMM 5.2** (executable file "epaswmm5.exe", version 5.2.4, 64-bit edition, downloaded from the EPA website at https://www.epa.gov/water-research/storm-water-management-model-swmm).

1-2 **Open** the project "**ANC3-1_Uncontrolled.inp**" in SWMM 5.2 and **Run** the simulation.

1-3 **Save** the current project and then **Save As "ANC3-3_Alt2A-Bioretention.inp"**. In the Title/Notes Editor, change the scenario description to read "Scenario: Future land use conditions + **Proposed** stormwater management system **(green infrastructure improvements)**", and then **OK**.

1-4 In **Microsoft Excel**, open the spreadsheet "**ANC3-3_LID-Alternatives.xlsx**". Review the LID Control and LID Usage parameters in the **"Bioretention" worksheet**. Except for the underdrain flow coefficient (which is a function of the LID footprint area), the Lucy1 and Lucy2 controls have the same LID Control parameters (i.e., they have the same vertical profile and use the same porous media in the Soil and Surface layers). These parameters are illustrative of typical LID installations. The tables in Chapter 6 of the SWMM Reference Manual Volume III - Water Quality are helpful for use in real-world design applications. Note the LID Usage parameters depend on the footprint, orientation, and characteristics of the subcatchment in which the LID controls are located. The only common parameter is the initial degree of saturation (and note a value of 25% initial saturation is used since a single design storm event is to be simulated). Note that all of the parameters have been formatted for direct use in the SWMM5 input file, in columns U-AE of the worksheet.

1-5 **Save** the current project and then **exit SWMM 5.2** (select File | Exit from the Main Menu) and keep the Excel spreadsheet open.

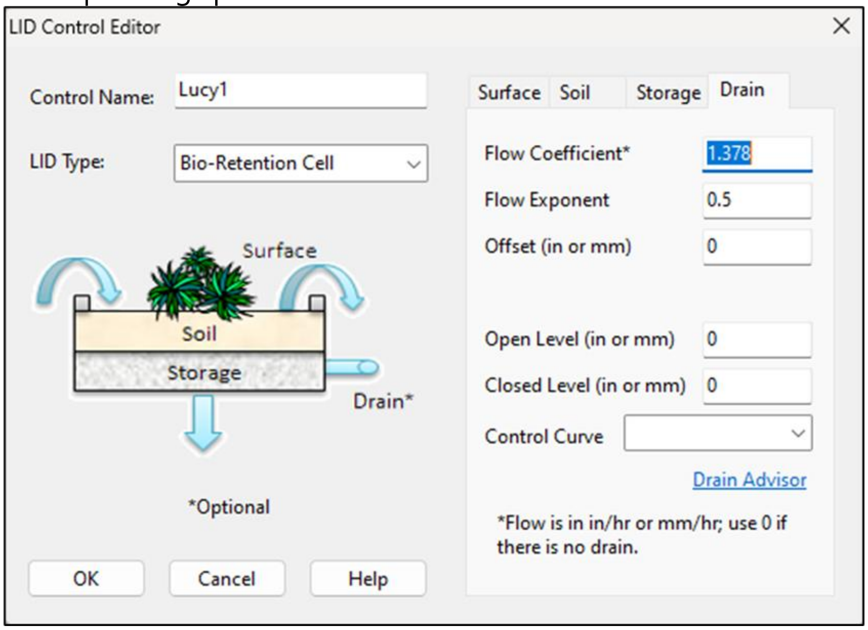
1-6 In **Notepad** (or another text editor), **open the input file "ANC3-3_Alt2A-Bioretention.inp"**. In Excel, **copy the range of cells U3:AE19** to the clipboard (CTRL +C). In the text editor, place the cursor at the end (bottom) of the file, and **paste the clipboard contents** (CTRL +V) into the input file. **Save the input file** and **close** the text editor.

```
ANC3-3_Alt2A-Bioretention.inp
File   Edit   View
[SYMBOLS]
;;Gage           X-Coord            Y-Coord
;;-------------- ------------------ ------------------

[LID_CONTROLS]
;;Name  Type/Layer      Parameters
Lucy1   BC
Lucy1   SURFACE 12      0.1     0       0       0
Lucy1   SOIL    24      0.42    0.18    0.07    3       40      4.5
Lucy1   STORAGE 24      0.35    0       0       NO
Lucy1   DRAIN   1.378   0.5     0       0       0       0
Lucy2   BC
Lucy2   SURFACE 12      0.1     0       0       0
Lucy2   SOIL    24      0.42    0.18    0.07    3       40      4.5
Lucy2   STORAGE 24      0.35    0       0       NO
Lucy2   DRAIN   1.218   0.5     0       0       0       0

[LID_USAGE]
;;Subcatchment  LID Process     Number  Area    Width   InitSat FromImp ToPerv  RptFile DrainTo FromPerv
S07     Lucy1   1       3800    40      25      60      0       *       *       30
S08     Lucy2   1       4300    80      25      50      0       *       *       10
```

1-7 **Open** the project "**ANC3-3_Alt2A-Bioretention.inp**" in SWMM 5.2. **Select LID Controls** (under Hydrology in the Project panel) and confirm the values in the LID Control Editor match the corresponding spreadsheet entries.



