GREEN ROOF BENEFITS AND PERFORMANCE

Waukesha County Storm Water Workshop

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GRAEF

March 30, 2017

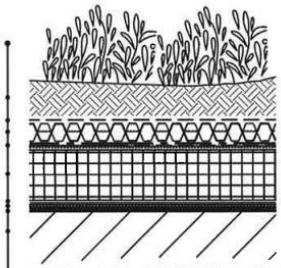
Green Roof Definitions

- Green Roof – Water stored in soil media and drainage mat, evapotranspired by plants and discharged through flow control roof drains
- Blue Roof – Water stored in gravel or open space, discharged through flow control roof drains
- Purple Roof – Next generation version of the green roof – has least sheet flow, retains the most water.

Green Roof Definitions

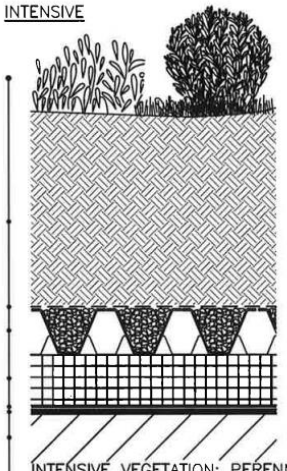
- Extensive Systems – 3 to 6 inches deep, lightweight, lower maintenance
- Intensive Systems – 6 to 36 inches deep, heavier, more plant variety, more maintenance
- Lawn Systems – 6 to 12 inches deep, designed with turf grasses for pedestrian traffic

EXTENSIVE



- HARDY, DROUGHT TOLERANT PLANTS
- LITETOP EXTENSIVE MEDIA (3"–6")
- SYSTEMFILTER
- GARDENDRAIN GR15 OR GR30 (option: filled w/lt.wt. aggregate)
- MOISTURE MAT & HYDRODRAIN AL (IF NECESSARY) (refer to details GA–2A & GA–2B)
- DOW STYROFOAM INSULATION
- HYDROFLEX 30 & ROOT STOP
- MM 6125EV–FR
- SUBSTRATE (concrete, gyp.bd., plywood)

INTENSIVE



- INTENSIVE VEGETATION: PERENNIALS, SHRUBS, SMALL TREES, URBAN AGRICULTURE
- LITETOP INTENSIVE MEDIA (6"+)
- SYSTEMFILTER
- GARDENDRAIN GR30 OR GR50 (filled w/lt.wt. aggregate)
- DOW STYROFOAM INSULATION
- HYDROFLEX RB II OR HYDROFLEX 30 & ROOT STOP HD
- MM 6125EV–FR
- SUBSTRATE (concrete, gyp.bd., plywood)

NOTES:
- ADDITIONAL COMBINATIONS OF GARDEN ROOF ASSEMBLY COMPONENTS ARE POSSIBLE TO FIT SPECIFIC PROJECT REQUIREMENTS.
- CONSULT HYDROTECH FOR VARIATIONS ON ABOVE ASSEMBLIES.

HYDROTECH

GARDEN ROOF ASSEMBLY

AMERICAN HYDROTECH, INC.

TYPICAL STANDARD GARDEN ROOF ASSEMBLIES EXTENSIVE AND INTENSIVE

NO SCALE	GA–1A

Discovery World – Lawn System

Green Roof Benefits

- Environmental
  - Managing Water Where it Falls
  - Reducing Urban Heat Island Effects
  - Improving Air Quality
  - Increasing Urban Green Space and Wildlife Habitat

Green Roof Benefits

- Economic
  - Extending Roof Life by Protecting Roof Membrane
  - Potentially Lowering Building Heating and Cooling Costs
- Social
  - Reconnecting Communities to the Natural Environment
  - Providing Urban Green Space and Educational Opportunities

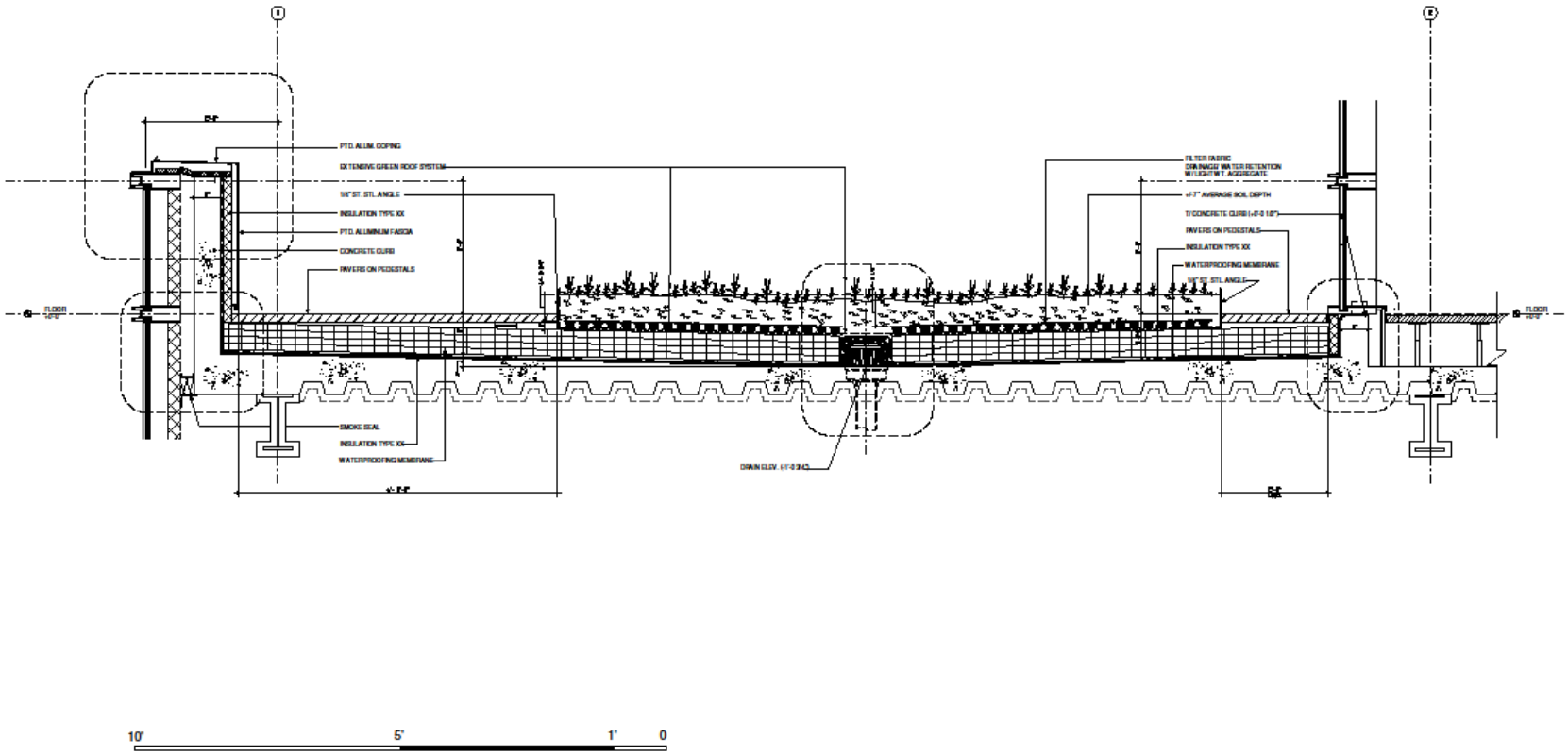
Northwestern Mutual's Downtown Office Development

