The Pioneer Grant Program

The 2016 Pioneer Grant Program aims to reduce nutrient and/or sediment contaminant loads to the Maryland portion of the Chesapeake Bay and Maryland Coastal Bays from any nonpoint source: agriculture, urban or suburban stormwater, air, and septic by seeking proposals that focus on new techniques, information, or programs that increase the rate at which load reductions can occur.

Chesapeake Rivers Association, Inc

The Effectiveness of Regenerative Stormwater Conveyance Structures

2010-2012

Project Track: New Information

Research Question: How effective are regenerative stormwater conveyance structures at reducing nutrient runoff and total suspended soilds?

Research Results: The main objective of this monitoring effort was to assess the effectiveness of two types of Regenerative Stormwater Conveyance (RSC) systems in the adjacent catchments of Brewer and Clements Creeks in the Severn River watershed. In the Brewer Creek catchment, the conveyance system is a sand seepage wetland complex implemented in a lowland channel reach near the tidal interface. At Clements Creek, the conveyance system includes a series of step pools constructed in a zero-order stream at the top of the watershed. The effectiveness of each system should be determined by its ability to attenuate runoff and reduce loads of nitrogen, phosphorus, and total suspended solids (TSS) exported to downstream waters under a wide range of hydrological conditions.

PROJECT PARTNERS

Severn RIVERKEEPER®

University of Maryland CENTER FOR ENVIRONMENTAL SCIENCE CHESAPEAKE BIOLOGICAL LABORATORY

ANNE ARUNDEL COUNTY MARYLAND

Chesapeake Rivers Association, Inc

The Effectiveness of Regenerative Stormwater Conveyance Structures

2010-2012

Summary of Project

Monitoring Sites

The Seepage Wetland Complex at Howards Branch (SWC): Designed by Underwood Associates, the sand seepage wetland complex was built in 2001 in a stream reach 737-feet long and 120-feet wide just above the tidal interface of Howards Branch. The reach drains an area of 94 ha of forest and low-density residential land, and a floodplain ranging between 10-15 feet in elevation.
Clements Creek's headwater RSC: Designed by Biohabitats and constructed by Underwood Associates, this RSC was implemented in the winter of 2009-2010 by the Severn Riverkeeper Program in a severely eroded intermittent stream that turned into a ravine because of a piped County stormwater outfall installed at the top of the stream in the community of Carriage Hills. Before construction, the eroded stream channel was 10 to 20 feet deep, extending for about 400 feet and dropping in elevation by about 50 feet. The construction of the RSC involved filling the eroded stream reach with a sand/compost mix to create a series of step pools, berms, and riffle weirs. The stream reach drains an area of about 5.7 ha within the Hockley Branch tributary system.

Monitoring Approach

The Seepage Wetland Complex at Howards Branch (SWC): The effectiveness of the SWC that was implemented several years ago at Howard's Branch was monitored using the mass balance approach, where water discharge and pollutant loads entering the stream reach upstream of the restoration are compared with the discharge and loads exiting the restored reach downstream. Pollutant loads are calculated as a product of discharge and concentrations, therefore, water samples for determination of concentrations and discharge data were collected during a wide range of hydrological conditions, including baseflow and stormflow conditions. During baseflow conditions, water samples were collected monthly, while during stormflows they were collected on an event basis. Instantaneous discharge was measured immediately prior to baseflow sampling and also during different stage levels in order to construct a discharge rating curve (stage-discharge relation). The rating curve was used to predict discharge when no observed data were available.
Clements Creek's headwater RSC: The effectiveness of the recently implemented RSC was assessed by using a paired catchment approach, where the water discharge and pollutant loads in the restored stream were compared with those of an adjacent degraded stream (control). The drainage areas of the two streams had similar land use, topography, soil characteristics and climate, allowing us to determine the effects of restoration while accounting for climatologic and temporal variations during the study period.

Like for Howards Branch, water samples were collected regularly during baseflow conditions and on an event basis during storms. The only difference in the case of Clement's Creek is that samples were collected and discharge measured only at a downstream site in the restored stream and in a corresponding position in the adjacent control stream. Occasionally, samples were collected at the top of the streams.