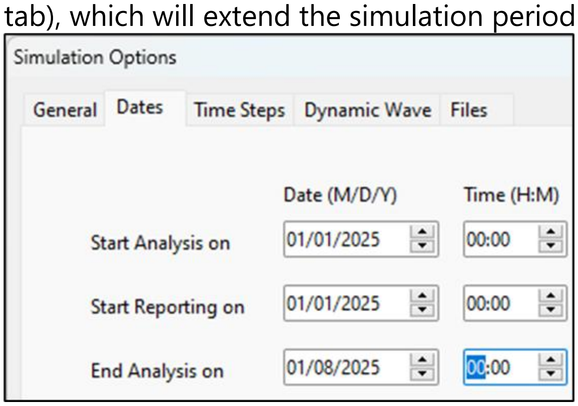
1-8 The LID Usage Editor can be accessed through the subcatchment attributes. **Select subcatchment S07** (or S08, these are the only two subcatchments that have LID controls in them) and **click the ellipsis** beside the LID Controls property, **select Edit** button for the LID control and confirm the values in the LID Usage Editor match the corresponding spreadsheet entries.

1-9 **Run** the simulation and review the **LID Performance** summary table (select Report | Summary from the Main Menu, and then select LID Performance from the drop-down list). The Final Storage value is 7.5 inches for both LID controls and this is much higher than the Initial Storage value of 5.3 inches. It is good practice to adjust the simulation parameters so that these quantities are the same, this is especially critical when doing a water budget analysis. Extending the simulation period will usually be sufficient to reduce the final storage.

Topic: LID Performance — Click a column header to sort the column.

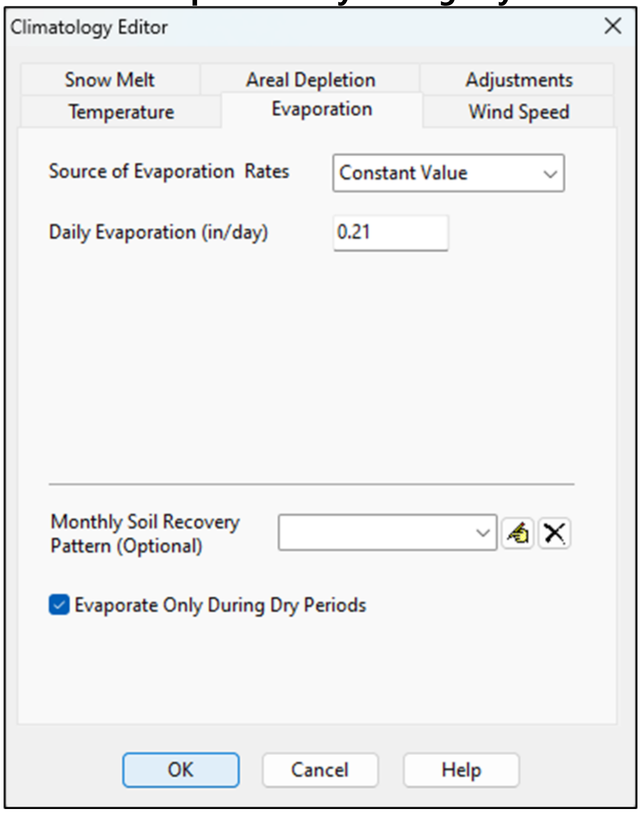
Subcatchment	LID Control	Total Inflow in	Evap Loss in	Infil Loss in	Surface Outflow in	Drain Outflow in	Initial Storage in	Final Storage in	Continuity Error %
S07	Lucy1	23.55	0.00	0.00	0.00	21.37	5.34	7.53	-0.02
S08	Lucy2	22.61	0.00	0.00	0.00	20.41	5.34	7.54	-0.01

1-10 Change the **simulation end date to 00:00 on 01/08/2025** (under Simulation Options in the Dates tab), which will extend the simulation period to one week.



1-11 **Run** the simulation and review the **LID Performance** summary table. Note that the Final Storage values in the LID Performance Summary table are now 6.1 inches. While some more of the captured runoff in the LID has been discharged through the underdrain, there is still a significant amount of water in the soil layer. Evaporation is typically zeroed out for design storm simulations. However in this case, evaporation needs to be accounted when running the simulation for an extended period after the rain.

1-12 Change the **evaporation rate to 0.21 in/day** (in the Evaporation tab of the Climatology editor) and **check the Evaporate Only During Dry Periods** box.



1-13 **Run** the simulation and note that the Final Storage values in the LID Performance Summary table are now 5.4 inches, which closely matches the Initial Storage values. Note also that the bioretention cells only reduce flooding at the downstream end of the system, as the Node Flooding Summary table shows that flooding at CBMH02 and CBMH03 persists.

Topic: LID Performance   Click a column header to sort the column.