36,400 SF of Green Roof

NM Green Roof as Seen from the Tower.

Hydrotech Green Roof System

NM's Green Roof - Growing Media is an Average of 7 inches Deep



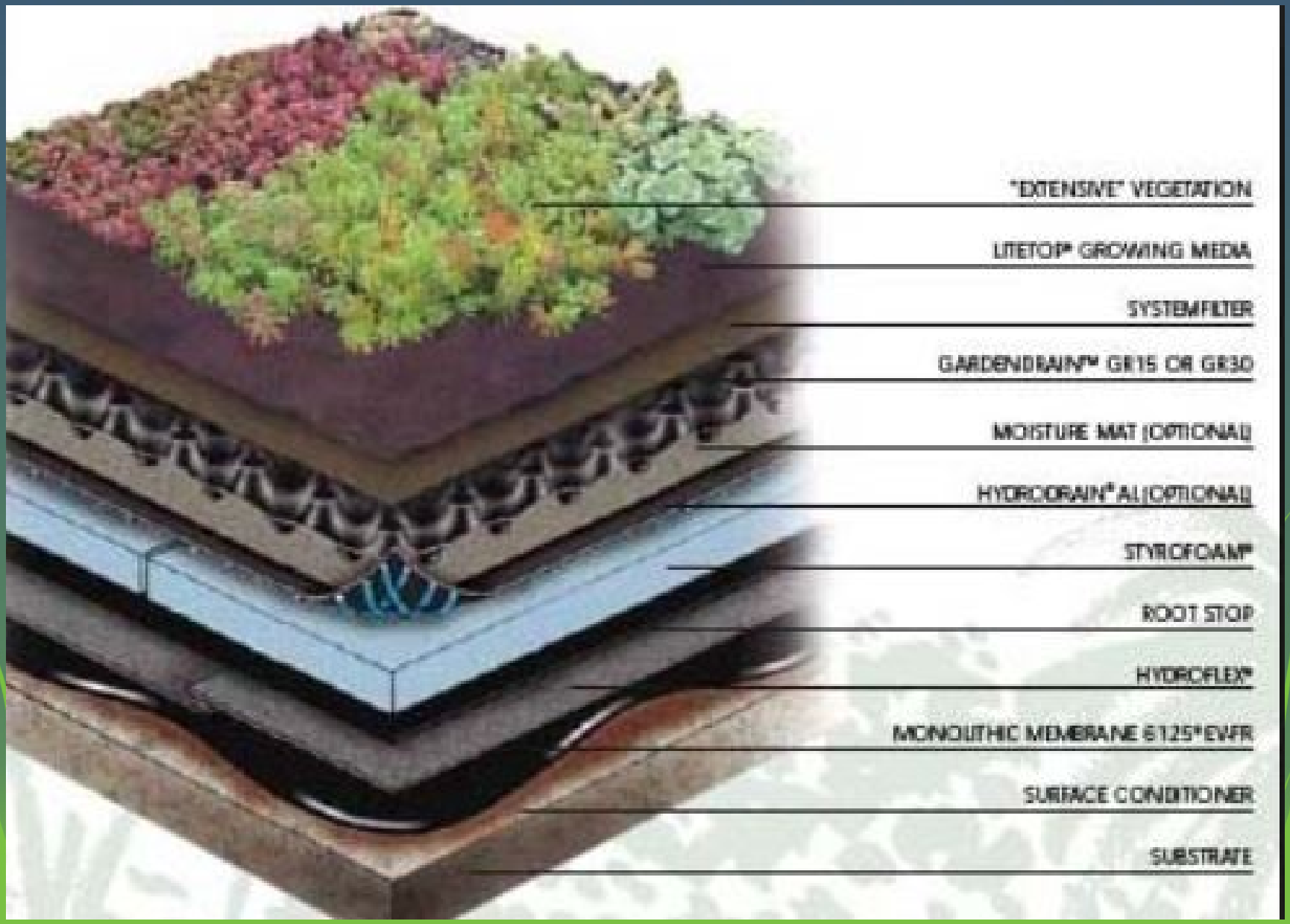
10' 5' 1' 0

NORTHWESTERN MUTUAL CAMPUS CONNECTION
KENDALL/HEATON ASSOCIATES
KHA 120333

GARDEN ROOF DETAIL
KH.090.1
31 MAR 2014
SCALE: N.T.S.

