Storage Capacity in Step Pool Stormwater Conveyance Systems

John Whelan; Advisors: Dr. Karen Prestegaard; Rosemary Fanelli
Department of Geology, University of Maryland at College Park

I. Problem

- Stream restoration practices are designed for stormwater and erosion management, thus it is important to document whether they function as planned. Because Step Pool Stormwater Conveyance (SPSC) systems are a relatively new method of restoration, there is little field data available on their performance. For these systems to function as stormwater retention sites, however, they must be able to infiltrate and store stormwater or to store stormwater in surface pools. Groundwater monitoring will help to determine if these SPSC systems have sufficient subsurface storage capacity to be viable options for stormwater retention and water quality remediation.

II. Hypotheses

1. These SPSC systems are built of sand and gravel and should have high infiltration capacities due to high sand permeability.
2. Therefore, stormwater retention limitations are due to limited storage rather than infiltration capacity.

III. Study Site

- The site I will be monitoring is the Carriage Hills tributary in Annapolis MD. This site has both a restored SPSC system as well as a urban, incised channel.

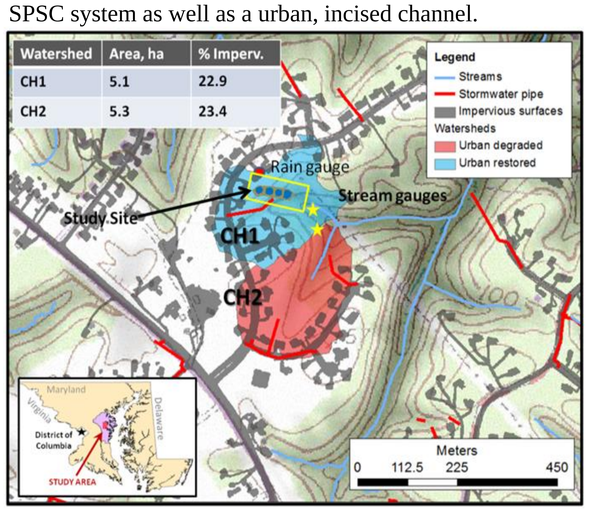
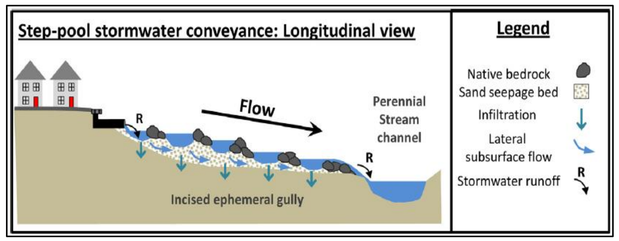
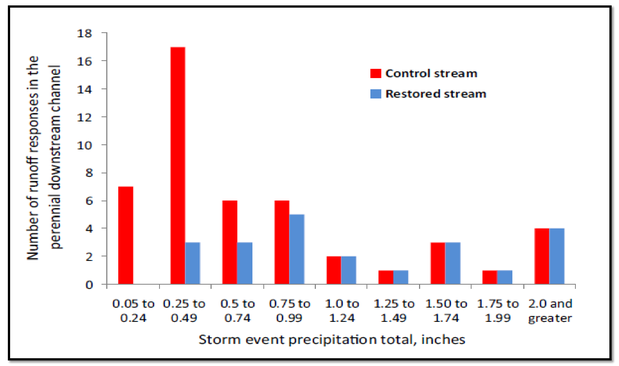


Diagram from R. Fanelli

IV. Previous Work



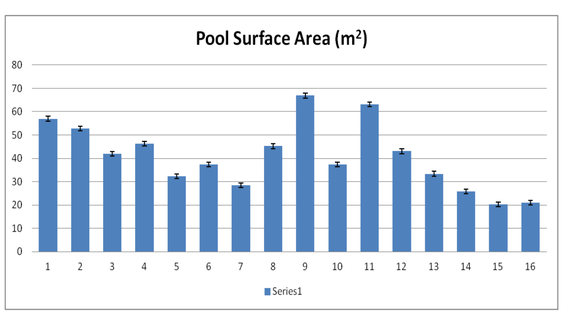


Upper diagram shows a conceptual diagram of a SPSC system. The lower diagram shows runoff responses for the restored and un-restored stream at Carriage Hills. For storms with precipitation of more than one inch, there were equal numbers of runoff responses (Palmer et al., 2013)

V. Measurements

1. Infiltration Rate
   - Single ring infiltrometer using the falling head method. All pools will be tested for 2 seasons.
2. Water Table Elevation
   - Wells were installed in several pools throughout the system, head measurements are taken weekly. Selected wells will be instrumented with data loggers.
3. Pool Surface Area
   - Surface area was measured for all 16 pools
4. Soil Stratigraphy
   - Sediment samples were collected at measured depths to obtain depth from the surface to clay layer

