Bio-infiltration
Do it right the first time

May 24, 2016

3RWW Wet Weather Workshop

G. Eric French

President, Eisler Landscapes Inc.

Eisler LANDSCAPES

3 Rivers Wet Weather

Rain garden - Bio swale - RGA (retentive grading area)???

- The terms rain garden and bio swale are often thrown around in the trade so what is the difference?

- The differences are very subtle.

- A rain garden does not have an underdrain

Let’s start with Bio swales

1) Often a large area- 1,000 sq. ft. or more
2) Has an underdrain
3) Can have a gravel bed for water storage
4) Utilizes engineered soils for increased water infiltration and storage capacity
5) Typically associated with commercial sites.
6) Usually engineered as part of the storm water BMP’s for a NPDES permit submitted to the county conservation district.

Bio-Swale at a public park during construction

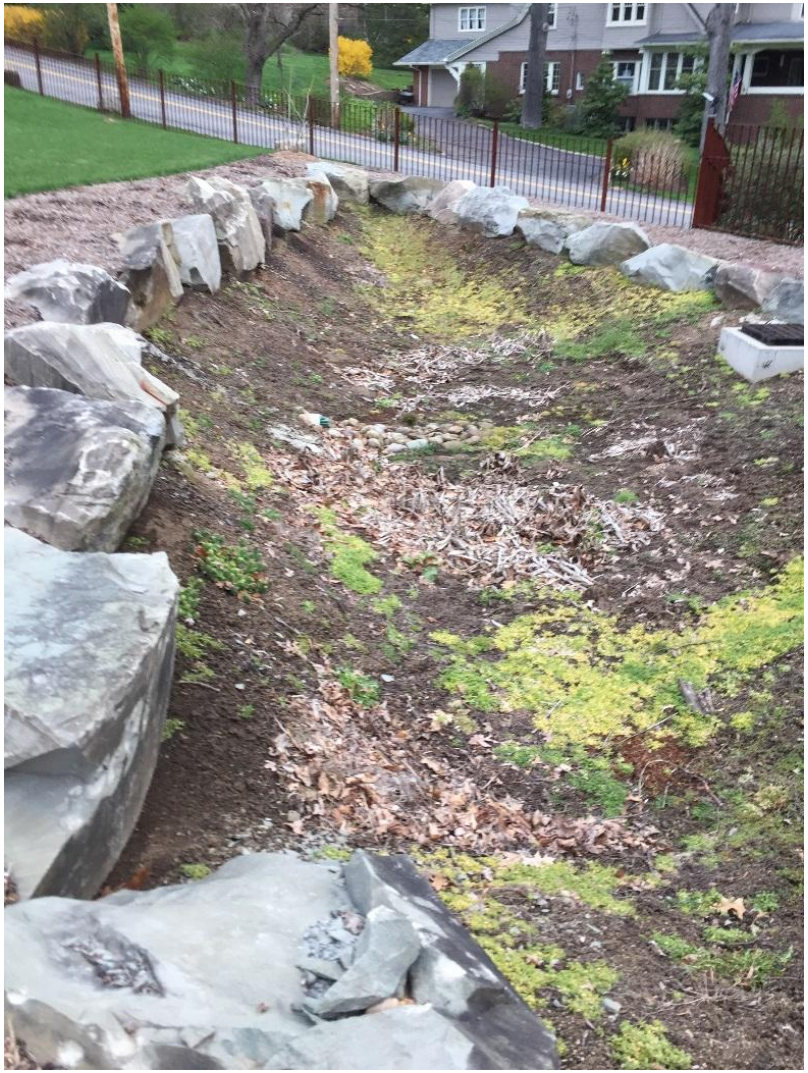
Bio-swale at an urban institution

Rain garden:

1) Does not have an underdrain thereby creating a drainage relief.
2) Typically small – only a few hundred square feet
3) Mostly associated with residential sites
4) Uses modified site soils
5) Typically planted with an aesthetic intent.
6) Associated with gutter disconnect or small parking area run off.

This is a small rain garden catching parking lot run off at a commercial site.

Here is an example of an awful rain garden on a residential site.



Good results start with a good design

- **Site assessment is the first step**, **we have 2 types of sites:**

- **New construction** - For new construction the site can be manipulated to sheet into the surface run off and/or convey it with the storm piping into the infiltration bed for maximum capture.

- **Existing site-** The design team needs to work within the parameters of the existing site. This sometimes means not all of the run off can be captured.

Site selection for the infiltration bed

- When working on a large existing site or minimally disturbed site, it is easier to check the existing soil type for infiltration suitability.

- Large sites often offer more than one suitable site for infiltration.

- Soil profiles can vary greatly on the same site.