NM Green Roof

Hydrotech Green Roof Cross-Section



NM Green Roof Facts

- **The Green Roof System will capture up to 79,000 gallons from a Single Storm Event**
  - The 7-inch Deep Growing Media Holds about 2.7 inches of Water.
  - Equivalent to about a 2-Year Storm Event
  - Water is Held in the Soil, and Used by the Plants or Evaporated
  - Excess Water Goes Through the Media to a Drain
  - The Green Roof System will Capture about 512,000 Gallons on an Annual Basis

NM Green Roof – Regular and Overflow Drains

MMSD Green Roof Benefits Calculator

Green Roofs

Green roofs help to reduce the amount of runoff from rooftops by holding stormwater in the plantings and growing media.

Use the calculator to see how much water can be saved by a green roof and to calculate the reduced energy use.

Property Type

Commercial

Size (sq. ft.):

36400

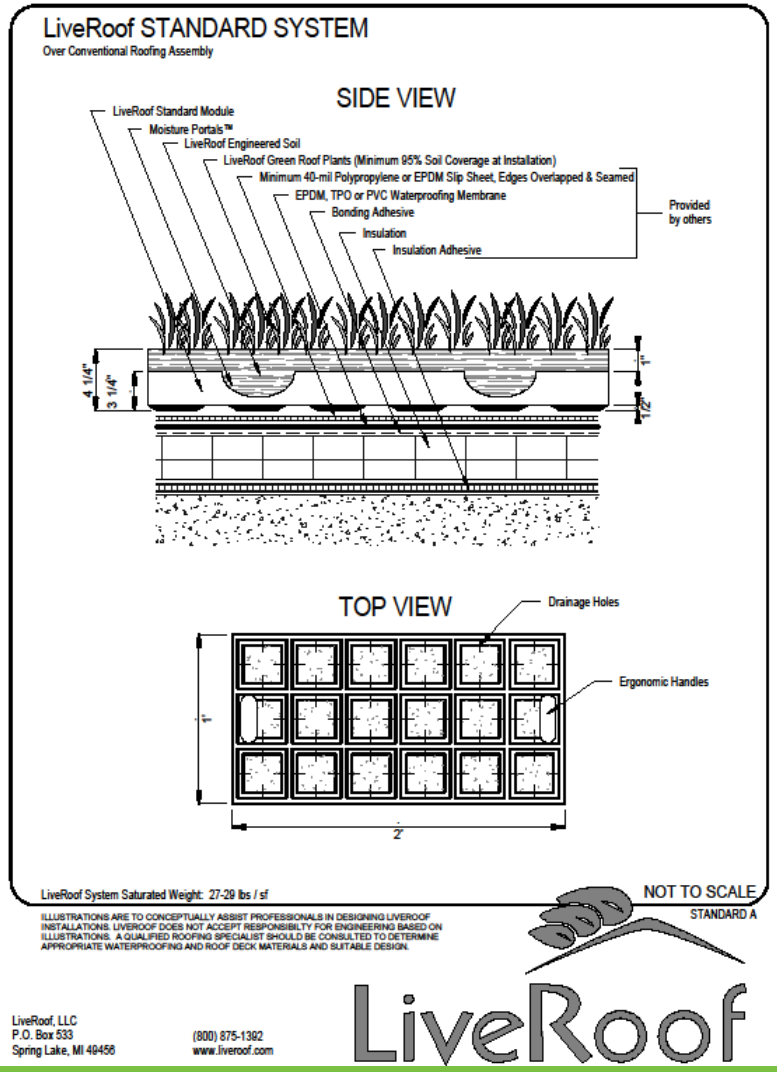
Calculate

Energy Use (equiv. kWh/year)	563.6
CO2 reduction (kg/year)	807.1
# Days Car Removed from Roadway	50
Median Runoff Reduction (%/year)	60%
Recharge obtained / year (k-gal)	469.7
TSS Removed (lbs/year)	394.5
Total Capital Costs	$1,157,520.00
Total Cost/gallon	$0.10
Maintenance Costs / year	$14,924.00

scroll over for details

Columbia St. Mary's Hospital

Columbia St. Mary's Hospital



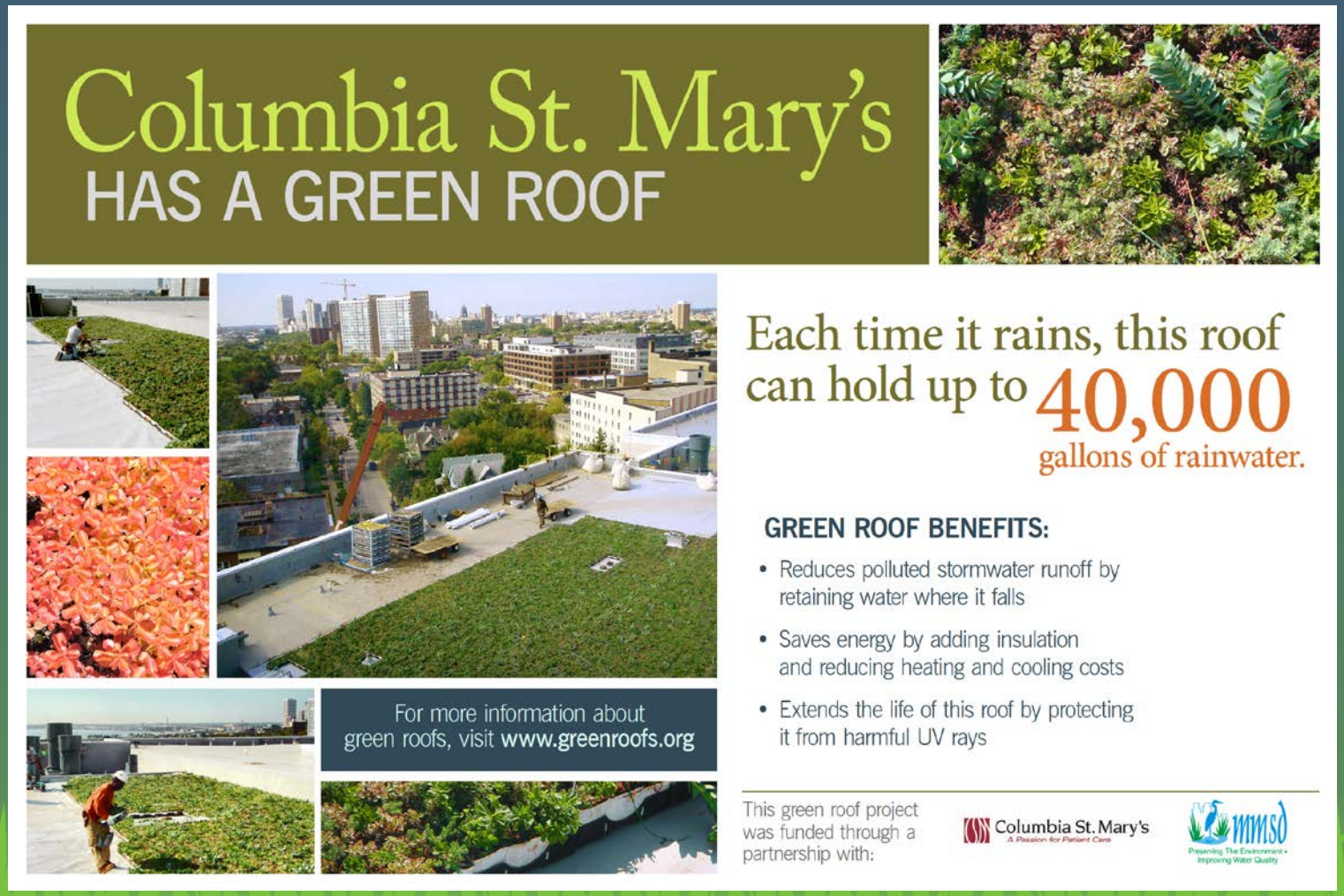
5th Floor Plant List
Allium schoenoprasum 'Forescate' *
Euphorbia myrsinites *
Sedum reflexum
Sedum sieboldii 'Nana' *
Sedum spurium 'Tricolor'
Sedum takesimense 'Gold Carpet'
*Modules will include 2 accent plants per module, with full coverage of the other sedum.