Sampling Methods

At all sites, baseflow samples were collected manually (as grab samples) in 1L acid washed HDPE bottles. Stormwater samples were collected with automated samplers (Teledyne ISCO 6712 full-size portable sampler) in polyethylene 500 ml bottles at intervals of 5 to 15 minutes during different storm events, for the complete duration of the hydrograph (rising and falling limbs). Following collection, baseflow samples were filtered immediately in the field while stormflow samples were transported to the Chesapeake Biological Laboratory in ice coolers to be processed. In the laboratory, the unfiltered samples were stored in the refrigerator at 4oC and filtered within 8 hrs using glass fiber filters (GFF's) with a nominal pore size of 0.7 μm to separate dissolved and particulate constituents. Dissolved and particulate samples were stored in a freezer at -20oC prior to analysis at the CBL Nutrient Analytical Services Laboratory (NASL).

Hydrological measurements
Except for the downstream site at Howard's Branch, where a Pashall flume was installed to determine discharge, instantaneous discharge was measured at each site using the cross-sectional area method (Gordon et al. 2004). Discharge was measured immediately following sample collection during baseflow conditions and also at different stage heights during stormflow events. At each site, continuous stage height data was recorded in 5- to 10-minute intervals using pressure transducers (Onset HOBO water level loggers) installed within the stream bed. The pressure transducer data recorded was converted into continuous discharge data using a rating curve (stage-discharge relation).

In addition to continuous discharge, rain depth was measured continuously during the monitoring period using a tipping bucket rain gage (Onset HOBO RG3-M). The gage was installed in an open canopy area adjacent to the restored reach at Carriage Hills in the summer of 2011. Prior to installation of the rain gage, rain data were obtained from the National Climate Data Center (NCDC) for the BWI airport station.

Precipitation data were used in a rainfall-runoff model to determine unmeasured peak discharge and minimize error associated with extrapolating discharge estimates from the stage-discharge relation. In addition, precipitation data was coupled with the discharge data from each stream (restored and control) in order to determine whether or not the step-pool design modified the frequency of stream runoff responses to storms (i.e. the number of times that stormwater was conveyed downstream).

Parameters measured
All water samples were analyzed for a suite of chemical constituents, including:
Total dissolved nitrogen (TDN), dissolved organic nitrogen (DON), nitrate (NO3), ammonium (NH4), and N in particulate form (PN)
Total dissolved phosphorus and phosphate (TDP, PO4)
Total suspended solids (TSS)

Analytical Methods
Nitrate was determined using an ion chromatograph (Dionex IC 1000), following the EPA 300.0 Method for Inorganic Anions by Ion Chromatography. In this method, a small volume of water sample is injected into the ion chromatograph, and the anions of interest are separated and measured, using a system comprised of a guard column, separator column, suppressor device, and conductivity detector. When the anions are injected into the ion chromatograph, they are separated on an analytical column and a sodium carbonate/bicarbonate solution serves as a mobile phase. Once separated, the anions pass through an anion suppressor where they are converted to their

highly conductive acid forms and the sodium carbonate/ bicarbonate eluent is converted to very weakly conductive water. The separated anions in their acid forms are measured by conductivity and are identified on the basis of retention times compared to standards.

Ammonium (NH4) was determined using the Berthelot Reaction method (Kerouel and Aminot 1987) in which a blue-colored compound similar to indophenol forms when a solution of ammonium salt is added to sodium phenoxide, followed by the addition of sodium hypochlorite (Kerouel & Aminot, 1987).

Dissolved inorganic orthophosphate (P) was determined following the EPA Method 365.1 (1979). In the method, ammonium molybdate and potassium antimony tartrate react in an acid medium with dilute solutions of orthophosphate to form an antimonyphosphomolybdate complex which is reduced to an intensely blue colored complex by ascorbic acid. Color is proportional to orthophosphate concentration.