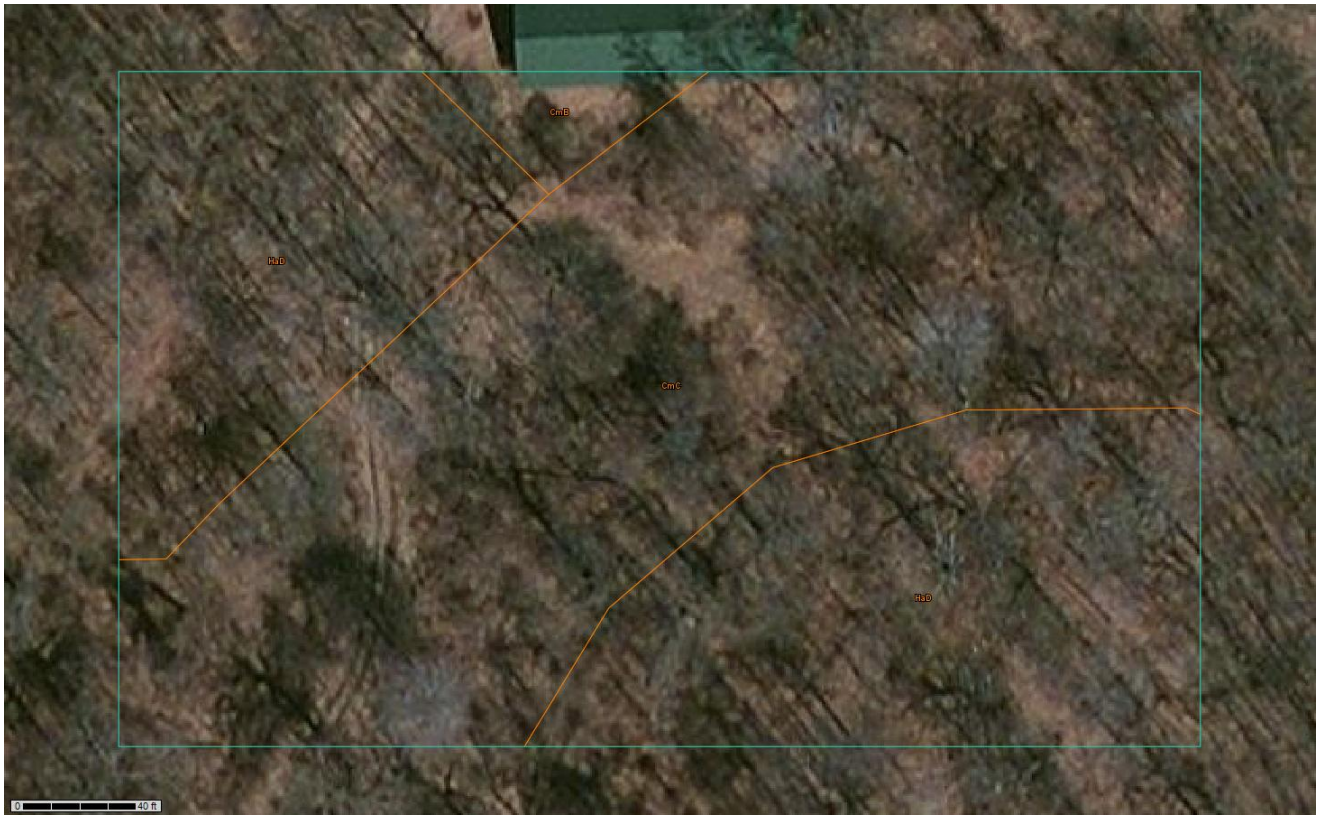
Existing soil should naturally infiltrate - **some do not**

This site was excavated for a rain garden on a large project.

A quick check to the USDA soils maps could have helped in this situation

- http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

- This is Clymer C soil – not suitable for infiltration



Regardless of the soil survey nothing beats a site exploration pit test.

- Although Pennsylvania does not have rules regarding pre construction exploration for bio infiltration systems it does have very strict regulations for on lot sewage disposal.

- The required soil conditions necessary for successful bio-infiltration are very similar to on lot septic disposal.

- Soil limiting zones such as clay lenses, plow hard pans, and rock negatively impact infiltration rates.

- Performing a pit test is the only sure way to discover these site limitations and allow design modification. One pit per 50 L.F. of trench is recommended.

Additional testing:

- Use of a double ring infiltrometer or the new self contained dual head infiltrometer will give exact results regarding the percolation capacity of an existing site. Remember to test at the **bottom** of the proposed trench, not the undisturbed surface.