CSM Green Roof - Membrane

CSM Green Roof – Plant Tray Delivery

CSM Green Roof – Plant Trays

MMSD Grant Program



Green Roof Design Considerations

- Safety -- fall protection systems
- Wind – Could lead to uplift
- Adjacent walls and overhangs – could lead to concentrated flows, excess heat or shade, or snow loads
- Access

St. John’s on the Lake - Green Roof

St. Luke’s Medical Center - Green Roof

UW Cancer Center at Pro-Health Care - Green Roof Healing Garden

Green Roof Growing Media

- Light weight mineral material with a minimum of organic material
- Pore space, air space and absorptive capacity are keys
- Water holding capacity just under 50% by volume, which includes air space and absorption
- LiveRoof – a 4-inch depth of media will hold 1.76 inches of water

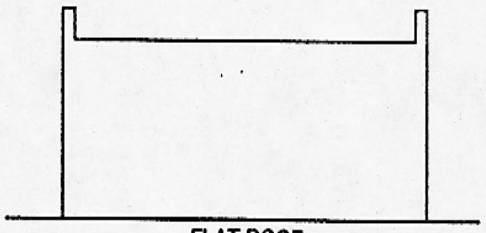
Calculating System Performance

- Determine Storage Volume
  - Building roof plans
  - Roof slope
  - Storage cell area
  - Incremental areas and volumes

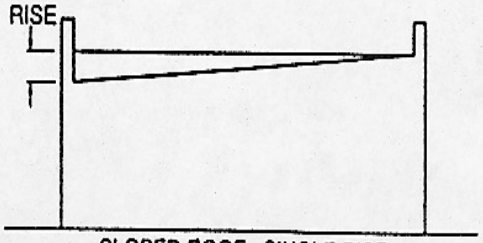
Types of Roofs

ROOF TYPES

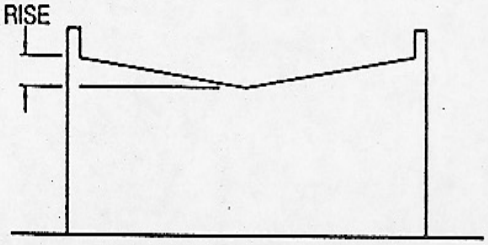
The roof to be drained may vary from flat to a slope of 6" rise. Rise is measured, vertically from the low point or valley to the high point or ridge. (Refer to Fig. 2 below.)