Total dissolved nitrogen (TDN) concentrations were determined on filtered water samples using the persulfate digestion method, where all N is converted into nitrate (D'Elia et al. 1977), and then passed through a granulated copper-cadmium column to be reduced to nitrite. The nitrite is determined by diazotizing with sulfanilamide and coupling with N-1- naphthylethylenediamine dihydrochloride to form a colored azo dye. Color is proportional to nitrogen concentration.
The potassium persulfate method was also used for determining total dissolved P (TDP) concentrations. The method consists of oxidizing organic and inorganic P to orthophosphate under heated acidic conditions. Ammonium molybdate and potassium antimony tartrate then react in an acid medium with dilute solutions of orthophosphate to form an antimony-phosphomolybdate complex, which is reduced to an intensely blue-colored complex by ascorbic acid. Color is proportional to orthophosphate concentration.

Particulate N, or the nitrogen content of the particulate matter retained on the GFF, was measured with a Perkin Elmer 2400 CHN Elemental Analyzer. In this method, samples are combusted in pure oxygen (O2) under static conditions. Products of combustion are passed over suitable reagents in the combustion tube where complex oxidation occurs. In the reduction tube, oxides of nitrogen (N) are converted to molecular N. The carbon dioxide (CO2), water vapor and N are mixed and released into the thermal conductivity detector where the concentrations of the sample gases are measured.
Total suspended solids (TSS) concentrations were determined by filtering a known volume of well mixed sample through a 47 mm pre-weighed GFF. Prior to filtration, each GFF was dried at 105oC overnight, cooled at room temperature in desiccators, and weighed. Following filtration, filters were frozen at -20 oC until analysis. Upon analysis, filters were dried at 105oC overnight, cooled at room temperature in desiccators, and weighed. Concentrations were calculated as the weight of the filter (minus the filter's weight) divided by the volume of water filtered. Results are expressed in mg/L. The detection limits associated with all the analytical methods described above are listed in Table 1.

Table 1. Parameters measured and method detection limits.

Parameter	Method Detection Limit
Nitrate + Nitrite, mg/L as dissolved N	0.01 mg/L
Ammonium, mg/L as dissolved N	0.004 mg/L
Orthophosphate, mg/L as PO4-P	0.0007 mg/L
Total Dissolved Nitrogen (mg/L as N)	0.006 mg/L
Total dissolved P, mg/L as PO4-P	0.0015 mg/L

Particulate Nitrogen (mg/L) as N	0.006 mg/L
Total Suspended Solids (mg/L)	2.4 mg/L

Results
Clements Creek's headwater RSC: Baseflow samples were collected at the modified (restored) and control headwater streams of Clements Cr. in Carriage Hills from January, 2011 to Sept, 2012, with a total of 23 baseflow samples collected at each site throughout this period. Stormflow sampling started a few months later, and included the period between April, 2011 and Sept. 2012, with a total of 16 different storm events targeted for sample collection. However, out of the 16 events, only 14 resulted in successful water sampling. Technical problems associated with equipment prevented successful sampling in the two events.

During the storm events with successful sampling, a total of about 6 to 24 individual stormflow samples were collected from each site. However, stormflow runoff was not always produced in the restored stream, therefore, some of the storm events included only samples from the control site. Overall, about 800 individual samples were collected in both streams during stormflow conditions, and processed and analyzed.

The rain data collected with the tipping bucket rain gauge installed adjacent to the restored stream was combined with discharge information collected downstream of the restoration and at an equivalent position along the control stream to determine the frequency of runoff responses over a period of 1 year at each stream. The results show that the production of runoff during storm events was about twice as high in the degraded control stream compared to that of the restored stream below the step-pools. Consequently, out of the 14 storm events sampled successfully during the monitoring period, only 10 produced runoff in both, the control and restored streams. Essentially, samples were collected during storm events ranging between 0.31 and 6.78 inches, but only events larger than 0.64 inches produced simultaneous runoff in both streams.