Subcatchment	LID Control	Total Inflow in	Evap Loss in	Infil Loss in	Surface Outflow in	Drain Outflow in	Initial Storage in	Final Storage in	Continuity Error %
S07	Lucy1	23.53	1.25	0.00	0.00	22.25	5.34	5.37	-0.01
S08	Lucy2	22.57	1.25	0.00	0.00	21.29	5.34	5.38	-0.01

Topic: Node Flooding   Click a column header to sort the column.

Node	Hours Flooded	Maximum Rate CFS	Day of Maximum Flooding	Hour of Maximum Flooding	Total Flood Volume 10^6 gal	Maximum Ponded Depth Feet
CBMH02	0.01	1.27	0	11:52	0.000	0.000
CBMH03	0.14	5.74	0	11:54	0.011	0.000

With only modest reductions in peak flow and total volume, further interventions will be necessary.

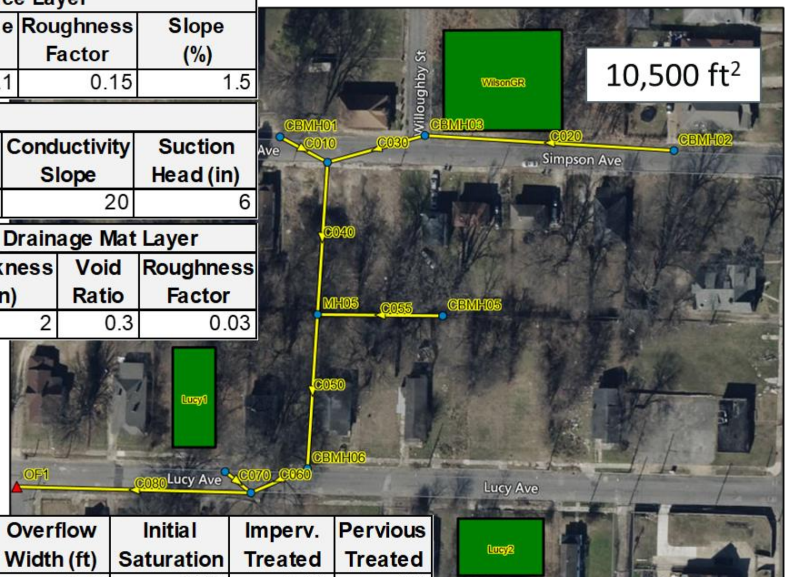
2 Set Up and Evaluate Option B: Bioretention and Green Roof

In this scenario, a green roof will be added to the main building of the new development in subcatchment S03. The size and layout are shown below along with the various design parameters.

LID Control	Surface Layer: Berm Height (in)	Veg. Volume (fraction)	Roughness Factor	Slope (%)
WilsonGR	3	0.1	0.15	1.5

LID Control	Soil Layer: Thickness (in)	Porosity (fraction)	Field Capacity	Wilting Point	Conductivity (in/hr)	Conductivity Slope	Suction Head (in)
WilsonGR	4	0.63	0.21	0.12	3.6	20	6

LID Control	Drainage Mat Layer: Thickness (in)	Void Ratio	Roughness Factor
WilsonGR	2	0.3	0.03



Subcatch-ment	LID Control	Subcatch. Area (ac)	Footprint Area (sf)	Overflow Width (ft)	Initial Saturation	Imperv. Treated	Pervious Treated
S03	WilsonGR	1.3011	10,500	210	25%	34%	0%

2-1 **Save** the current project and then **Save As "ANC3-3_Alt2B-BCandGR.inp"**.

2-2 In **Microsoft Excel**, open the spreadsheet "**ANC3-3_LID-Alternatives.xlsx**". Review the LID Control and LID Usage parameters in the **"GreenRoof" worksheet**. Parameters have also been formatted for direct use in the SWMM5 input file, in columns R-AB. The green roof takes up most of the building rooftop, a footprint area of 10,500 sq.ft. Such a large footprint is not a typical installation for small institutional buildings like this example.

2-3 **Save** the current project, **exit SWMM 5.2**, and keep the Excel spreadsheet open.

2-4 In **Notepad** (or another text editor), **open the input file "ANC3-3_Alt2B-BCandGR.inp"**. In Excel, **copy the range of cells R5:Z8** to the clipboard (CTRL +C). In the text editor, **paste the clipboard contents** (CTRL +V) in the **[LID-CONTROLS] section** of the input file, after the set of Lucy2 LID Control parameters (line 117 or so, see screenshot next page).

2-5 In Excel, **copy the range of cells R12:AB12** to the clipboard (CTRL +C). In the text editor, **paste the clipboard contents** (CTRL +V) in the **[LID-USAGE] section** of the input file, after the set of Lucy2 LID Usage parameters (see screenshot next page). **Save the input file** and **close** the text editor.

2-6 **Open** the project "**ANC3-3_Alt2B-BCandGR.inp**" in SWMM 5.2. Confirm the values in the LID Control Editor and LID Usage Editor match the corresponding spreadsheet entries.

2-7 **Run** the simulation and review the LID Performance and Node Flooding Summary tables.

