Briefing Paper#5 – Laboratory Simulation of Capping in the South River

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The objective of this research is a better understanding of mercury availability, mobility and methylation in sediments from South River, VA using laboratory studies and mathematical modeling to complement ongoing field studies. Although work to-date by the South River Science Team has led to estimates of the amount of methylation occurring in various portions of the river there remains uncertainty in these estimates. The goal of the current work is

1. To test the relative potential for methylation in representative areas of the river (fine-grained bank and channel deposits and coarse mid-channel deposits) to support refinement of the conceptual model of the river

2. To evaluate the ability to reduce mercury and methyl mercury impacts through management of small portions of the river, namely fine grained deposits, intermixed gravel and bank sediments.

The fine-grained sediment in near shore and bank areas may contribute disproportionately to methylation and the risk of the mercury in the river and also represent areas that could feasibly be managed through traditional sediment management approaches, i.e. bank stabilization and in-situ sediment capping or treatment. Mesocosms are being used to evaluate mercury availability, mobility and methylation rates in conditions representative of both subaqueous and bank sediments in the laboratory. The primary advantage of these mesocosms is the ability to allow development of representative redox profiles in the sediment, which is critical to the speciation of mercury and the rate of mercury methylation. We have demonstrated these tools at a number of contaminated sediment sites for the evaluation of contaminant migration and release in sediments for undisturbed conditions as well as after remediation by capping or in-situ treatment.

An additional component of the effort is to populate the mesocosms with benthic organisms in order to evaluate potential exposure and risk to such organisms and to evaluate both the ability of monitoring tools such as DGTs to evaluate that risk and the ability of management approaches, e.g. capping, to mitigate that risk.

The work will take place in two distinct steps

1. Baseline studies with sediments from RRM 3.5 and RRM 11.8 in each of the distinct sediment environments, bank sediments, near shore fine grained channel margin deposits, and interbedded gravel deposits
2. Studies of manipulation of the mesocosms with different treatment and/or capping approaches.

Current Status

Work to-date has been focused on developing the baseline studies of sediments from RRM 3.5 and RRM 11.8. Sediments were collected in early summer of 2013 and mesocosms have been set up to evaluate mercury availability and mobility and methylation. A summary of mesocosms constructed to date are shown in Table 1. Multiple replicates are used for each treatment.

