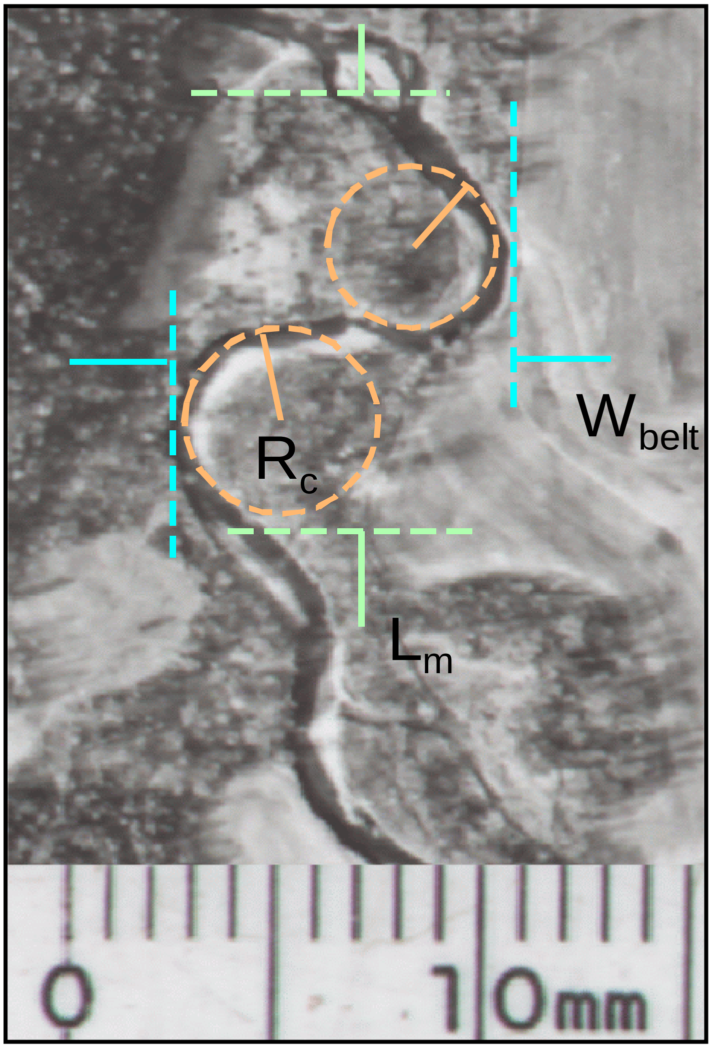
Vermont Stream Geomorphic Assessment

Appendix H



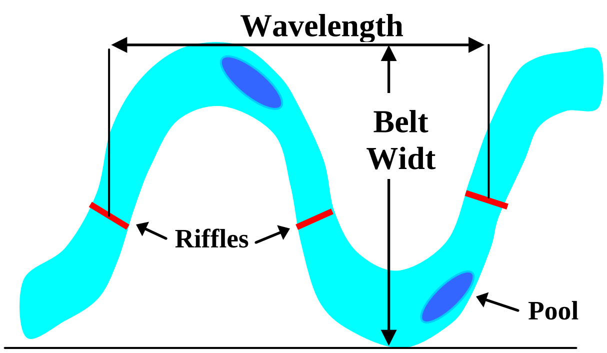
Meander Geometry

Vermont Agency of Natural Resources
April, 2004

Meander Geometry Formulas & Measurements

Meander Geometry Formulas

Rivers are in a dynamic equilibrium between their sediment loads and the energy available from stream flow to perform work and transport the sediment load. The meander geometry (patterns) of rivers develop naturally to provide for the dissipation of the energy of moving water and the transportation of sediment. Rivers exhibit continual adjustments in channel length (sinuosity) that result in maintaining a slope such that the stream system neither degrades nor aggrades. When the alignment of the river is changed, by reducing natural sinuosity, the reach length is decreased, increasing local slope, and setting in motion a series of channel adjustments (Rosgen, 1996)



Naturally straight, alluvial channels are very rare. Even within straighter channels, the deepest thread or thalweg follows a sinuous course between the straight alignment of the banks (Thorne, 1997). The fact that unconfined, single thread streams follow a sinuous or meandering course is related to the vertical oscillations of the stream bed (i.e., pools and riffles). Flow characteristics (turbulence and secondary or lateral currents) cause the selective entrainment, transport, and deposition of bed materials which produces systematic sorting of grain sizes between scour pools and riffle bars. Riffles are the topographic high points in the undulating profile (with symmetrical cross-sections), and pools are the intervening low points. The high velocity flow, scour, and secondary currents work against the one bank in the asymmetrical pool generating bank instability and retreat. This process leads directly to the development of a sinuous channel, with riffles becoming points of inflection, where the flow switches from one side of the channel to the other (Thorne, 1997).