Although the addition of the large green roof reduces the flooding rate and more than half the flooding volume at CBMH03, node flooding persists. Again, further interventions will be necessary.

```
ANC3-3_Alt2B-BCandGR.inp
File   Edit   View
[LID_CONTROLS]
;;Name           Type/Layer Parameters
;;-------------- ---------- ----------
Lucy1            BC
Lucy1            SURFACE    12         0.1        0          0          0
Lucy1            SOIL       24         0.42       0.18       0.07       3          40         4.5
Lucy1            STORAGE    24         0.35       0          0          NO
Lucy1            DRAIN      1.378      0.5        0          0          0          0

Lucy2            BC
Lucy2            SURFACE    12         0.1        0          0          0
Lucy2            SOIL       24         0.42       0.18       0.07       3          40         4.5
Lucy2            STORAGE    24         0.35       0          0          NO
Lucy2            DRAIN      1.218      0.5        0          0          0          0

WilsonGR        GR
WilsonGR        SURFACE 3       0.1     0.15    1.5     0
WilsonGR        SOIL    4       0.63    0.21    0.12    3.6     20      6
WilsonGR        DRAINMAT        2       0.3     0.03

[LID_USAGE]
;;Subcatchment   LID Process      Number  Area       Width      InitSat    FromImp    ToPerv     RptFile DrainTo FromPerv
;;-------------- ---------------- ------- ---------- ---------- ---------- ---------- ---------- ------- ------- --------
S07              Lucy1            1       3800       40         25         60         0          *       *       30
S08              Lucy2            1       4300       80         25         50         0          *       *       10
S03     WilsonGR        1       10500   210     25      34      0       *       *       0
```

Summary Results

Topic: LID Performance   Click a column header to sort the column.

Subcatchment	LID Control	Total Inflow in	Evap Loss in	Infil Loss in	Surface Outflow in	Drain Outflow in	Initial Storage in	Final Storage in	Continuity Error %
S03	WilsonGR	10.09	0.83	0.00	0.00	9.92	1.14	0.48	-0.03
S07	Lucy1	23.53	1.25	0.00	0.00	22.25	5.34	5.37	-0.01
S08	Lucy2	22.57	1.25	0.00	0.00	21.29	5.34	5.38	-0.01

Summary Results

Topic: Node Flooding   Click a column header to sort the column.

Node	Hours Flooded	Maximum Rate CFS	Day of Maximum Flooding	Hour of Maximum Flooding	Total Flood Volume 10^6 gal	Maximum Ponded Depth Feet
CBMH02	0.01	0.44	0	11:52	0.000	0.000
CBMH03	0.11	3.88	0	11:54	0.005	0.000

3 Set Up and Evaluate Option C: Bioretention, Green Roof, and Permeable Pavement

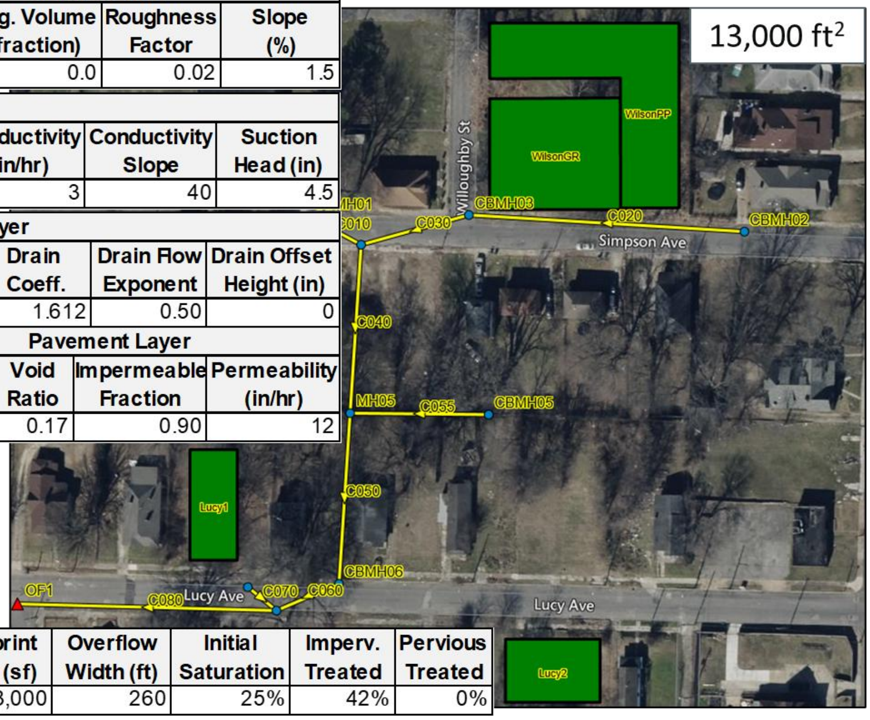
In this scenario, permeable pavement will be added to the parking lot of the new development in subcatchment S03. The size and layout are shown below along with the various design parameters.