New Construction

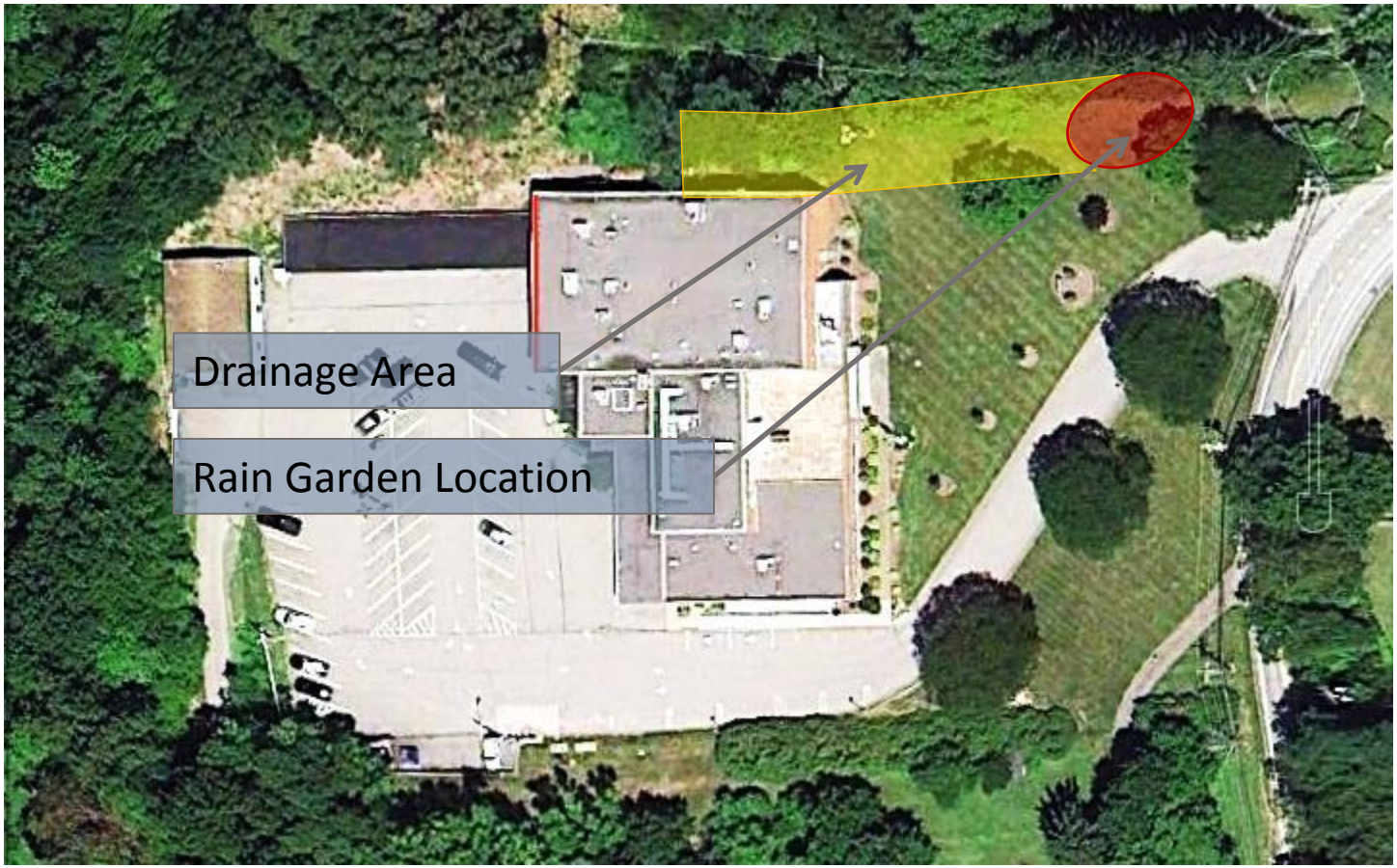
For new construction with significant earth work or urban areas, finding suitable soil can be challenging.

The design team often does not have access to the site or the budget to perform on site testing; however, there are several rules of thumb to follow.

Rules of Thumb for New Construction

- Check the geotechnical report for bore logs to see the character of the upper profiles and depth to stone.
- Fill areas can infiltrate faster than cut areas. Be careful not to oversaturate fill areas due to the potential of landslide.
- Do not construct the infiltration beds over utility trenches. Remember water will always follow the path of least resistance and that can mean right into the foundation wall along a utility trench.
- Keep the infiltration trench at least 15’ away for foundation walls.

Once we define the capture area we can start the process of sizing the rain garden based on the infiltration rate of the soils and desired storage capacity.



In areas that have no or very slow infiltration in the undisturbed area, an underdrain is added to assure water does not pond in the trench. The water is conveyed to the sewer system or to a surface waterway.

There are still benefits to using bio-infiltration in these situations:

- Cleaner water
- Reduced and delayed runoff surge
- Habitat creation
- Reduced water temperature
- Increase in aesthetics

Run off is calculated using site specific information

Site Information		
Type	**Area**	**Runoff coefficient**
Roof	3,000 s.f.	0.75
Lawn	7,168 s.f.	0.18

Design Storm Information			
	Precip. Frequency		
Duration	**1 year**	**2 year**	**5 year**
5-min	0.315	0.376	0.455
10-min	0.489	0.587	0.707
15-min	0.600	0.717	0.868
30-min	0.794	0.96	1.19
60-min	0.969	1.18	1.49
2-hr	1.100	1.34	1.69
3-hr	1.170	1.41	1.78
6-hr	1.410	1.7	2.11
12-hr	1.660	1.98	2.45
24-hr	1.950	2.32	2.83

Data from NOAA Precipitation Frequency Data Server 8/10/11, Station Name: Emsworth L/D Ohio River, 36-2574; http://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=pa

- Determine surface types and area,
- And runoff coefficients
- Chart selected design storms

Runoff Volumes are then calculated to size the RGA

Runoff Volumes						
	Precip. Frequency					
Duration	1 year		2 year		5 year	
5-min	1,115 c.f.	8,342 gal.	1,331 c.f.	9,958 gal.	1,611 c.f.	12,050 gal.
10-min	1,731 c.f.	12,950 gal.	2,078 c.f.	15,545 gal.	2,503 c.f.	18,723 gal.
15-min	2,124 c.f.	15,890 gal.	2,538 c.f.	18,988 gal.	3,073 c.f.	22,987 gal.
30-min	2,811 c.f.	21,027 gal.	3,399 c.f.	25,424 gal.	4,213 c.f.	31,515 gal.
60-min	3,430 c.f.	25,662 gal.	4,177 c.f.	31,250 gal.	5,275 c.f.	39,459 gal.
2-hr	3,894 c.f.	29,131 gal.	4,744 c.f.	35,487 gal.	5,983 c.f.	44,756 gal.
3-hr	4,142 c.f.	30,985 gal.	4,992 c.f.	37,341 gal.	6,302 c.f.	47,139 gal.
6-hr	4,992 c.f.	37,341 gal.	6,018 c.f.	45,021 gal.	7,470 c.f.	55,879 gal.
12-hr	5,877 c.f.	43,962 gal.	7,010 c.f.	52,436 gal.	8,674 c.f.	64,883 gal.
24-hr	6,903 c.f.	51,642 gal.	8,213 c.f.	61,440 gal.	10,019 c.f.	74,946 gal.