Researchers have developed meander geometry formulas to relate channel dimensions with plan form measurements. Leopold et.al. (1964) noted that riffles were spaced 5 to 7 channel widths apart and that meander wavelengths measured 10 to 14 channel widths (as wavelengths are comprised of 2 riffle-pool sequences). Thirty years of further observations and measurements have not yielded different results (Thorne, 1997). Williams (1986) using data collected from 153 rivers around the world found that the relationship between channel width and the meander belt width is expressed by the formula $B=3.7W^{1.12}$ (measuring width in feet and for channels ranging from 5 to 13,000 ft wide). This formula results in a meander width ratio approximately equal to six (i.e., the belt width is equal to about 6 bankfull channel widths). Calculating the regime meander belt width for a meandering type stream is particularly valuable for evaluating the lateral channel adjustments that are likely to occur in the channelized reach.

Meander geometry is not only related to channel width (which correlates with discharge) but also to sediment load and boundary materials. For instance, stream banks having greater resistance to erosion (i.e., consisting of cohesive clay materials) may result in a narrower channel and tighter, shorter wavelength bends (Knighton, 1998). Clay plugs and other resistant outcrops, that are frequently encountered by rivers meandering across alluvial flood plains, may distort or deform meander bends. This is often the reason why perfectly formed meanders are rarely encountered (Thorne, 1997). Streams with very high sediment loads generally have shorter wavelengths and larger belt widths. If in a high bed load stream, the stream banks are resistant to erosion (i.e., with cohesive soils and vegetation), then channel width is typically found to be narrower.

Where a meandering stream has planform dimensions that are much larger than what would be expected, the stream may be meandering in a confined or narrow valley formed by a much larger stream that existed at a time when the watershed hydrology was very different. For example, a number of valleys in Vermont were formed after the glaciers receded by rivers that meandered and worked through and landscape with much larger flows and sediment transport capacity than the rivers that flow there today. The current day rivers flow "passively" in meandering valleys without sufficient power to readily erode the valley walls.

Meander Geometry Measurement

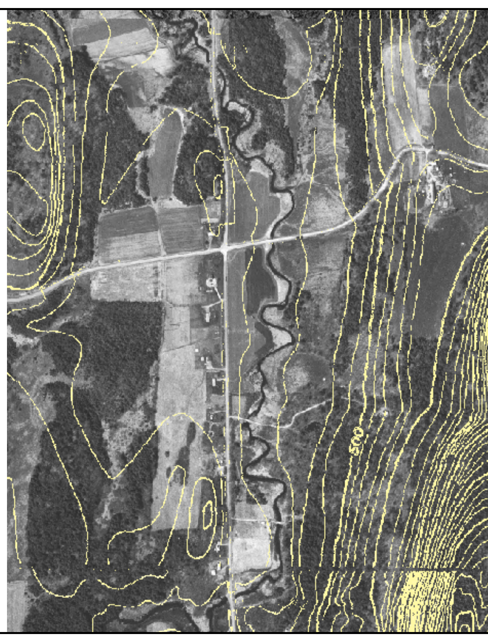
The following reaches are shown as examples of where to measure representative channel wavelengths and belt widths. Example 1 also includes an example of calculating average values which are then divided by the estimated or measured reference channel width to generate values for wavelength and meander width ratios.