LID Control	Surface Layer: Berm Height (in)	Veg. Volume (fraction)	Roughness Factor	Slope (%)
WilsonPP	3	0.0	0.02	1.5

LID Control	Soil Layer: Thickness (in)	Porosity (fraction)	Field Capacity	Wilting Point	Conductivity (in/hr)	Conductivity Slope	Suction Head (in)
WilsonPP	12	0.42	0.18	0.07	3	40	4.5

LID Control	Storage Layer: Thickness (in)	Void Ratio	Seepage (in/hr)	Clogging Factor	Drain Coeff.	Drain Flow Exponent	Drain Offset Height (in)
WilsonPP	24	0.35	0	0	1.612	0.50	0

LID Control	Pavement Layer: Thickness (in)	Void Ratio	Impermeable Fraction	Permeability (in/hr)
WilsonPP	6	0.17	0.90	12



Subcatch-ment	LID Control	Subcatch. Area (ac)	Footprint Area (sf)	Overflow Width (ft)	Initial Saturation	Imperv. Treated	Pervious Treated
S03	WilsonPP	1.3011	13,000	260	25%	42%	0%

3-1 **Save** the current project and then **Save As "ANC3-3_Alt2C-BCandGRandPP.inp"**.

3-2 In **Microsoft Excel**, open the spreadsheet "**ANC3-3_LID-Alternatives.xlsx**". Review the LID Control and LID Usage parameters in the **"PermeablePavement" worksheet**. Parameters have also been formatted for direct use in the SWMM5 input file, in columns Y-AI. The permeable pavement takes up the entire parking lot, a footprint area of 13,000 sq.ft. It is a block paver system, such that the impermeable fraction is 0.9 (i.e., water infiltrates through permeable cells between the blocks, in 10% of the footprint area).

3-3 **Save** the current project, **exit SWMM 5.2**, and keep the Excel spreadsheet open.

3-4 In **Notepad** (or another text editor), **open the input file "ANC3-3_Alt2C-BCandGRandPP"**. In Excel, **copy the range of cells Y5:AG10** to the clipboard (CTRL +C). In the text editor, **paste the clipboard contents** (CTRL +V) in the **[LID-CONTROLS] section** of the input file, after the set of WilsonGR LID Control parameters (line 121 or so, see screenshot next page).

3-5 In Excel, **copy the range of cells Y14:AI14** to the clipboard (CTRL +C). In the text editor, **paste the clipboard contents** (CTRL +V) in the **[LID-USAGE] section** of the input file, after the set of WilsonGR LID Usage parameters (see screenshot next page). **Save the input file** and **close** the text editor.

3-6 **Open** the project "**ANC3-3_Alt2C-BCandGRandPP.inp**" in SWMM 5.2. Confirm the values in the LID Control Editor and LID Usage Editor match the corresponding spreadsheet entries.

3-7 **Run** the simulation and review the LID Performance and Node Flooding Summary tables.

The addition of the permeable pavement eliminates the flooding at CBMH02, however the flooding at CBMH03 persists. One more intervention will be necessary.

ANC3-3_Alt2B-BCandGRandPP.inp

File Edit View

```
[LID_CONTROLS]
;;Name           Type/Layer Parameters
;;-------------- ---------- ----------
Lucy1            BC
Lucy1            SURFACE    12         0.1        0          0          0
Lucy1            SOIL       24         0.42       0.18       0.07       3          40         4.5
Lucy1            STORAGE    24         0.35       0          0          NO
Lucy1            DRAIN      1.378      0.5        0          0          0          0

Lucy2            BC
Lucy2            SURFACE    12         0.1        0          0          0
Lucy2            SOIL       24         0.42       0.18       0.07       3          40         4.5
Lucy2            STORAGE    24         0.35       0          0          NO
Lucy2            DRAIN      1.218      0.5        0          0          0          0

WilsonGR         GR
WilsonGR         SURFACE    3          0.1        0.15       1.5        0
WilsonGR         SOIL       4          0.63       0.21       0.12       3.6        20         6
WilsonGR         DRAINMAT   2          0.3        0.03

WilsonPP        PP
WilsonPP        SURFACE 3       0       0.02    1.5     0
WilsonPP        PAVEMENT        6       0.17    0.9     12      0       0       0
WilsonPP        SOIL    12      0.42    0.18    0.07    3       40      4.5
WilsonPP        STORAGE 24      0.35    0       0       NO
WilsonPP        DRAIN   1.612   0.5     0       0       0       0

[LID_USAGE]
;;Subcatchment   LID Process      Number  Area       Width      InitSat    FromImp    ToPerv     RptFile DrainTo FromPerv
;;-------------- ---------------- ------- ---------- ---------- ---------- ---------- ---------- ------- ------- --------
S03              WilsonGR         1       10500      210        25         34         0          *       *       0
S03     WilsonPP        1       13000   260     25      42      0       *       *       0
S07              Lucy1            1       3800       40         25         60         0          *       *       30
S08              Lucy2            1       4300       80         25         50         0          *       *       10
```

Summary Results

Topic: LID Performance   Click a column header to sort the column.

Subcatchment	LID Control	Total Inflow in	Evap Loss in	Infil Loss in	Surface Outflow in	Drain Outflow in	Initial Storage in	Final Storage in	Continuity Error %
S03	WilsonPP	8.82	0.13	0.00	0.00	9.35	3.45	2.79	-0.00
S03	WilsonGR	8.82	0.83	0.00	0.00	8.65	1.14	0.48	-0.02
S07	Lucy1	23.53	1.25	0.00	0.00	22.25	5.34	5.37	-0.01
S08	Lucy2	22.57	1.25	0.00	0.00	21.29	5.34	5.38	-0.01

Summary Results

Topic: Node Flooding   Click a column header to sort the column.