In addition to reducing the frequency of stormflow runoff, the restored stream substantially reduced peak flows in comparison to the control stream for rain events larger than 0.64 inches. This indicates that the restoration reduced the export of pollutants in the stream associated with storm events smaller than 0.64 inches.

I estimated that the smaller storm events accounted for about 89% of the precipitation events during the monitoring period, but contributed to only about 37% of the total volume of water entering the study catchments during that period. For this reason, I predict that the effectiveness of the RSCs at reducing the annual loads of pollutants exported downstream is controlled by the capacity of the system to reduce pollutant concentrations and discharge during large events rather than by its capacity to reduce loads during smaller events. However, concentrations in storm water will play an important role.

Nitrogen – The water quality data obtained from stormflow samples collected at Carriage Hills show that flow-weighted mean total N concentrations (TN) were similar between the control and restored streams. In the control stream, concentrations varied from about 0.8 to 2.1 mg/L, while in the restored stream they varied between 0.3 and 2.3 mg/L (Fig. 5). In general, the highest flow-weighted mean concentrations were found in the control stream, and were associated with small rain events. However, concentrations were also relatively high in the restored stream during some events between 1 to 1.5 inches.

The relatively high concentrations of TN in the control stream during small storm events reveal a potentially strong groundwater source in these headwater streams, which is diluted during large rain events. In contrast, the cause for the relatively high TN concentrations in the restored stream during larger events is unclear, and it illustrates the complexity of the N dynamics in the RSCs. The fact that storms of similar sizes have completely different N concentrations in the restored stream may be an indication that different factors, such as the amount of residual water left in the stream pools prior to a storm event, rain intensity, water residence time, and the length of time between storm events act together to determine the fate of N in the restored stream runoff.

Out of the storms that produced storm runoff in both, the restored and control streams, nitrate concentrations were lower in the restored stream in 50% of the events, while ammonium concentrations were lower in 20% of them. Concentrations of TDN and TN were also lower in the restored stream in 50% and 60% of the events, respectively.

In the control stream, nitrate had the highest concentrations in the majority of the storm events sampled, but DON was present in significant amounts as well. In the restored stream, nitrate was dominant, but ammonium had relatively high concentrations in 30% of the events sampled. High water residence time in the stream pools, higher rates of organic matter decomposition (mineralization) and low oxygen concentrations in the water column may be important factors leading to the differences in the forms of dissolved N exported in the restored stream.

In both streams, most of the N exported to downstream waters was in dissolved form (TDN). Yet, the contribution of N in particulate form (PN) was sometimes as important as in dissolved form, especially in the control stream. For instance, in some of the largest storm events collected in the control stream, PN concentrations were about as high as TDN concentrations. Moreover, TDN concentrations during these storms were similar in the restored and control streams, indicating that a decrease in TN concentrations in the restored stream may be caused by lower PN concentrations rather than by retention of TDN.

Total Suspended Sediment – Flow-weighted mean concentrations of TSS in the monitored streams varied from less than 10 mg/L to more than 600 mg/L. The control stream had the highest concentrations, while they never surpassed 250 mg/L in the restored stream. Consistently, concentrations were higher in the control than in the restored stream, except in the events of November 2011 and April 2012.

There was large variation in flow-weighted concentrations among storms but storm size, determined by storm depth, did not seem to influence concentrations or determine the difference between the streams. For instance, the largest storm event sampled (approx. 7 inches) generated the highest peak discharges in both streams but did not result in the highest TSS concentrations. Also, for two storms of similar sizes (Apr and Jul 2012), flow-weighted mean concentrations were quite different.

One possible explanation for the disconnection between storm size and concentrations in the control stream might be that there is a source of TSS in the stream channel and, once this material is transported downstream during the rising limb of the hydrograph, concentrations decrease in the falling limb. In the restored stream, it is likely that TSS material in the channel is transported only after stream runoff topples over the step pools in the system. This scenario is illustrated in Figure 9, which shows that TSS concentrations in samples collected at consecutive intervals during superstorm Sandy (henceforth referred to as Sandy) increased first in the control stream and later in the restored stream.