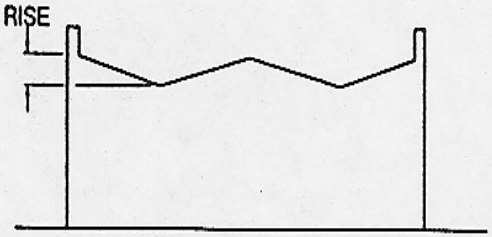
FLAT ROOF



SLOPED ROOF - SINGLE RISE



SLOPED ROOF - DOUBLE RISE



SLOPED ROOF - MULTIPLE RISE

Fig. 2

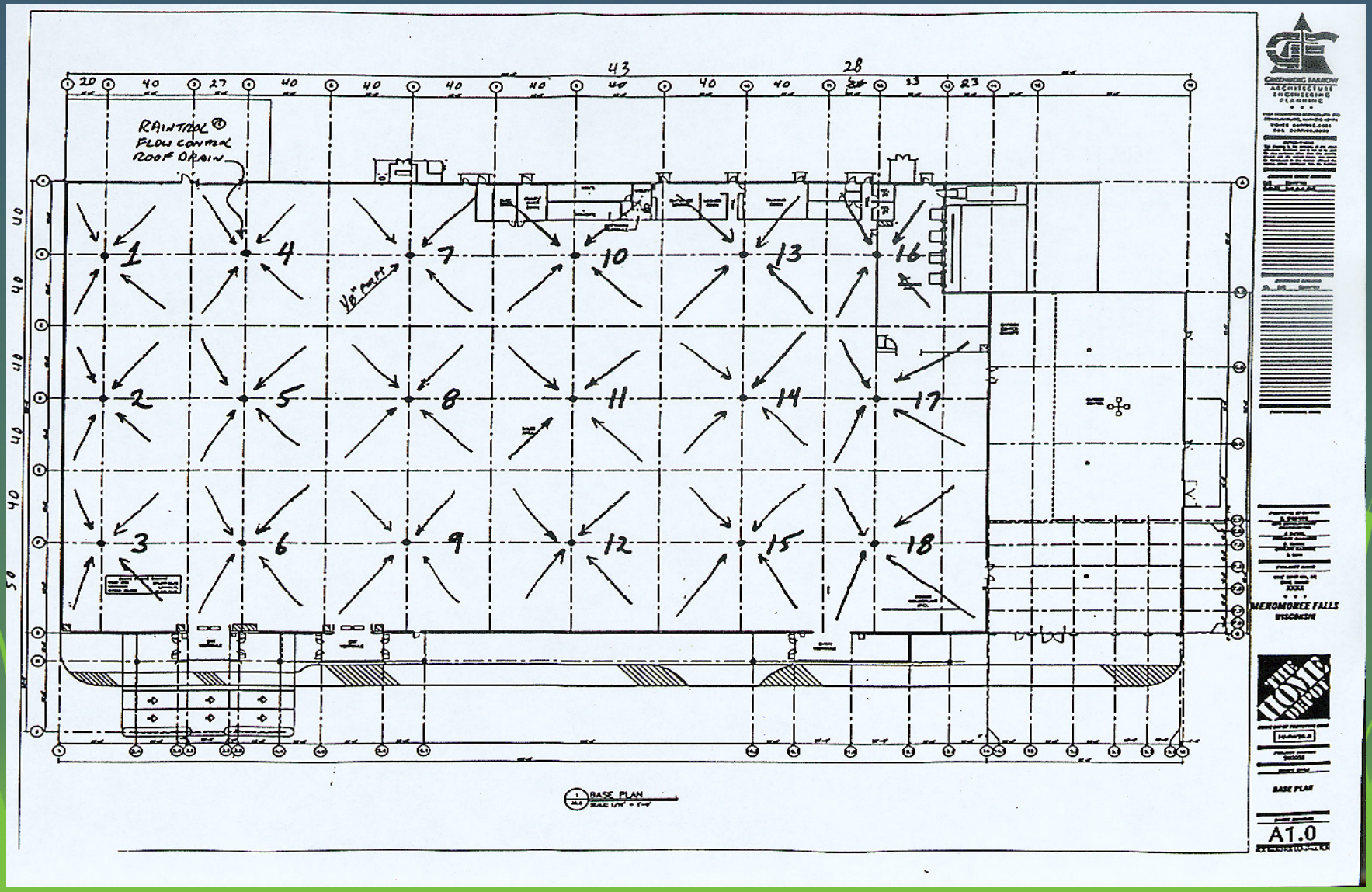
Green Roof Slopes

- LiveRoof:
  - Maximum Slope of 40 percent
  - Minimum Slope of 0.17 percent (1/4-inch per 12 feet)
- Hydrotech:
  - Have an anchoring system that allows for steeper applications
  - Can install on flat roof, with drainage mat beneath growing media
- Typical Roof Slope – 1/8-inch per foot (1 percent)

Mequon Nature Preserve

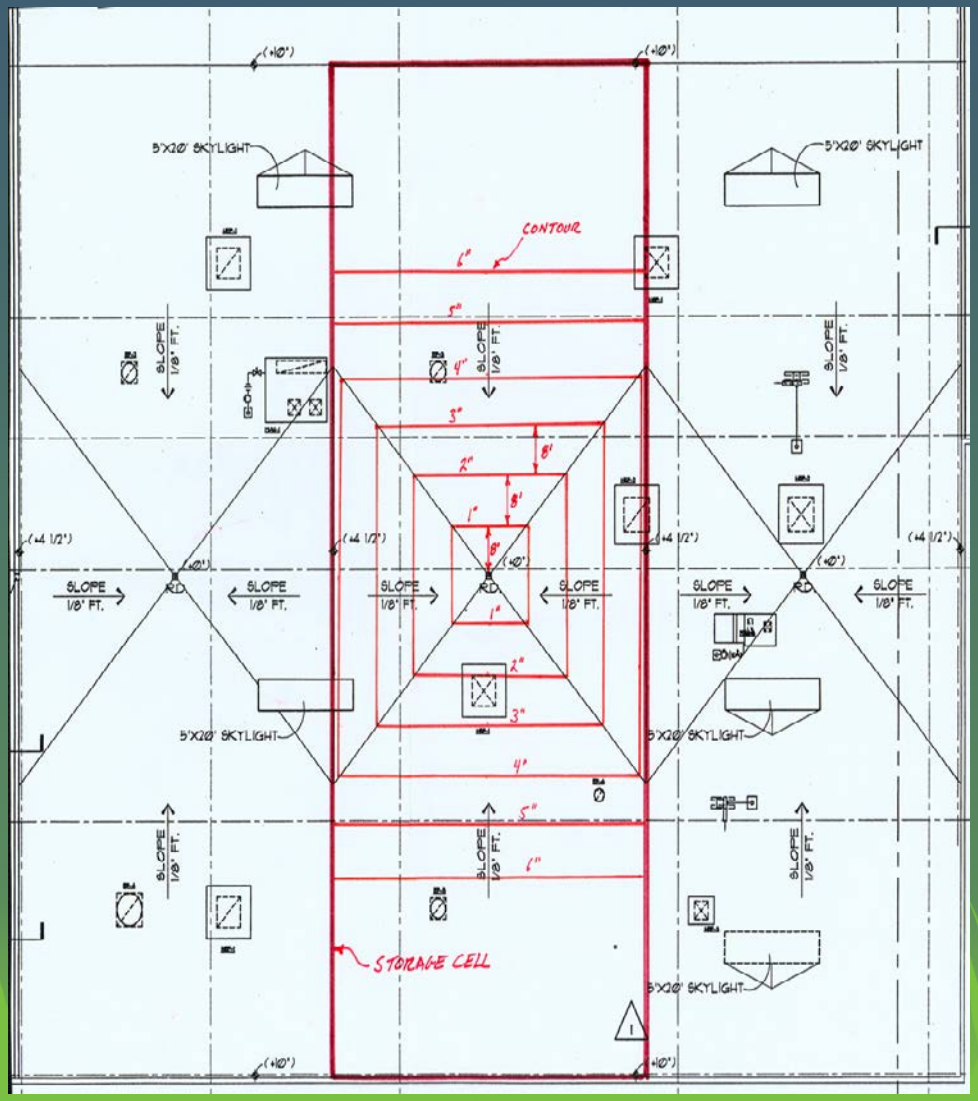
Rooftop Storage Cells

(slope = 1/8-inch per foot)