- Runoff Volume in Cubic Feet=

  A x C x P

  A= Area

  C= Runoff Coefficient

  P=Precipitation

- Runoff Volume in Gallons=

  c.f. x 7.48051948

Calculate Infiltration Rate

Native Soils Infilration Rate
$D=T_pK$
D=Depth
T_p=Permited ponding time, here 3 days or 72 hours
K=infilration rate in ft/day, here .54 x .5*
D=72 x .54 x .5
D= 19.44
* "Soil infiltration rate K depends on soil texture. During construction, compaction must be avoided in order to preserve infiltration capacity. Nevertheless, inadvertent compaction and sedimentation reduce infiltration rate, so in design a safety factor is applied to K, commonly equal to 0.5; in other words, the infiltration rate used in design is in effect half of the value indicated the soil texture." -Landscape Graphic Standards

- Generate custom report from USDA Web Soil Survey

http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm

- Look up infiltration rate in Landscape Graphic Standards
- Calculate infiltration rate based on soil classification
- Use Infiltration rate from the infiltrometer

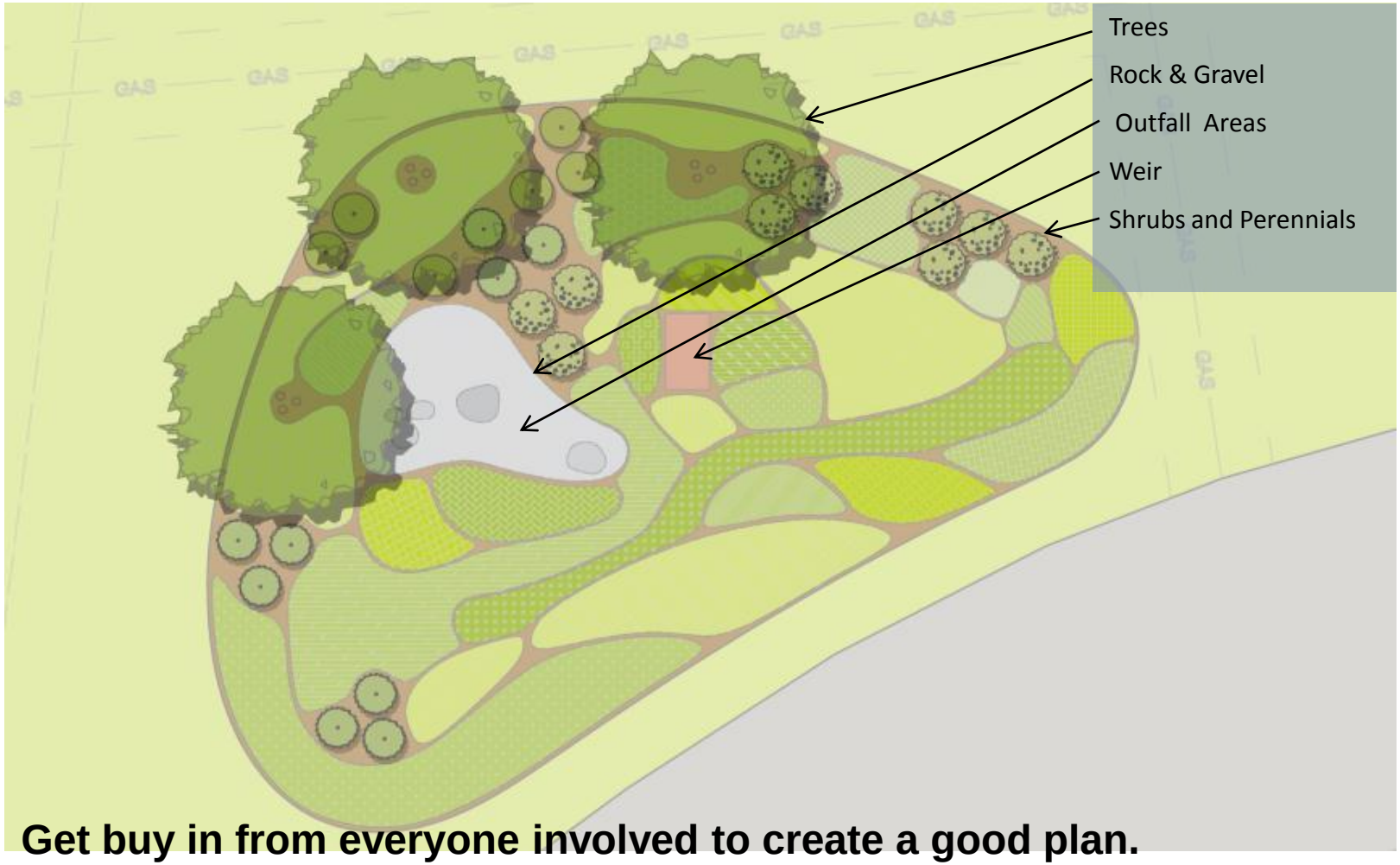
Calculate storage capacity per S.F. of Rain Garden

Storage Capacity per s.f. of rain garden				
S=RP+D				
S=Soil Water Storage				
R=Rooting Depth				
P=Porosity of material Gravel= 0.4 Soil= 0.6				
D=Depth of ponding				
	Depth of Soil (gravel bed 1/2 of soil depth)			
Height of Weir	**1**	**2**	**3**	**4**
12 in.	13.5 gal./s.f.	19.4 gal./s.f.	25.4 gal./s.f.	31.4 gal./s.f.
18 in.	17.2 gal./s.f.	23.2 gal./s.f.	29.2 gal./s.f.	35.2 gal./s.f.
24 in.	20.9 gal./s.f.	26.9 gal./s.f.	32.9 gal./s.f.	38.9 gal./s.f.