Phosphorus – Flow-weighted concentrations of phosphate and TDP in the streams monitored at Carriage Hills varied from less than 0.001 to about 0.02 mg/L. Except for one event in July 2012, flow-weighted mean concentrations of P were always lower in the restored than in the control stream. Also, the variation in P concentrations did not seem to be associated with changes in precipitation depth since some of the highest concentrations observed in the control stream occurred during storms that accumulated less than 1 inch of rain as well as in storms with more than 2 inches.

Load reductions
Large storms accounted for most of the precipitation that entered the study catchment during the study period. Therefore, any reduction in flow-weighted mean concentrations of pollutants such as N, TSS and P during large storms can possibly yield to a considerable reduction in the annual loads exported to downstream waters.

According to our data, flow-weighted mean concentrations of TN and TSS were lower in the restored than in the control stream in 60% and 80% of the storm events sampled, respectively, when runoff was produced in both streams. Concentrations of TDP were also lower in the restored stream in 90% of the events. Therefore, assuming a similar distribution of storm sizes and load reduction rates for the entire year, it is possible to conclude that the control stream exported higher loads of TN, TSS and TDP than the restored stream during the monitoring period.

Large storms, such as Sandy (6.78 inches) for instance, do not necessarily produce the highest flow-weighted mean concentrations; yet, they can produce high loads of pollutants because of the magnitude of their discharge. In the case of TSS, I estimated that loads were, on average, about 70% lower in the restored than in the control stream during the storm events sampled. During the largest storm event, in particular, the restored stream exported nearly 70% less TSS than the control stream.

The rain events sampled contributed about 45% of the annual precipitation during the monitoring period, and the TSS loads associated with these events was 151 kg in the control stream versus 45 kg in the restored stream. And even though these numbers represent only a portion of the total annual loads, they provide a perspective of the load reduction potential (or export prevention) of this type of restoration.

Load reduction for TN was less dramatic, and may fall within the margin of accumulated errors associated with discharge estimates, sampling procedures and laboratory analyses. According to my calculations, the TN load in the restored stream during the 14 storm events sampled was about 72% of that in the control stream, and the amount of N load reduction was on the order of about 1 kg N. Again, the loads from the rain events sampled were just a fraction of the annual load. But even if we assume that the annual loads in the control and restored streams were 5 times as high as in the loads estimated for the events sampled, load reduction would still be in the order of about 1 kg N/ha/yr, which is not a significant amount in the overall scheme of load reduction efforts in the Chesapeake Bay.

The Seepage Wetland Complex at Howards Branch (SWC):

From the time when the monitoring program began at Carriage Hills, 23 baseflow samples were collected at Howard's Branch as well. However, limited access to the monitoring sites at Howard's Branch resulted in fewer storm events sampled there than in Carriage Hills during the same period (7 events at Howard's Branch versus 16 at Carriage Hills).

In the first 4 events sampled at Howard's Br., samples were collected at two sites; above and below the restored reach. In the 3 remaining events, however, stormflow samples were collected in 3 sites as the upstream site was substituted by 2 different sites located above the confluence of the small tributaries that drain into the restored reach. This substitution was necessary because the original site (upstream) became too shallow and too wide for proper discharge measurements and water sample collection due to sediment accumulation and hydrological changes in the system.

The rain depth of events sampled for stormflow at Howard's Br. ranged between 0.24 to 6.79 inches, and each event generated about 24 samples collected simultaneously in each sampling site. Therefore, the chemical data presented here for stormflow conditions are based on a total of about 190 and 210 stormflow samples collected in 2011 and 2012, respectively.

As mentioned before, stormflow samples were initially collected at Howard's Br. in two sites (upstream and downsteam of the restored reach), and later in 3 sites. The 2 sites were sampled throughout 2011 and the 3 sites in 2012. The sites sampled in 2012 included the same downstream site, plus two new sites upstream named forest and urban sites. These new sites drain forested and urbanized sub-catchments, respectively.