Storage Volume Determination

(slope = 1/8-inch per foot)



Green Roof Storage Calculator

ROOFTOP STORAGE VOLUME CALCULATOR

PROJECT:

Roof Elev.: 800.00 **1 weir per drain/zone** **6 Zones**

Depth (In.)	Depth (Ft.)	Elev. (Ft)	Length (Ft.)	Width (Ft.)	Area (Sq. Ft.)	Area (Acres)	Volume (Acre-Ft.)	Vol. Sum (Acre-Ft.)	Tot. Vol. (Acre-Ft.)	Flow/weir (gpm)	Tot. Flow (cfs)
0	0.000	800.000	0.0	0.0	0.0	0.0000	0.0000	0.0000	0	0.0	0
1	0.083	800.083	16.0	16.0	256.0	0.0059	0.0002	0.0002	0.0010	9.2	0.1230
2	0.167	800.167	32.0	32.0	1024.0	0.0235	0.0011	0.0013	0.0078	18.6	0.2486
3	0.250	800.250	48.0	48.0	2304.0	0.0529	0.0031	0.0044	0.0264	28.4	0.3797
4	0.333	800.333	64.0	64.0	4096.0	0.0940	0.0060	0.0104	0.0627	38.6	0.5160
5	0.417	800.417	80.0	66.0	5280.0	0.1212	0.0089	0.0194	0.1164	49.1	0.6564
6	0.500	800.500	96.0	66.0	6336.0	0.1455	0.0111	0.0305	0.1829	60.0	0.8021
7	0.583	800.583	112.0	66.0	7392.0	0.1697	0.0131	0.0436	0.2616	60.0	0.8021

HydroCAD Storage Table

Pond 35: Green Roof - Proposed

Summary | Hydrograph | Discharge | Storage | Events | Sizing

```
Inflow Area =      0.030 ac,100.00% Impervious,  Inflow Depth >  5.82"   for  100 yr event
Inflow     =       0.27 cfs @   12.13 hrs,  Volume=          0.015 af
Outflow    =       0.12 cfs @   12.23 hrs,  Volume=          0.015 af,  Atten= 57%,  Lag= 6.3 min
Primary    =       0.12 cfs @   12.23 hrs,  Volume=          0.015 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 100.35' @ 12.23 hrs   Surf.Area= 1,470 sf   Storage= 182 cf

Plug-Flow detention time= 28.0 min calculated for 0.015 af (100% of inflow)
Center-of-Mass det. time= 27.2 min ( 769.7 - 742.6 )
```

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	405 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Voids (%)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	1,470	0.0	0	0
100.08	1,470	32.0	38	38
100.17	1,470	32.0	42	80
100.25	1,470	32.0	38	118
100.33	1,470	32.0	38	155
100.42	1,470	100.0	132	288
100.50	1,470	100.0	118	405

Device	Routing	Invert	Outlet Devices
#1	Primary	100.00'	**Special & User-Defined** Head (feet) 0.00 0.08 0.17 0.25 0.33 0.42 0.50 Disch. (cfs) 0.000 0.030 0.040 0.050 0.060 0.340 0.650

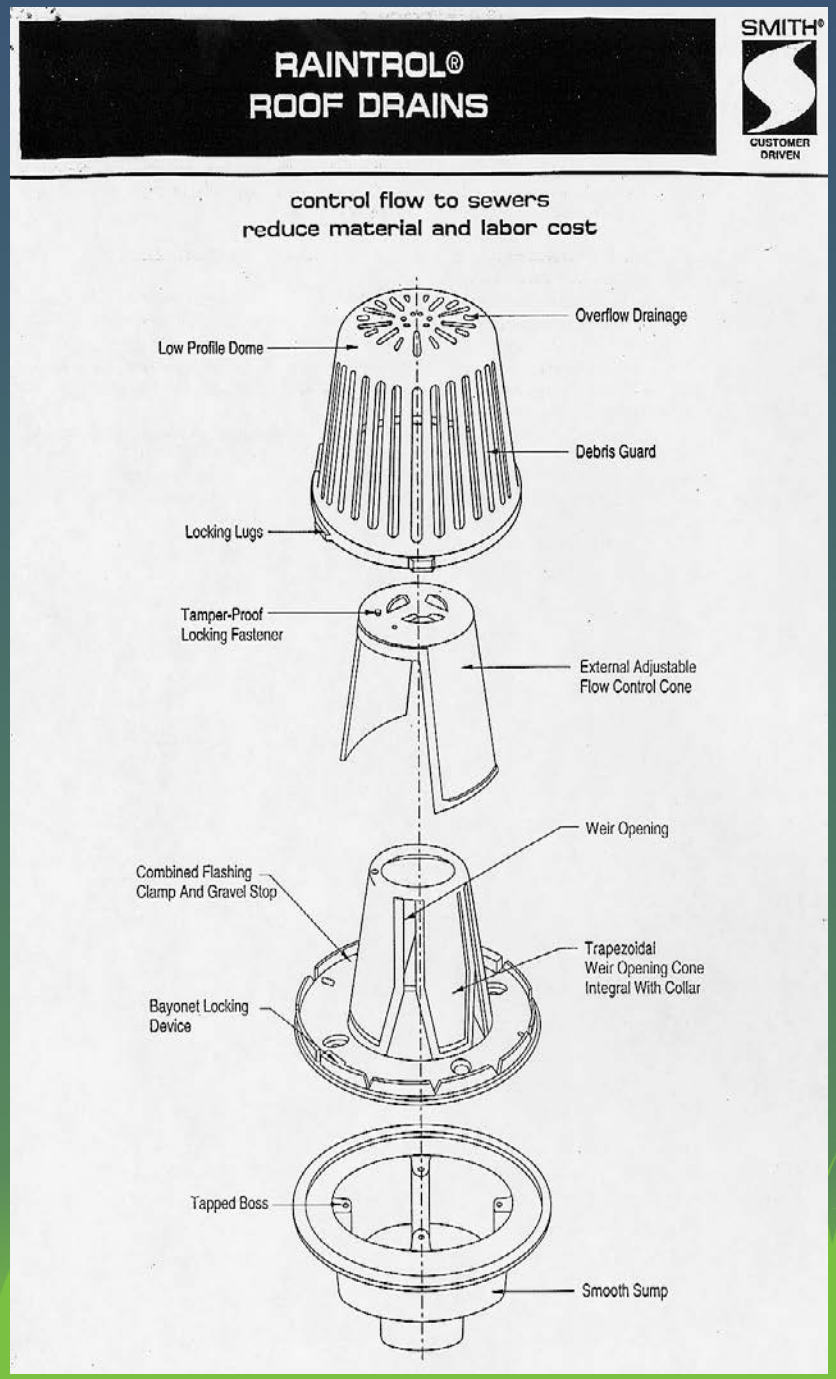
Primary OutFlow Max=0.12 cfs @ 12.23 hrs HW=100.35' (Free Discharge)
└1=**Special & User-Defined** (Custom Controls 0.12 cfs)