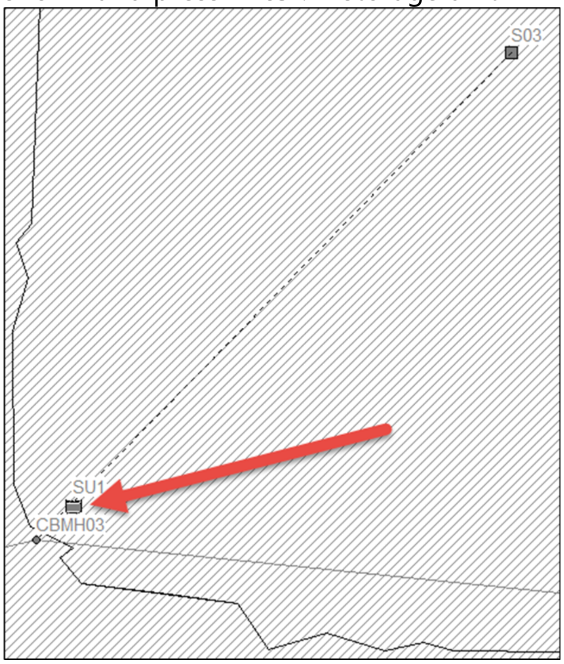
Node	Hours Flooded	Maximum Rate CFS	Day of Maximum Flooding	Hour of Maximum Flooding	Total Flood Volume 10^6 gal	Maximum Ponded Depth Feet
CBMH03	0.02	1.54	0	11:54	0.000	0.000

4 Set Up and Evaluate Option D: Add Cistern

All of the water treated by the various LID controls in the new development has been discharged into the piped collection system. In this scenario, the drain flow from the Green Roof and Permeable Pavement in subcatchment S03 will be discharged into a proposed cistern located in the main building, for later reuse.

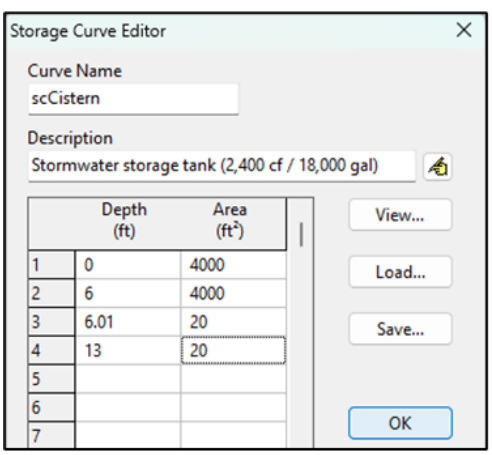
4-1 **Save** the current project and then **Save As "ANC3-3_Alt2D-LIDwithCistern.inp"**.

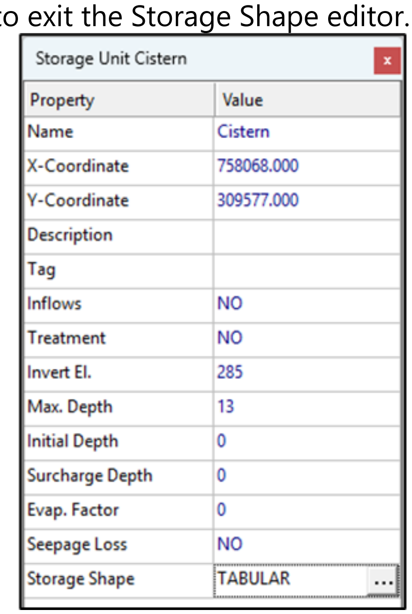
4-2 **Zoom** in on the **southwest corner of subcatchment S03** and then **select Storage Units** (under Hydraulics | Nodes in the Project panel). Click the **Add** button and then **select a point** in the map as shown and press **Enter**. A storage unit will be added to the model with the default name of "SU1".



4-3 **Select the SU1** storage unit and **rename it as Cistern**, set the **Invert El. to 285 ft**, **Max. Depth to 13 ft**, and change the **Storage Shape** from Functional to **Tabular**.

