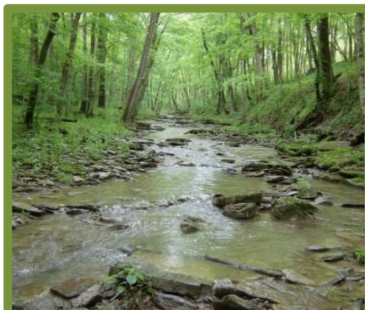

Woolper Creek Watershed Hydromodification Report

Woolper Watershed Initiative Steering Committee
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Woolper Creek Watershed Initiative

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In collaboration with the Woolper Creek Watershed Initiative, this report presents the findings from hydrogeomorphic surveys that were collected at 18 sites throughout the Woolper Creek Watershed. While much of the Woolper Creek Watershed remains undeveloped with relatively stable, healthy streams, hydromodification has become a measurable impairment in the developed portions of the watershed.

What is Hydromodification?

Hydromodification is one of the leading sources of stream impairments across the United States. It includes channelization (stream straightening), construction of dams, and streambank erosion caused by erosive stormwater runoff (EPA, 2010). All of these actions can affect channel stability, resulting in excess bed material transport, stream widening through bank erosion, and stream deepening through incision of the channel bed. Such instabilities greatly impact overall stream function because the physical stability of the stream system is important for sustaining aquatic habitat, maintaining water quality, and promoting healthy biological communities (Figure 1 adapted from Center for Watershed Protection).

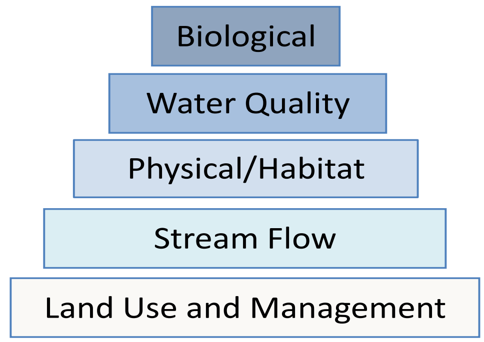

Figure 1 – Stream Function Pyramid

How does the urban flow regime impact channel stability?

The dominant cause of hydromodification in the Woolper Creek Watershed is the erosive, urban flow regime associated with the conventional watershed development that has begun to impact many of the headwater reaches of Woolper Creek. As one of the most rapidly developing counties in Kentucky, Boone County's streams are experiencing several negative impacts associated with conventional development practices. Stream stability and habitat quality tend to decrease in developed watersheds and impervious area has been correlated to channel enlargement, bed coarsening, riffle shortening, and pool deepening in a peer-reviewed study of 40 monitoring locations from across the Northern Kentucky region (Hawley *et al.*, 2013).

What is the initial response to hydro-modification?

One of the initial responses to watershed development is that the increased runoff and erosive power of the urban stream flow literally picks up the smaller rocks on the stream bed and carries them downstream. This means that the stones that remain at the site gradually become coarser (Hawley *et al.*, 2013). Transport of stream bed material is a natural process, but developed watersheds tend to erode the particles at much higher rates than undeveloped watersheds. As streams continue to evolve to carry larger volumes of stormwater runoff from developed regions, stream downcutting and bank erosion lead to property loss and high levels of sediment being delivered to the stream. These responses were widely documented in the Gunpowder Creek Watershed monitoring program, a watershed that has experienced a larger amount of headwater development and over longer periods of time than Woolper Creek. Stream monitoring in Gunpowder Creek confirmed that bank erosion was a dominant source of the large amounts of suspended sediment found in the water column, and was considered to be the most concerning water quality pollutant in the developed headwater streams.

Monitoring in the Woolper Creek Watershed illustrates streambed instability in the developed headwater streams.

Because the headwater development of Woolper Creek has occurred relatively recently, receiving streams are still undergoing their initial responses to urban development. Bank erosion and sediment pollution (TSS) were not as prevalent as in Gunpowder Creek; however, stream surveys documented high amounts of bed material instability in the developed headwaters of Woolper Creek. Stream bed instability was observed at nearly all of the developed sites. For example, the median particle (d_{50}) at Allen Fork site ALF 4.0 (1.73 mi^2, 23% impervious) increased nearly 200% in one year from 36 mm to 107 mm. Similarly, the median particle at site WPC 12.3, one of the most developed subwatersheds in the upper reaches of Woolper Creek (1.83 mi^2, 27% impervious), increased by nearly 100% in one year from 61 mm to 120 mm (Figure 2). In contrast, 5 years of monitoring in the undeveloped watershed of Double Lick Creek at site DLC 1.0 (1.82 mi^2, 3% impervious) has documented very little change in the bed material composition; for example, the median particle has ranged between 46 mm and 60 mm, and has never changed by more than 20% in any given year (Figure 3).