Table | Shrink | Print | Export | Edit | Help

Calculating System Performance

- Determine Discharge Rate
  - Raintrol® controlled flow roof drains
  - Number of weirs per drain
  - Number of drains

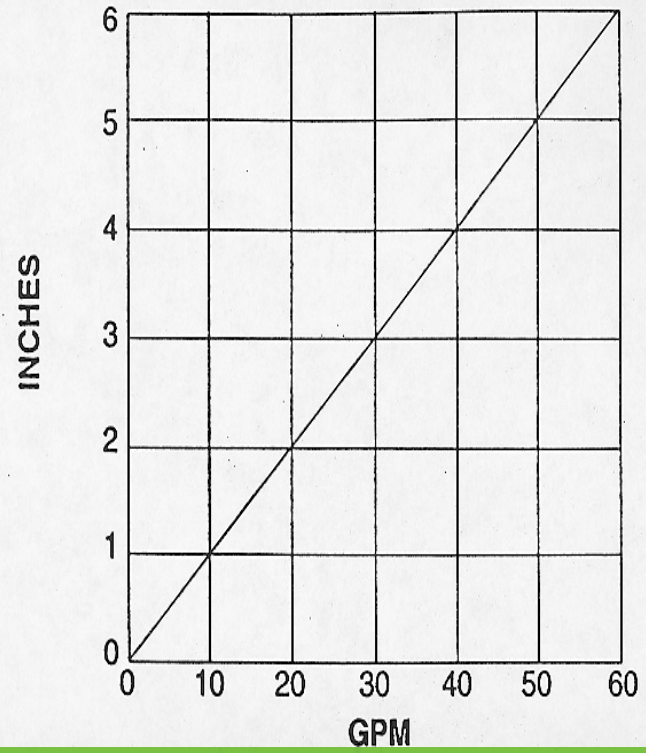
Raintrol® Controlled Flow Roof Drain



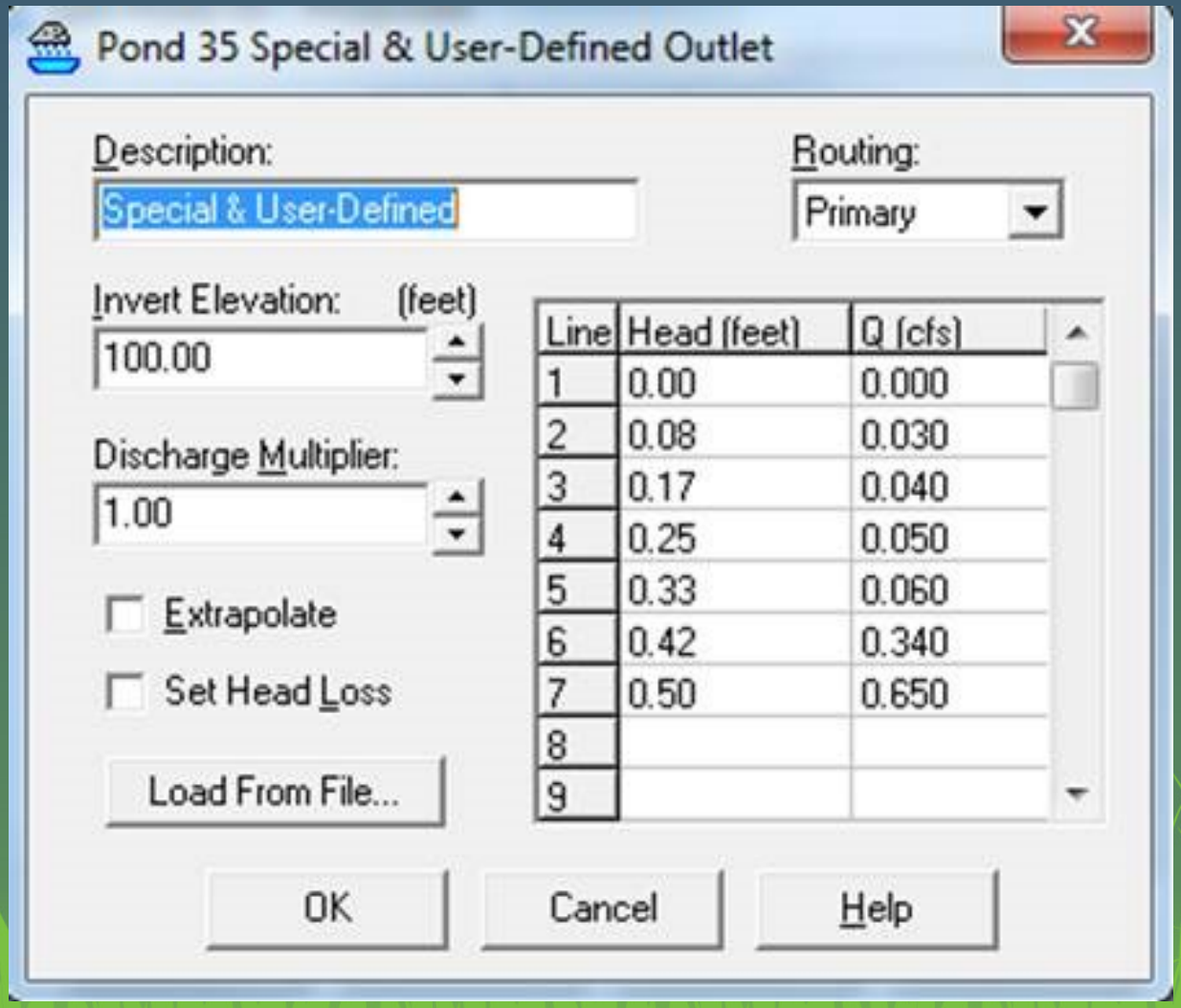
Raintrol® Controlled Flow Roof Drain

Roof Drain Discharge Table

FLOW RATE VS. BUILD-UP - ONE WEIR						
Depth - Inches	1	2	3	4	5	6
Flow - G.P.M.	9.2	18.6	28.4	38.6	49.1	60.0

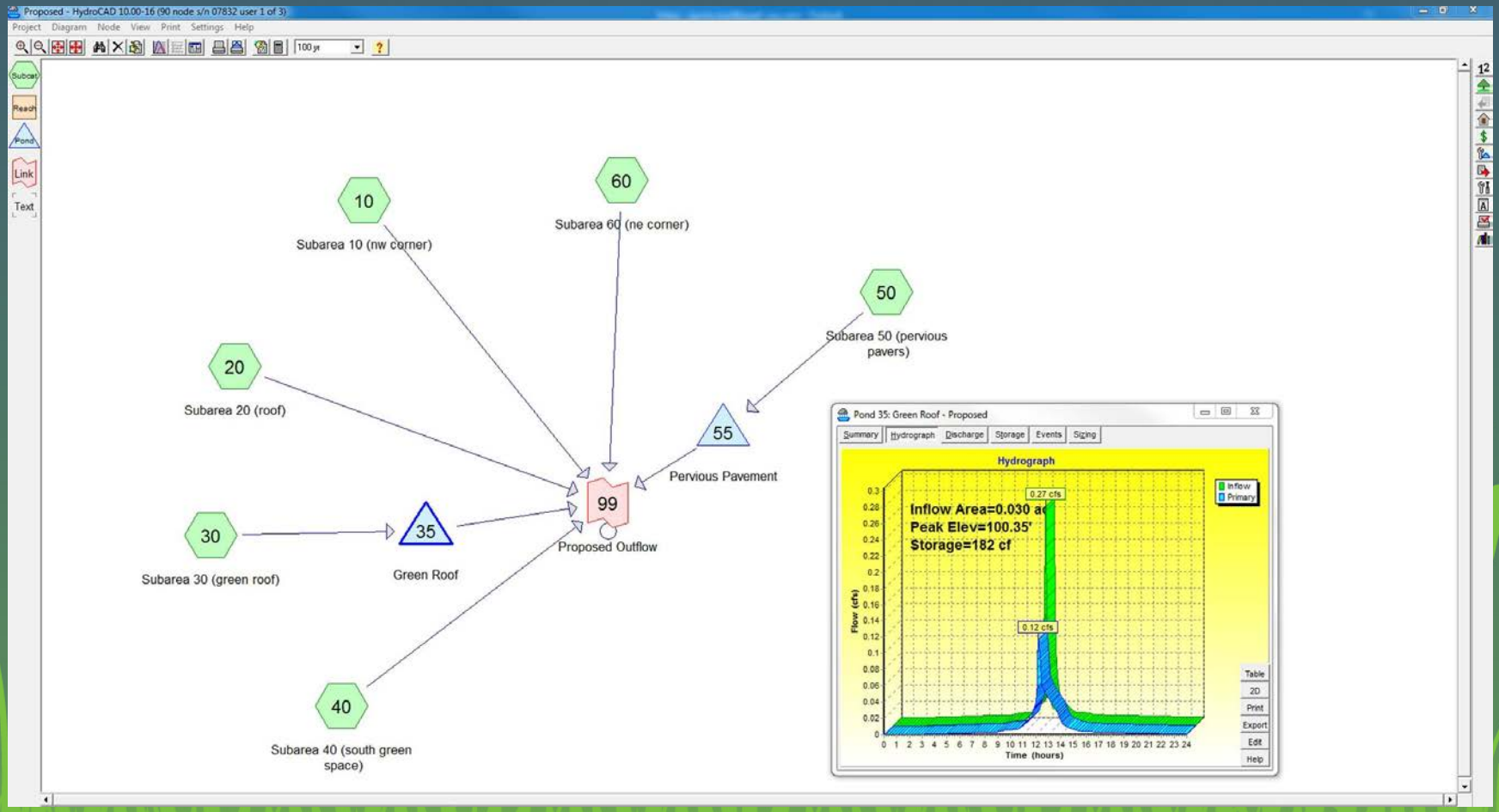


HydroCAD Discharge Table



Line	Head (feet)	Q (cfs)
1	0.00	0.000
2	0.08	0.030
3	0.17	0.040
4	0.25	0.050
5	0.33	0.060
6	0.42	0.340
7	0.50	0.650
8		
9		

Hydrologic Modeling Results



O & M Considerations

- Foot Traffic
  - Okay, but avoid repetitive and frequent walking on same path, or included pavers
  - Lawn systems are designed for pedestrian use
- Fertility Management
  - Soil testing and fertilization
  - Late season fertilizing advisory - avoid

Rockwell Automation - Winter

O & M Considerations

- Irrigation
  - For prolonged dry periods (four weeks)
  - Thinner systems and systems on slopes will need more
  - Hose spigot is usually sufficient
- Plant Care
  - Weed Control – by hand , twice monthly
  - Pesticides – use is discouraged
  - Mowing – maybe once per year, depending on the system

Questions?