Table 1: Mesocosm Experiment for the South River

Updated: 9/18/2013

RM and Deposit Type	Mesocosm Label	Type of Sample	Construction	Tubifex Added	Voltammetry	Overlying water DOC	DGT Deployment in Overlying Water***	Profiler DGT Deployment***	Coring	Extraction of Tubifex
11.8 Gravel Deposit	11.8-G-C1	Control	6/10/2013	-	Ongoing approx. every 3 weeks	Ongoing approx. every 3 weeks	Ongoing approx. every 2 weeks	9/24/2013	9/24/2013	-
	11.8-G-C2	Control with potting soil cap*	8/23/2013	-	Ongoing approx. every 3 weeks	Ongoing approx. every 3 weeks	Ongoing approx. every 2 weeks	9/24/2013	9/24/2013	-
	11.8-G-S1	Tubifex sample with potting soil cap*	6/10/2013, Cap added 8/23/2013	8/27/2013	Ongoing approx. every 3 weeks	Ongoing approx. every 3 weeks	Ongoing approx. every 2 weeks	9/24/2013	9/24/2013	9/24/2013
11.8 Bank Deposit	11.8-B-C1	Control	6/10/2013	-	Completed 9/3/13	Completed 9/5/13	Completed 8/25/2013	9/5/2013	9/5/2013	-
	11.8-B-S1	Tubifex sample	6/10/2013	8/8/2013	Completed 9/3/13	Completed 9/5/14	Completed 8/25/2013	9/5/2013	9/5/2013	9/5/2013
11.8 Fines Deposit	11.8-F-C1	Control	6/10/2013	-	Completed 9/3/13	Completed 9/5/15	Completed 8/25/2013	9/5/2013	9/5/2013	-
	11.8-F-C2	Autoclaved Control**	8/8/2013	-	Completed 9/3/13	Completed 9/5/16	Completed 8/25/2013	Approx. 11/10/2013	Approx. 11/10/2013	-
	11.8-F-S1	Tubifex sample	6/10/2013	8/8/2013	Completed 9/3/13	Completed 9/5/17	Completed 8/25/2013	9/5/2013	9/5/2013	9/5/2013
	11.8-F-S2	Tubifex sample	6/10/2013	8/8/2013	Completed 9/3/13	Completed 9/5/18	Completed 8/25/2013	9/5/2013	9/5/2013	9/5/2013
3.5 Gravel Deposit	3.5-G-C1	Control	6/17/2013	-	Ongoing approx. every 3 weeks	Ongoing approx. every 3 weeks	Ongoing approx. every 2 weeks	TBA	TBA	-
	3.5-G-S1	Tubifex sample	6/17/2013	TBA	Ongoing approx. every 3 weeks	Ongoing approx. every 3 weeks	Ongoing approx. every 2 weeks	TBA	TBA	TBA
3.5 Bank Deposit	3.5-B-C1	Control	6/17/2013	-	Ongoing approx. every 3 weeks	Ongoing approx. every 3 weeks	Ongoing approx. every 2 weeks	TBA	TBA	-
	3.5-B-S1	Tubifex sample	6/17/2013	TBA	Ongoing approx. every 3 weeks	Ongoing approx. every 3 weeks	Ongoing approx. every 2 weeks	TBA	TBA	TBA
	3.5-B-S2	Tubifex sample	6/17/2013	TBA	Ongoing approx. every 3 weeks	Ongoing approx. every 3 weeks	Ongoing approx. every 2 weeks	TBA	TBA	TBA
	3.5-B-S3	Tubifex sample	6/18/2013	TBA	Ongoing approx. every 3 weeks	Ongoing approx. every 3 weeks	Ongoing approx. every 2 weeks	TBA	TBA	TBA

*Potting soil cap was necessary to support T.tubifex community

**Established to compare to the background bioturbation of the mesocosms

***Date of Extraction

In the sediment collected for these studies from RRM 3.5, there was no separate predominately fine-grained near shore channel margin deposit and so only a bank deposit and intermixed gravel deposit were included in the study.

Initial efforts were focused on allowing sediments to develop natural redox gradients when saturated with water. Approximately 2 months was allocated to this development. In early August a benthic organism, *Tubifex tubifexi,* was added to selected mesocosms to evaluate mercury bioaccumulation and the ability of our monitoring approaches to predict that bioaccumulation. Although not representing a dominant species in the South River, these organisms are burrowing deposit feeders that will readily access a substantial volume of sediments and rapidly equilibrate with the sediment. That makes the organisms ideal to assess potential bioavailability and bioaccumulation. After approximately an additional month, selected mesocosms were sampled with coring and porewater measurement by DGT. Voltammetry was also employed to evaluate reduction to link to observed methylation rates. This data is currently being analyzed and interpreted and will be substantially complete for these initial baseline studies by the end of 2013. Initial analyses suggests a porewater total mercury (THg) concentration of the order of 1000 ng/L in all treatments. This is fortuitous since it will be easier to compare different remedial approaches in the future. Although the THg concentrations in porewater are quite uniform, the sediment characteristics are quite different between the fine-grained bank sediments and sand. This is expected to result in substantially different redox conditions and methylation rates. Analysis is ongoing.