- Look up porosity rates of material based on soil report
- Calculate Storage Capacity per Square Foot of Rain Garden

*Note: This **does not** include absorption rates of plant materials.

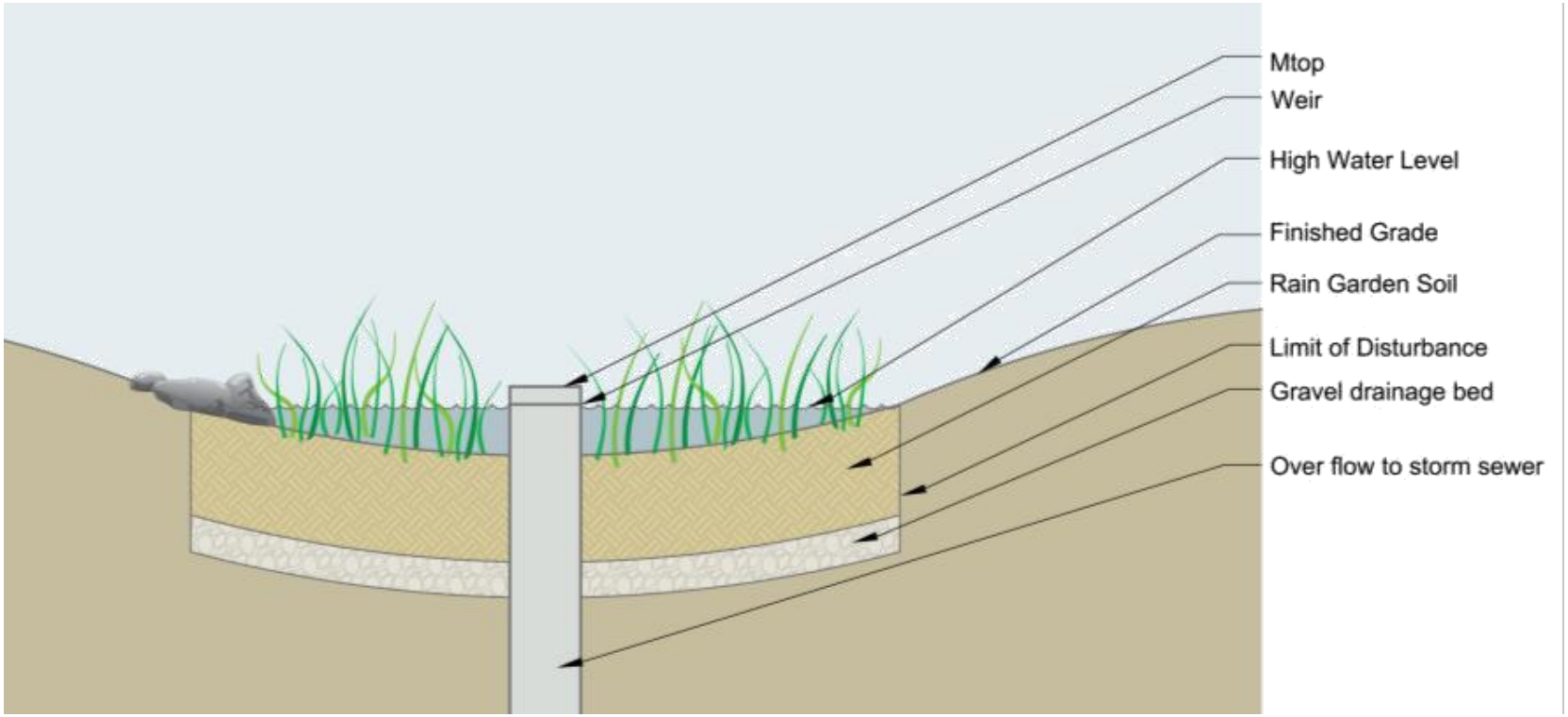
Rain Garden Plan



Get buy in from everyone involved to create a good plan.

A common problem is that maintenance personnel do not have an understanding of what is being accomplished.

Typical Section of a RGA



Lets get started building our RGA

- We first need to place a PA-ONECALL: 1-800-242-1776 to get all utilities marked.
- Layout the area to be excavated
- Assure the E & S controls are in place
- Determine the topsoil stockpile area location

Proper excavation equipment is key to successful construction.

The contractor should be able to reach into the area without entering it which avoids compaction.

Building a weir on an existing storm inlet.

Notice the excavated area is not being occupied by heavy machinery.

Adding Gravel drainage layer

Again, no equipment is in the RGA causing compaction.

Infiltration soil can be made on site by amending existing topsoil. Note the straw being used instead of geo-textile.

Finished Grading

Time to get the area stabilized ASAP.

Planting needs to be done quickly after the infiltration soils are placed. Do not allow the soils to sit for months getting fouled with silt.

Completed Garden

Picture taken after 4 days of steady rain

2 years later the plantings have grown in.

Common construction problems we have encountered.

