SOUTH RIVER CONCEPTUAL SYSTEM MODEL UPDATE OCTOBER 2005

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Background

The South River drainage basin from the site to the confluence with the North River is approximately 235 square miles. The Blue Ridge Mountains form the eastern boundary of the South River drainage basin (maximum elevation 3,060 ft.). The western boundary of the drainage basin is gentler in slope due to predominantly carbonate bedrock with a maximum elevation of 1,460 ft. (Patterson Ridge). Intermittent creeks form sub-basins within the South River drainage basin, most of which reportedly run dry during the summer months. The exception to this may be Paine Run which is fed by a mountain spring. The floodplain of the South River is relatively narrow and based on FEMA maps constitutes and area of approximately 5.5 square miles from the plant site to the confluence with the North River. As a comparison the total area of the drainage basin from plant site to the confluence is 104 square miles.

The South River watershed is located in a largely rural area with pockets of higher density residential areas (e.g. Waynesboro). Agricultural farmlands and grazing land occupies most of the alluvial plain of the river. The higher elevations are for the most part forested and protected as national parks. The 25 miles from the former DuPont plant site downstream to the North River may be characterized as follows:

Forested	67%
Agriculture	24%
Urban	9%

Primary Sources of Mercury

It is envisioned that releases from the plant occurred nearly continuously from 1929 to 1950, with some periods of possibly higher level releases. Through atmospheric deposition and runoff from the site, mercury was transported into the South River. Periodic flooding resulted in deposition of Hg associated sediments in the South River floodplain. Characterization of composited floodplain soil samples in the late 1970s to 1980 show the highest average concentrations from RRM 5 to RRM 10 (approximately 20 ppm).

For the South River study the main questions are:

- Does the current inventory of mercury vary spatially in the floodplain?
- Where and how is the mercury most likely to be recycled into the aquatic system?
- Where are the locations or sub-environments that are conducive to methyl mercury production?
- Can anything be done to mitigate the supply of total and bioavailable mercury?

Transport of Mercury in the System

Within water body systems, mercury commonly exists adsorbed to sediment. Within the South River, it is postulated that the majority of the inventory of mercury is stored in floodplain deposits. Recent results from the geomorphic study indicate that the first twelve miles of the river have a gentler gradient than the next 13 miles. This is consistent with the current observations that in the first ten to thirteen miles:

- there is a higher probability of encountering fine-grained sediments in the river,
- the inventory of mercury in the floodplain is likely to be higher,
- there is a higher probability of encountering quiescent waters where methylation may occur
- fish tissue concentrations appear to crest at Crimora and then decrease to Port Republic.

Of interest to us is the portion of mercury that is reintroduced into the aquatic system allowing it to bioaccumulate through the aquatic food chain. Mercury in dissolved form is a small fraction of the total mercury, although proportionately, it plays a much greater role in the formation of methylmercury. Because of the strong association of mercury with solids, the movement of mercury in the South River system is likely to be closely tied with the movement of sediments. The mechanism or rate at which mercury that sorbed to particles desorbs from aged soils and sediments is not fully understood.

Under the current conceptual system model, after high river flow events, bank failure and erosion reintroduces mercury associated particles into the river system from the floodplain (both inorganic and organic species are possible). In addition, during major storms when the floodplain is inundated, dissolved and particulate associated mercury and methyl mercury in back waters (such as ponds, old cutoff channels, and former mill races) may be washed into the river system. Wetting and drying of the banks may be another important mechanism for getting bioavailable mercury into the aquatic system. It is important to note that sediment mercury transport during high flow events is significant when considering the long-term effects of mercury in the watershed.

During low flow conditions, quiescent sub-environments in the river system and in the floodplain may facilitate methylation of mercury. Mercury in the aquatic system may methylate on substrate of high organic (detritus) fine-grained material variously known as hydric sediment, the nepheloid layer, or “fluff.” Dissolved or colloidal mercury in groundwater discharging into the river may also be an important contribution during low flow periods. The surficial layers of the fine-grained sediment reservoirs within the wetted perimeter of the channel such as the deposits identified by Pizzuto and Skalak may also be important for internal cycling of mercury in the system. Fine-grained sediments beneath the natural armour layer have not been explored at length but these may also provide an ongoing supply of mercury through desorption of mercury to pore water. The table below summarizes some of the fine-grained sediment deposits that may have associated mercury in the South River system.

Mercury Associated with Possible Fine-grained Sediment Deposits
In-channel natural pools (<10 ft deep)
Pools behind dams (some dams are partially breached)
Wetlands
Floodplain deposits
Abandoned mill races
Accumulation of fine sediments (clays and silts) in eddies behind leaning and downed trees and wood debris
Fine-grained sediment accumulations below the in-channel natural armour layer
Veneer of fine-grained sediments along banks
High organic, low density fluff layers in more quiescent areas of the river (usually near-bank)

Recent Developments in the Detection of Sources

To date, close interval water sampling chemistry in the river channel has not shown discrete significant inputs of Hg to the system at different locations. Instead, a relatively constant increase in mercury concentration is observed suggesting a diffuse low level source along the length of the river. However, water chemistry near the banks shows higher concentrations of Hg and MeHg than in the channel center. This may indicate that the source is a near bank phenomenon. Close interval sampling near the bank may allow sampling of inputs before mixing with the main stream of the river. In addition, discrete inputs to the aquatic portion of the system or significant MeHg production areas may be identified.

Near Term Work Needed for the CSM

The team should continue to explore different tools and methods broadly for detection of significant sources. It may be that different tools in different environmental compartments may be more effective in some areas than others depending upon the source type or dominant processes. The team should continue to track seasonal changes in biota tissue and compare to patterns in other media. Patterns of mercury in the environmental compartments on longer-term cycles should be evaluated when possible.

Significant inputs to the system should be characterized in light of potential remedial actions. It is likely that sources of mercury (external and internal) may be different for different reaches. One approach is to attempt to identify sources from the aquatic (river) side as a first step (utilizing the tools identified above) and trace the source back to its origin. The next step would be to identify the processes that are important for remedy alternative evaluation and selection.