Although only a partial indicator, an indication of the different redox behaviors in the various treaments can be illustrated by showing the oxygen levels as a function of depth (Table 2 mesocosm designations

ending in C# represent control mesocosms (no benthic organisms) and cells that end in S# are organism populated mesocosms. The resolution of measurements for this analysis is only 0.5 cm and indicates only the presence or absence of oxygen at detectable levels. As a result the measurements show some variability. The data suggest, however, that oxygen is rapidly consumed in the sediments and that organism populated mesocosms show deeper oxygen penetration than non-organism populated mesocosms. Because of the greater percentage of fine-grained deposits in the bank and fine grained sediment mesocosms, the activity of the deposit feeding organisms is greater in those mesocosms.

Table 2: Depth of Sediment Until Oxygen Depletion

Updated: 9/18/2013

RM and Deposit Type	Mesocosm Label	6/13/2013-6/17/2013	6/28/2013-6/29/2013	7/8/2013-7/9/2013	7/18/2013-7/19/2013	7/29/2013	8/9/2013-8/12/2013	8/13/2013	8/26/2013	9/2/2013-9/4/2013
11.8 Gravel Deposit	11.8-G-C1	0.5		1		1.5	1		1	
	11.8-G-C2	-		-		-	-		2	
	11.8-G-S1	1		1		1	1		1.5	
11.8 Bank Deposit	11.8-B-C1	0		0		0	0.5		1	1.5
	11.8-B-S1	0		0.5		1	1		1.5	1
11.8 Fines Deposit	11.8-F-C1	0		0.5		0.5			1.5	2
	11.8-F-C2	-		-		-	2		0	
	11.8-F-S1	0		0.5		0.5	0.5		0.5	1
	11.8-F-S2	0.5		0		0.5	0.5		1.5	1
3.5 Gravel	3.5-G-C1		0.5		0.5			0.5		0.5
	3.5-G-S1		0		0.5			0.5		1
3.5 Bank Deposit	3.5-B-C1		0.5		0.5			1		1
	3.5-B-S1		1		1			1.5		1.5
	3.5-B-S2		0.5		1			1.5		1.5
	3.5-B-S3		0.5		0.5			0.5		1

*Depth is in cm from Sediment-Water Interface

**Note Tubifex added to 11.8 on 8/8/2013

DGTs have also been used to measure THg and MeHg porewater profiles and coring and organism analysis has begun on some mesocosms. Analysis is ongoing. Porewater profiles are showing relatively uniform THg concentrations (approximately 800 ng/L) in bank sediments while fine grained channel margin deposits from near shore locations showing relatively low THg in the near surface and higher concentrations at depth. This is illustrated in Figure 1.

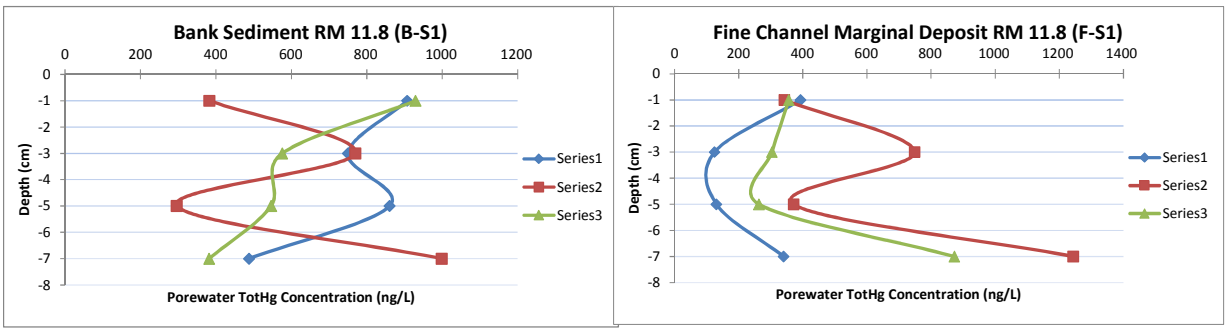

Figure 1 THg concentration profiles in selected mesocosms

The mesocosm experiments are continuing and analysis of these baseline experiments will be finalized in Fall 2013. Capping and/or in-situ treatment mesocosm experiments will be conducted subsequent to these experiments.