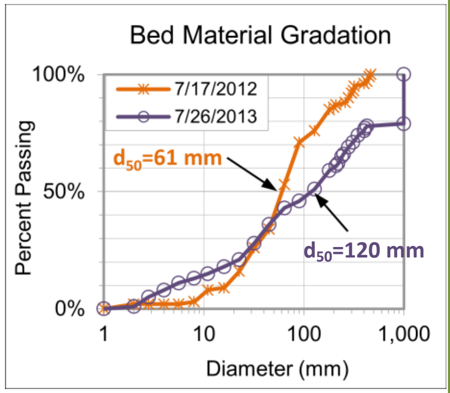

Figure 2 – Bed Material is Unstable at Developed Site WPC 12.3

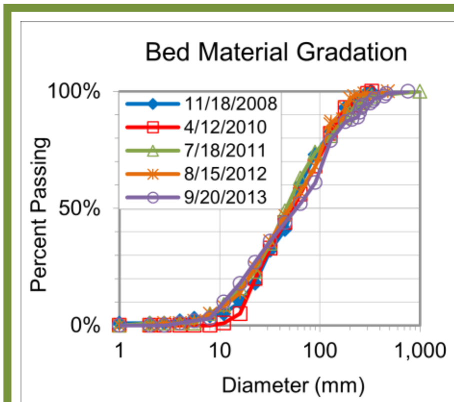

Figure 3 – Bed Material is Stable at Undeveloped Site DLC 1.0

Table 1 – Comparison of Reference Stream to One of the Most Developed Sites		
	DLC 1.0	WPC 12.3
Percent change in the median bed material particle between 2012 and 2013 surveys	17%	97%
Habitat Score (Barbour *et al*, 1999)	166	103
Biologic Rating (KY MBI)	Good	Fair

Habitat and biological conditions are impacted by streambed instability.

The monitoring sites with the most unstable stream beds tended to be associated with the poorest habitat, whereas the best habitat was found at sites with stable bed material (Table 1). The same tended to be true regarding the biological communities: the three undeveloped sites with less than 5% impervious area were rated as *Good* by Kentucky's Macroinvertebrate Index of Biotic Integrity, whereas all of the developed sites were rated *Fair*.

The urban flow regime causes channel instabilities.

The primary reason for the high rates of stream bed instability is the excess stormwater runoff that is created by watershed development and routed quickly and efficiently to the streams. As captured by flow monitoring gages, this makes the water depth in streams draining developed watersheds change much more rapidly than those draining undeveloped watersheds. For example, as measured in 15-minute increments, the water level in Double Lick Creek (1.82 mi^2, 3% impervious) rarely fluctuates by more than 1%: it only occurs ~3% of the time (Figure 4). That is, for about 97% of the time, water levels in Double Lick Creek are extremely stable. In contrast, the water levels in Allen Fork at site ALF 2.7 (3.59 mi^2, 21% impervious) change by more than 1% about 35% of the time. Furthermore, the water levels change by more than 10% about 4% of the time, and change by 100% about 0.2% of the time. In summary, the water levels in Allen Fork tend to change about 10 times more rapidly than the water levels in the Double Lick Creek. A similar observation can be made when analyzing the actual water depth relative to the average depth. The maximum water depth recorded in Allen Fork was about 5 times deeper than average, whereas the maximum water surface was only about 2 times deeper than average in Double Lick Creek. Deeper flows create the potential for more stream erosion and flooding. Stream erosion and flooding have been documented throughout the developed tributaries in the Woolper Creek Watershed (e.g. Figure 5); however, they are not reported to be a concern in Double Lick Creek.

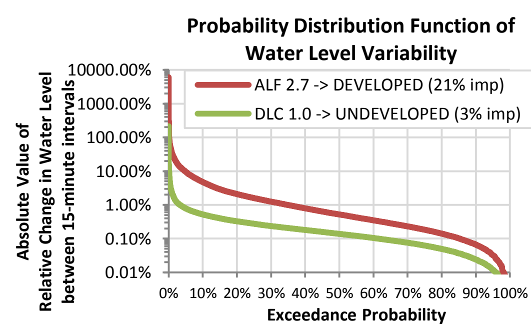

Figure 4 – Changes in Water Levels are Higher in more Developed Watersheds

Figure 5 – Flooding along a small unnamed tributary to Woolper Creek at site WPC13.3-UNT (0.31 mi^2, 24% impervious). Photo by Mark Jacobs ~24 hours after a 6-month storm on April 20, 2011