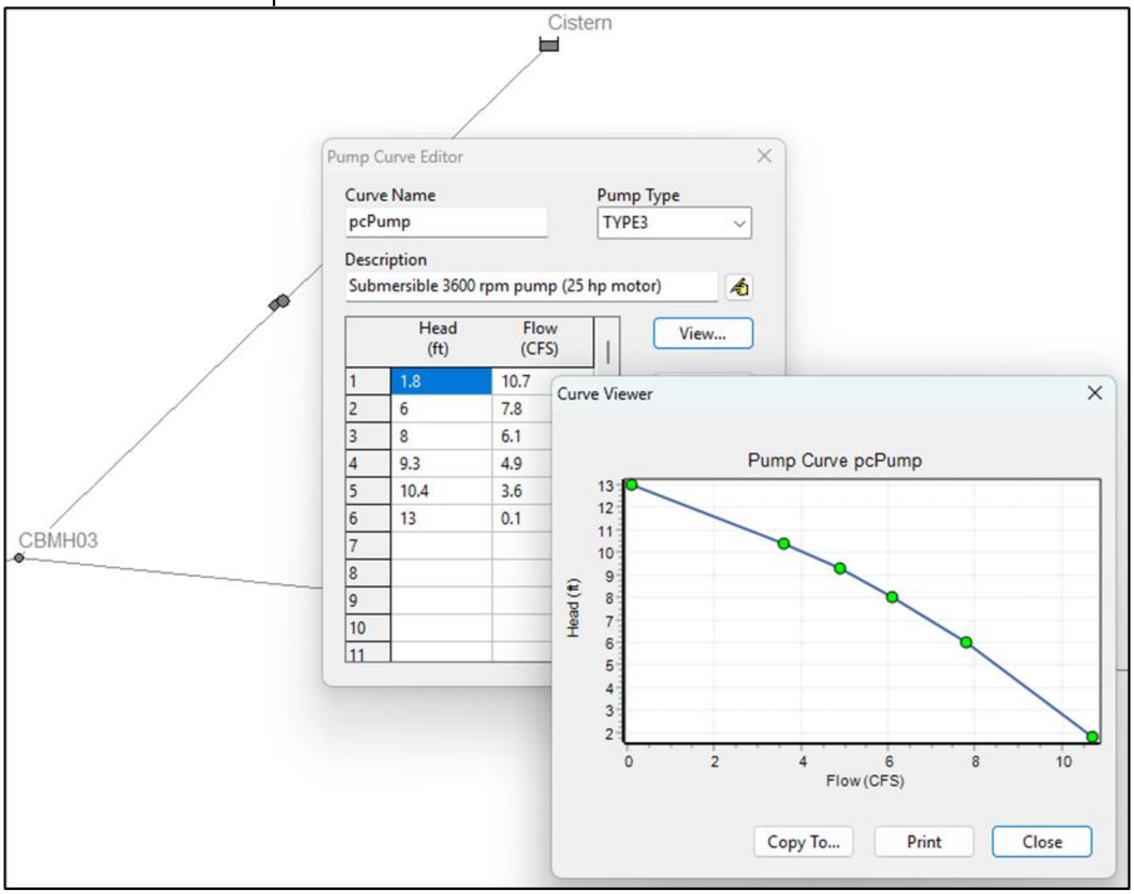
4-4 In the Storage Shape editor, click the **Edit Storage Curve** icon beside the Storage Curve Name drop-down list. Name the storage curve as **scCistern** and enter "**Stormwater storage tank (2,400 cf / 18,000 gal)**" in the Description field. In the Data table, enter the **Depth/Area data pairs (0, 4000; 6, 4000; 6.01, 20; 13, 20)**, and then **OK** twice to exit the Storage Shape editor.



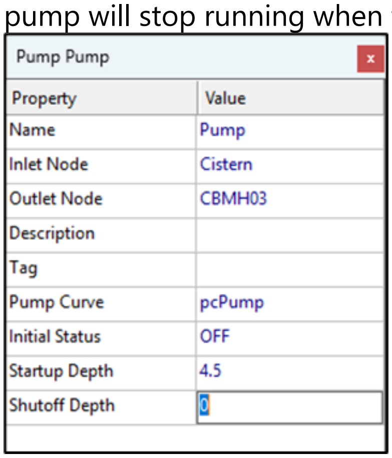


4-5 Select **Pumps** (under Hydraulics | Links in the Project panel). Click the **Add** button, then in the Map panel **select the Cistern** and then **select CBMH03**. The order of selection determines the Inlet Node and Outlet Node properties, respectively. A pump will be added to the model with a "P1" default name.

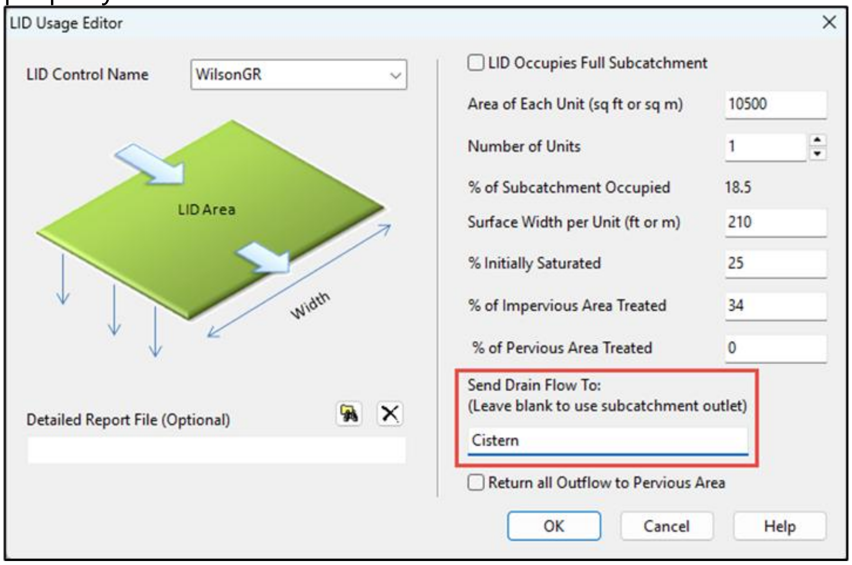
4-6 Select **Pump Curves** (under Curves in the Project panel). Click the **Add** button, and in the Pump Curve Editor, name the pump curve as **pcPump** and enter "**Submersible 3600 rpm pump (25 hp motor)**" in the Description field. Select a **TYPE3 Pump**, and in the Data table, enter the **Head/Flow data pairs (1.8, 10.7; 6, 7.8; 8, 6.1; 9.3, 4.9; 10.4, 3.6; 13, 0.1)**. Select the **View** button to display the curve, and then **OK** to close the Pump Curve editor.