- Poor / No Drainage
- Ground water infiltration
- Poor project sequencing
- Excessive use of geotextiles
- Inadequate design criteria

This excavation filled to the top the night after we dug it and had to be pumped out. After the underdrain was installed it never held water again.

Ground water in the bottom of the excavation is a bad sign.

Remember this slide?

Lets talk soils: what is the secret to success??

- Water moves in the soil column from large pore spaces into smaller pore spaces thru the action of adhesion and cohesion
- Water molecules wrap themselves around the soil particle and gravity pulls them down through the soil column thru adhesion
- The water particles coheir to one another and pull themselves down into soil.
- When the water reaches the inverse condition- small to large pore space, the molecules of water must reach saturation to keep moving downward. This condition creates a saturated zone in the soil. The rule of thumb is that the saturation zone is 30% of the soil depth.

Sand- 50-60% by volume is optimum for maximum drainage in your rain garden soil blend.

Asphalt sand is best, not mason sand.

You can tell you have enough sand when you cannot make a ball and bounce it in your hand or make a ribbon.

Clay soils will form a tight ball and make a long ribbon.

Organic matter- 20-30%

- Stabilized compost absorbs and holds water and cleans nutrients from the soil with biologic activity.

- If your project is funded with any money that comes from an EPA grant the compost will have to go through rigorous testing to assure there are no heavy metals in the compost.

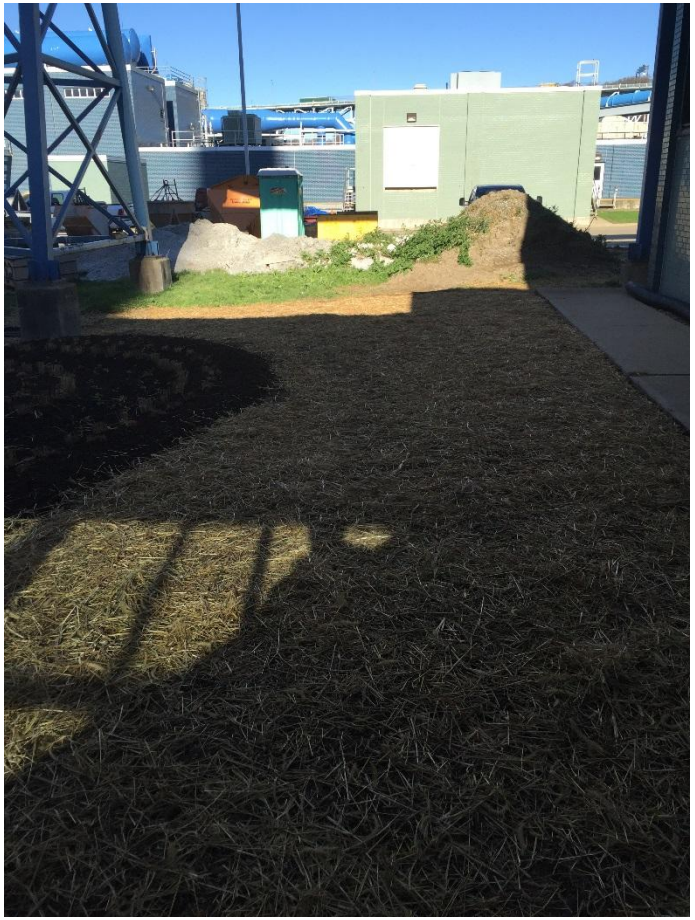
- The US Composting Council has a certification program called STA compost. The certified compost has been tested at the produce to assure quality and healthy compost.

- Do not use organic matter that has not been properly composted.

Topsoil in the mix – 20%

- Topsoil provides micro nutrients and promotes good plant growth.
- Using existing site top soil is the most economical if you can process it on site to remove any sods, roots, rocks and clumps.
- Do not process the topsoil if it is wet
- Blending the mix is the critical step. **Do not over blend!** Over blending coats the sand particles with soil creating cement.

Once the soils are installed into the RGA, get the area around the RGA seeded or stabilized ASAP.



Poor site management causes big problems. This rain garden on a construction site was being used as a lay down area during the winter.

This is a problem with project sequencing. The only good solution is to remove the geotextile and replace if you are forced to use the stuff.

Plugged geotextiles are the enemy of good infiltration.

This geotextile was fouled despite silt sock barrier.

Here is a well protected trench pre-soil. We were able to get the design team to switch the geotextile to straw.

This is an exfiltration trench, water is coming from the street into this gravel “tank” and then infiltrating into the soils. We were not worried about the fabric plugging here.

Extreme example of no drainage. Water can stand no longer than 72 hours before mosquitos start breeding.

Auguring can solve some drainage problems in the right type of soils. If you can enter a rock or shale layer the water will start percolating.

Additional underdrainage can be added to alleviate ponding.

This one is holding water!

It is supposed to! It has a liner. Know the design professional's intent before you start maintenance.

Little to no water is a big problem as well as too much water. This rain garden was sited in such a way it will receive almost no surface water.

Early spring can be deceiving with rain gardens and standing water. This rain garden is fine, the underlying soils are still frozen.

More early spring ponding. This condition is only temporary for a couple of days each year.

Weeds and tree seedlings are a common problem just as they are in regular landscapes.