VI. Results: Pool Surface Area



- Surface area measurements for all sixteen pools in the SPSC system at Carriage Hills (CH1)

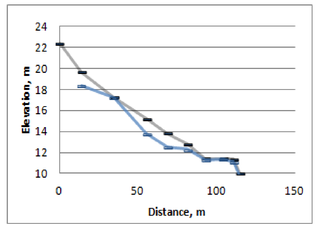
VII. Infiltration Rate

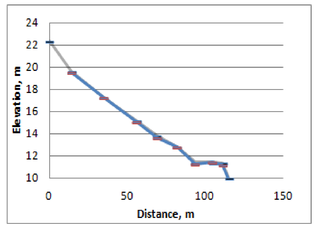
-Infiltration rate was measured in four pools throughout the system. In each selected pool, three separate infiltration measurements were made to identify heterogeneities.

Infiltration Rate=Q/πr²t

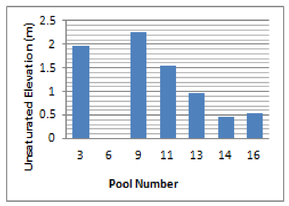
Site	Pool 1	Pool 4	Pool 9	Pool 13
Mean infiltration rate, cm/hr	8.5E-03	1.3E-02	9.1E-03	2.0E-02
Variance, cm/hr	8.5E-07	3.7E-05	1.4E-05	3.4E-06
Standard deviation, cm/hr	9.2E-04	6.0E-03	3.7E-03	1.8E-03

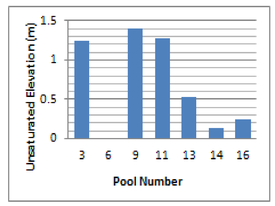
VIII. Water Table Elevation





- These graphs (above) show the subsurface behavior of the pools on two separate days. The left profile was measured two days after a significant precipitation event and the profile on the right was measured a few hours after a rain event.





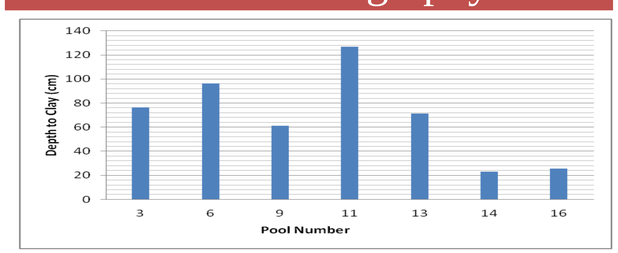
Unsaturated Zone Thickness (m)	Area (m^2)	Sy	Subsurface Area (m^3)
1.11	41.33	0.10	4.57

Unsaturated Zone Thickness (m)	Area (m^2)	Sy	Subsurface Area (m^3)
0.69	41.33	0.10	2.85

- Unsaturated zone thickness was used to calculate subsurface storage space for the two dates:

Subsurface Area= Area*Specific Yield*Unsaturated thickness

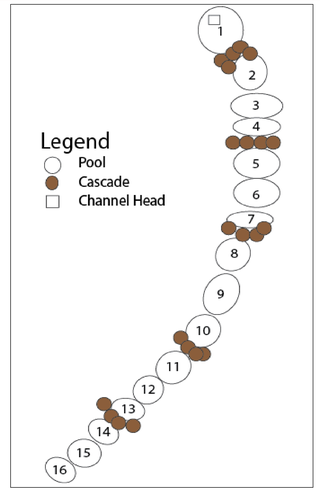
IX. Soil Stratigraphy



The depth to a low conductivity layer was measured during The installation of each well. Permeable thickness is 60-120 Cm in pools 1-13, but less than 25 cm in the lower pools

X. Restored Stream Schematic

- A schematic diagram of the SPCS is shown on the right. Preliminary Data suggest spatial Differences in ground Water heads, due to Heterogeneities in Permeability or Drainage. Therefore, I will install wells and Conduct infiltration Measurements in all 16 pool systems.



XI. Future Work

1. Continue to monitor the water table elevation (total head) on a weekly basis
2. Install wells in the remaining pools as well as in various locations in the adjacent un-restored channel
3. Conduct additional infiltration tests and slug tests in both the restored and un-restored channels
4. Install pressure transducers in several wells to collect continuous data during the summer (hydrographs)
5. Sieve analysis will be done to obtain grain size distribution for surface sediments and cores.

XII. Conclusions

- Preliminary data suggest that stormwater is being stored in the system; however infiltration and slow drainage rates seem to be limiting the effectiveness of stormwater retention due to poor drainage between events.

XIII. References

Palmer, M. A., Filoso, S., & Fanelli, R. M. (January 01, 2014). From ecosystems to ecosystem services: Stream restoration as ecological engineering. Ecological Engineering, 65, 62- 70.