4-7 **Select the P1** pump and **rename it as Pump**, set the **Pump Curve as pcPump**, **Initial Status as OFF**, and the **Startup Depth as 4.5 ft**. The Shutoff Depth can remain as the default zero value, indicating the pump will stop running when the wet well in the Cistern is fully drained.

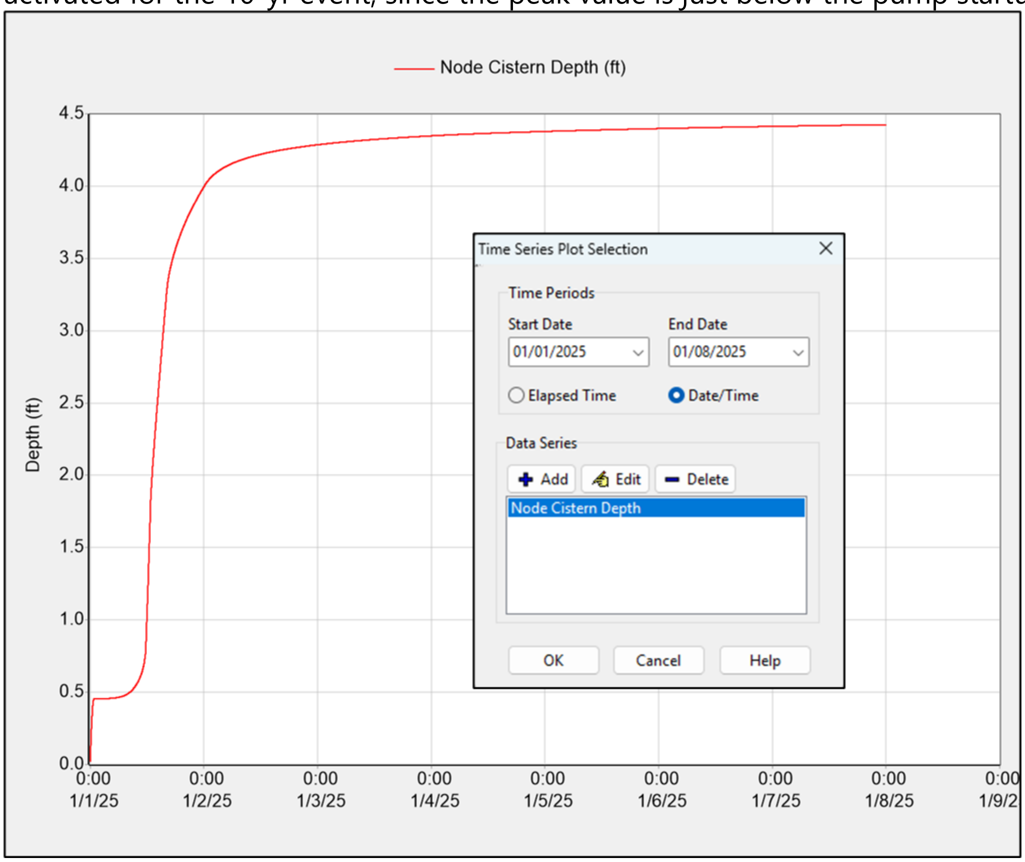


4-8 **Select subcatchment S03**, **click the ellipsis** beside the LID Controls property, and then **select Edit** button for the **WilsonGR** LID control. In the LID Usage Editor, change the **Send Drain Flow To** property to **Cistern**. Select the **WilsonPP** LID control, then **Edit**, and then change the **Send Drain Flow To** property to **Cistern**. Click **OK** twice to close the LID Controls editor.



4-9 **Run** the simulation and note there are no occurrences of node flooding.

4-10 Select the **Cistern** storage unit in the Map panel. Select the **Timeseries Plot** icon (alternatively, select Report | Graph | Timeseries in the Main Menu). In the Timeseries Plot Selection editor, **check Date/Time** to confirm the selected Data Series is **Node Cistern Depth**, and then **OK**. Note the pump is not activated for the 10-yr event, since the peak value is just below the pump startup depth of 4.5 ft.



This scenario achieves the desired performance level and the cistern is large enough to contain captured runoff from the LID controls for this design storm event.