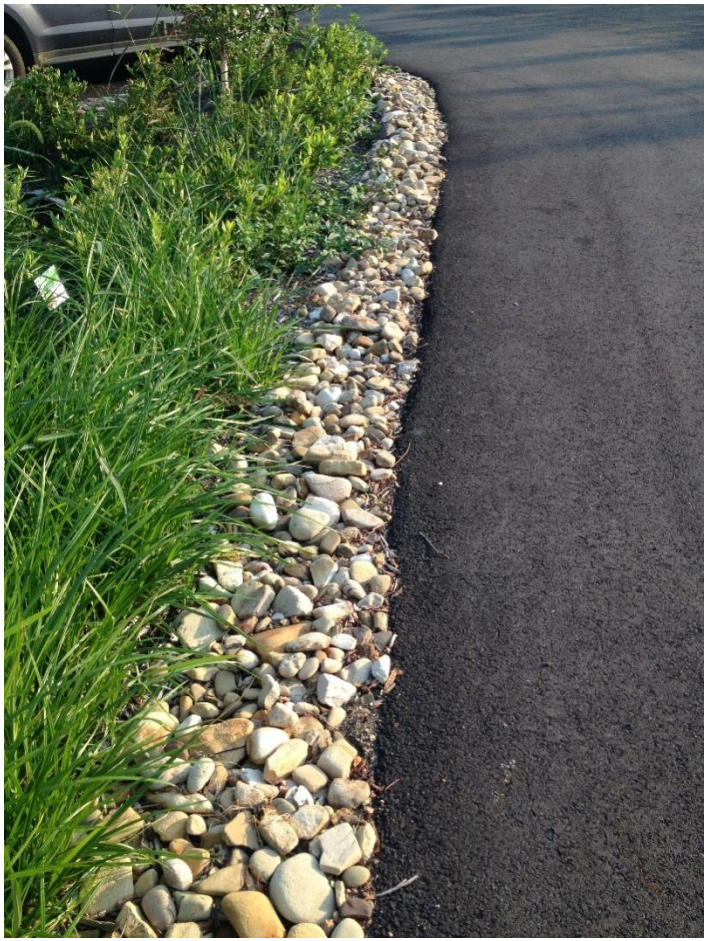
Nutsedge is a huge problem. Moist organic soils are a perfect habitat for Nutsedge.

Rain garden short circuit and excessive siltation from parking lot runoff. Not enough water is going to enter this rain garden to do any good. Notice the fouling of the surface.

Erosion is a common problem, these curb cuts are too small. The solution would be to make them larger and farther away from the inlet.

Here is a good example of erosion from concentrated inflow, again the rain garden needed more curb cuts.

Armoring the edge prevents erosion but be careful not to dam out the sheet flow.



Communication failures cause large headaches for everyone involved who are creating new and different solutions to old problems.

The average person does not understand what we are trying to accomplish, they just know it looks different than what they are used to seeing.

Good signage is the solution to keeping everyone happy.

Common maintenance problems

- Poor / No Drainage
- Dead and dying plants
- Weeds
- Little or no water entering rain garden
- Litter
- Blow outs

Plant Selection Criteria

- Can tolerate standing water
- Can tolerate dry conditions
- Native plants (or cultivars) are best. Plant communities :
  - Moist Prairie
  - Bottom Lands
  - Seasonal Wetlands
- Seasonal color and foliage
- Wildlife value

Trees and Shrubs for Rain Gardens and Bioswales

Plants	Dimensions	Colors
Amelanchier arborea **Common Serviceberry**	15-25' high 12-15' spread	White Spring Flowers
Betula nigra **River Birch**	30-50' high 15-35' spread	Tolerates dry or moist soils. Peeling bark reveals cinnamon inner bark
Ceanothus americanus **New Jersey Tea**	3-4' high 3-5' spread	White Spring Flowers that attract butterflies and hummingbirds
Celtis occidentalis **Hackberry**	40' high 30' spread	Rough corky bark that resists damage. Adaptable to many soil conditions and pH
Cornus amonmum **Silky Dogwood**	6-10' high 6-10' spread	Clusters of white flowers in Spring, blue fruits with white blush in Fall.
Cornus sericea **Redosier Dogwood**	7-10' high Equal spread	Fast growing, Very adaptable, Red Winter bark
Crataegus viridis 'Winter King' **Winter King Hawthorn**	20-25' high Equal spread	White flowers, red berries in Winter. Silver Bark
Hydrangea arborescens **Wild Hydrangea**	3-5' high 3-5' spread	Huge White Flowers from June to September
Ilex glabra 'Densa' **Inkberry Holly**	3-4' high 4-5' spread	Strong Environmental adaptability. Selected from native species. Glossy Evergreen
Itea virginica **Sweetspire**	6' high Equal spread	White late-Spring flowers Blue Summer Berries
Lindera bezoin **Spicebush**	6-8' high 6-8' spread	Yellow Spring Flowers
Myrica pennsylvanica **Bayberry**	5-7' high 4-6' spread	Nitrogen-fixing Gray-Blue berries in Fall-Winter
Ostrya virginiana **American Hornbeam**	25-30' high 16-20' spread	Graceful small tree, slow growing. Dark leaves
Physocarpus opulifolius **Ninebark**	5-10' high 10-12' spread	Rugged native, sun or shade. Flowers in May and June, reddish fruit in Sept and Oct
Rhus aromatica **Fragrant Sumac**	3-4' high 6-8' spread	Dependable and Hardy Fall Color; Yellow to Red
Sambucus canadensis 'Johns' **Johns American Elderberry**	5-12' high 5-12' spread	Multi-stemmed shrub. White flowers in early summer followed by clusters of purple/black fruits in August/Sept.
Spiraea albiflora **Japanese White Spiraea**	2-3' high 2-3' spread	White flowers framed by rich green foliage from June to August
Viburnum dentatum **Arrowwood**	4' high 4' spread	White Spring flowers, Blue Summer berries Excellent berry for song birds through Winter
Viburnum trilobum 'Compactum' **Cranberrybush Viburnum**	4-6' high Equal spread	Compact form. Selected from native species. White Spring Flowers