The flow-weighted mean concentrations of total N (TN) in the stormflow samples collected at Howard's Br. ranged from less than 0.25 mg/L to almost 2.5 mg/L, with the highest concentration observed in the upstream site during a 1-inch storm in May 2011. In 2011 (and in the years before, not included in this report), concentrations of TN were higher upstream of the restored reach than downstream. However, in the storm events sampled towards the end of 2011, and also throughout 2012, TN concentrations were usually higher downstream of the restoration than upstream (forest and urban).

Concentrations downstream were relatively high in comparison to those in the upstream forested site, which was expected. However, the fact that downstream concentrations were high in comparison to those in the urban site upstream was unexpected. I speculate that this change in the TN concentration patterns might have resulted from an increase in the direct connection between a seepage pond adjacent to the main channel and the stream reach near the downstream site.

According to field observations, the connection between this seepage pond and the main channel increased slowly since 2007 to the present, and now water runs directly from the pond into the downstream site during storm events. This pond receives discharge from a storm water drainage pipe from a community nearby, and thus has high concentrations of chloride and nutrients (data not shown here). As the pond water now runs to the end of the restored reach without going through sand berms, stream pools and floodplains, there is less opportunity for N processing and retention.

For the most part, the N in the downstream site was in dissolved form. However, the contribution of N in particulate form was considerable, especially during the last storm event sampled in 2011 and in the last two in 2012.

In all sites sampled upstream of the restoration, including the upstream site sampled in 2011 and the two sites (urban and forest) sampled in 2012, N in particulate form contributed a significant amount to the total N. In fact, PN accounted for more than 50% of the N in storm flow in most of the events sampled in the upstream and forested sites. Yet, the contribution of N in dissolved form was significant, especially in the urban site.

In the urban site, most of the dissolved N (TDN) was in the form of nitrate during the July and August rain events and in the form of DON during Sandy. In the forest site DON and NH4 were equally important, except during Sandy. In the events sampled upstream in 2011, DON was often more important than nitrate, but the number of events sampled was too small to determine trends for any of the sites.

Downstream of the restoration, TDN was mostly composed of nitrate (NO3), followed by DON and then ammonium (NH4). DON was particularly important during Sandy (10/29/2012), while the contribution of NH4 was negligible.

In contrast to TN, flow-weighted mean concentrations of TSS were always lower downstream of the restoration than in the upstream sites, except in the forest site. The forest site usually had concentrations lower than the downstream site, except during Sandy, where rain depth was close to 7 inches. Interestingly, concentrations in the forest and urban sites were similar during this event, as well as during the preceding one, which was a significantly smaller event.

Flow-weighted concentrations of total dissolved P (TDP) ranged from about 0.010 to 0.030 mg/L, while concentrations of PO4 ranged from 0.003 to 0.012 mg/L. In both cases, the forest site had the highest values probably because of higher influence from groundwater and less surface runoff, as observed in streams of the Neuse River in North Carolina. In general, concentrations tended to decrease from the upstream sites to downstream, especially in the case of PO4.

Load reductions
The Howard's Br. restoration has been monitored since 2007 and the data collected has indicated that the restoration reduced up to 35% of the TN loads in stream water, especially because of retention of PN during large storms. Previous data also showed that the restoration potentially retained more than 50% of the TSS loads. However, these new data show a slightly different scenario.

During the 7 storm events sampled, discharge downstream was about equal to that measured in the upstream sites combined*. Therefore, changes in concentrations rather than in discharge will determine loads upstream and downstream, and thus the potential for load reduction in the system.

According to this new data, flow-weighted mean concentrations of TN were higher downstream than upstream of the restored reach in most of the events, except for the first ones collected in 2011. More importantly, concentrations were significantly higher downstream of the restoration during the largest event, Sandy. Consequently, it is unlikely that there was any significant load reduction of TN at Howard's Branch during the monitoring period.

It is still likely, however, that TSS loads were substantially reduced along the monitoring period, especially as flow-weighted concentrations downstream of the restoration were less than half those in the upstream sites during Sandy. Likewise, P loads potentially decreased, especially because of concentration reduction during Sandy.