Perennials for Sunny Rain Gardens and Bioswales

Note: Plants listed as cultivars are used because the parent plants are not in production

Andropogon gerardii **Big Blue Stem**	4-6' high	Upright divergent shape Silvery, blue green foliage
Asclepias incarnata **Pink or Swamp Milkweed**	5' high	Bears dusty pink panicles in July
Aster divaricatus **Wood Aster**	2-3' high	Small, white (pink or blue) daisies on purple stems
Aster dumosus 'Woods Pink' **Wood's Pink Aster**	12-18" stems	Beautiful, pink flowers late in Summer, resistant to mildew
Aster dumosus 'Woods Purple' **Wood's Purple Aster**	12-18" stems	Purple flowers late in Summer
Aster novae-angliae 'Alma poetschke' **New England Aster**	36-42" stems	Rose pink flowers. Large and long-flowering, Aug till frost
Aster novae-angliae 'Purple Dome' **Purple Dome New England Aster**	1.5-2' high 1.5" daisies on 15-18" stems	Mildew and rust resistant
Caltha palustris **Marsh Marigold**	12-18" high	Large bright yellow flowers with deep green leaves in early Spring
Echinacea purpurea **Purple Coneflower**	2-3' high	Early Summer Purple flowers
Elymus arenarius **Blue Dune Lyme Grass**	2-3' high	Bright blue foliage
Eupatorium maculatum 'Gateway' **Joe-Pye Weed**	5-7' high	Bushel basket size, lavender-pink flowers on wine-colored stems
Helenium autumnale **Common Sneezeweed**	30" high	Compact form, vivid red flowers with irregular gold edging
Heliopsis helianthoides 'Summer Sun' **Oxeye 'Summer Sun'**	3-4' high	3-4" orange daisies blooms
Hemerocalis fulva **Orange Daylily**	3' high	Orange Summer flowers Long bloom time
Liatris spicata 'Kobold' **Blazing Star**	24-36" high	12-15" fluffy spikes of violet-lavender spikes midsummer
Lobelia cardinalis **Cardinal Flower**	24-28" high	Bright red flowers on dark green foliage in late summer
Lobelia siphilitica **Great Blue Lobelia**	2-3' high	Blue flower spikes in Aug and Sept, dark green foliage
Monarda didyma **Bee Balm "Marshall's Delight"**	2-3' high	Rich pink Summer flower. Mildew and deer resistant
Panicum virgatum ***Switchgrass***	4-5' high	Large fine textured, airy masses of pink flowers in Aug-Nov
Penstemon digitalis 'Husker Red' **White Beardtongue**	2-3' high	Deep bronze purple leaves small white bells on dark pink stem
Rudbeckia laciniata **Green-headed Coneflower**	3-12' high	cone-shaped, greenish-yellow centers and back-tilted golden rays

Solidago rugosa 'Fireworks' **Fireworks Goldenrod**	36-48"high	Compact clump forming plant with radiating golden yellow firework like flowers
Verbena hastate **Blue Vervain**	2-5' high	pencil-like flower spikes with ring of blue-purple flowers
Vernonia noveboracensis **New York Ironweed**	4-7' high	Similar to Joe Pye weed but with masses of deep purple flowers in late Summer
Veronicastrum virginicum **Culver's Root**	2-6' high	Elegant late summer color of white flowers, possibly pale pink

Perennials for Shady Rain Gardens and Bioswales

Plants	Dimensions	Descriptions
Caltha palustris **Marsh Marigold**	12-18" high	Large bright yellow flowers above shiny deep green leaves in late spring
Chelone glabra **White Turtlehead**	1-4' high	Pale, pinkish white flowers August-September
Geranium maculatum **Wild Geranium**	12-16" high	Late spring pale pink flowers with red-brown foliage
Iris versicolor **Northern Blue Flag**	24-36" high	Lavender-purple blooms early summer
Luzula acuminate **Hairy Woodrush**		Grass-like leaves and small greenish or brownish flower in dense spikes
Mertensia virginica **Virginia Bluebells**	12-24" high	Pink flower buds open to blue bell-shaped flowers. Foliage dies in mid summer
Phlox panculata 'David' **Summer Phlox**	4-5' high	Bright white clusters of fragrant flowers in Summer
Phlox panculata 'Eco Pastel Dream' **Summer Phlox**	36-42" high	Broad pastel lavender-pink flowers. Mildew resistant
Polemonium reptans 'Stairway to Heaven' **Spreading Jacob's Ladder**	12" high	Broad, cream variegated foliage tinged pink. Bears pink flowers
Senecio aureus **Golden Ragwort**	30" high	Bears golden yellow flowers in spring
Sisyrinchium angustifolium **Blue-eyed Grass**	1-1.5' high	Light blue, star shaped flowers with yellow centers
Tradescantia virginiana 'Concord Grape' **Spiderwort**	15-18" high	Narrow rush like, gray-blue foliage with rich purple flowers

Questions?

G. Eric French
President, Eisler Landscapes Inc.
Eric@EislerLandscapes.com
(724) 865-2830

Eisler LANDSCAPES

3 Rivers Wet Weather