Conclusions:

- The type of restoration at Carriage Hills resulted in load reduction for TSS, TN and TDP while the type of restoration at Howard's Branch likely reduced TSS loads and maybe TDP, but not TN. Therefore, the former type of restoration seems more reliable in terms of load reduction outcome than the latter.
- Given the magnitude of discharge at Carriage Hills versus Howard's Branch, loads are supposedly larger in the latter than the former, hence, load reduction may be more sizeable in the latter, especially for TSS. On the other hand, load reduction is probably similar on a per area basis. Therefore, costs associated with implementation should be an important consideration for these projects.
- It is likely that, for TSS, one restoration project like Howard's Branch is equivalent to 10 restorations in upper headwater channels with similar erosion problems in the Clement's Creek watershed. However, the effectiveness of Howard's Br. at retaining sediment may compromise its retention capacity in the future in addition to compromising other important ecosystem functions such as denitrification. The accumulation of fine sediment in the pools and ponds in the system may decrease denitrification rates. Therefore, ecosystem function trade-offs should be evaluated.

Project Evaluation

Obstacles encountered and corrective action

For the most part, the monitoring of the restoration project is on track, especially for the monitoring during baseflow conditions. However, a few setbacks (see below) put the monitoring of stormflow conditions somewhat behind schedule.

In the first month after the monitoring work officially started, it took us about a month or so to get all of the equipment installed in the field and properly tested. The amount of time that took us to fully install and properly test the equipment was not unusual. However, due to an unusually cold winter at the end of 2010 and beginning of 2011, we could not initiate sampling until spring of 2011.

In the beginning of spring in 2011, we successfully collected a set of 12 stormflow samples at the degraded control stream at Carriage Hills. At the time, however, we did not anticipate that the restored stream would not generate enough flow to trigger the automated sampler. Consequently, the first sampling effort resulted in the collection of samples only at the control site.

In order to readjust and avoid future problems, from then on we sought to target only storms larger than 0.25 inches and never encountered this problem again. At the same time, we found out that the steep slope of the streams monitored produced large amounts of debris and large sediment loads in the channels during storms, which often lead to equipment malfunction and damage. Therefore, several times stormflow sampling efforts resulted in no samples.

By mid spring, sampling started to occur more uneventfully. However, our main field assistant left the project at the beginning of the summer, which affected the number of storm events that we could sample. But even with limited amount of help, we have managed to collect 3 complete sets of storms in both the control and restored streams, which generated a large number of samples to process and analyze.

With our replacement field and lab technician who began working this month, we are now in the process of analyzing remaining samples, while we continue the sampling efforts in the field. In the next few months, we plan to collect at least 6 more storm events from both streams. We also plan to finish all of the lab analyzes, and complete our rating curves to calculate continuous discharge and annual loads.

Monitoring and Maintenance

Monitoring of the RSC is being performed by Chesapeake Biological laboratory scientists.

Community Involvement and Outreach Activities

Community outreach for this project will take place after the data has been collected and will center on presentation of the data at the Forum.

Partnerships

Severn Riverkeeper Program: -- charged with arranging the scientific monitoring of the two reaches (restored and degraded) in order to obtain data on the relative performance of the restored stream. Role is to serve as contract manager and facilitator for the envisioned RSC Forum, arrange stream access, provide all reporting and administrative requirements to funders, assemble information and coordinate production of reports, oversee project schedule, and insure dissemination of study findings to appropriate parties.

University of Maryland Center for Environmental Science – Chesapeake Biological Laboratory – Drs Solange Filoso and Michael Williams. In charge of directing the placement and maintenance of equipment, collection of water samples, and analysis of the data in determining the effectiveness of the restored stream in improving water quality. Will prepare a Final Report for publication and peer review and participate in the preparation of a PowerPoint Presentation for the RSC Forum.

CBL and Anne Arundel County Department of Public Works: are continuing to collect and analyze data from the previously restored reach at Howards Branch.

Accounting of Expenditures

CBT Funds: $65,000
Total Funds: $65,000