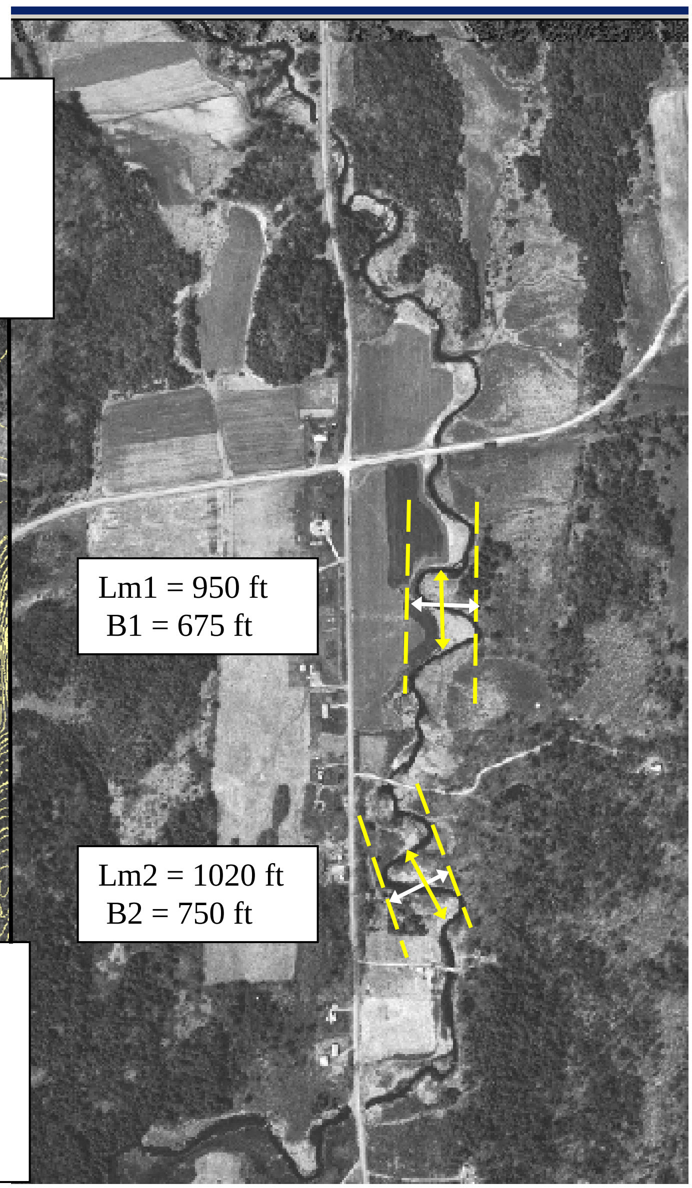
Example 1.

The areas selected for measuring representative wavelengths (Lm) and belt widths (B) were those unaffected by the 4 bridges in this reach. Average values for the reach would be calculated as:

Lm = (950 + 1020) / 2 = 985

B = (675 + 755) / 2 = 715



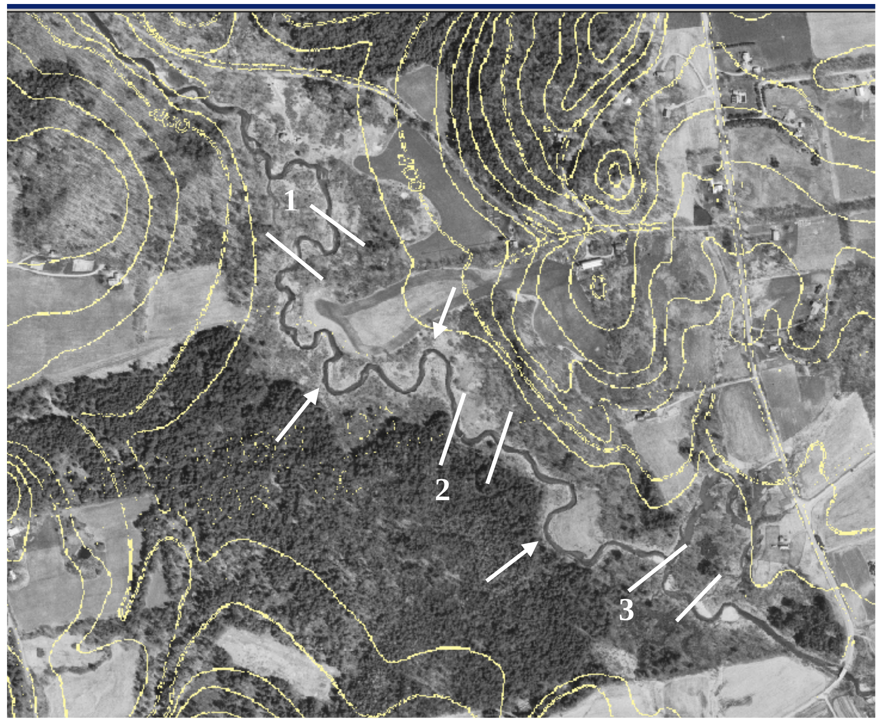


If the bankfull width estimated by the VT hydraulic geometry curves equals 75 ft. The wavelength and meander width ratios would be:

Lm / W = 985 / 75 = 13.1

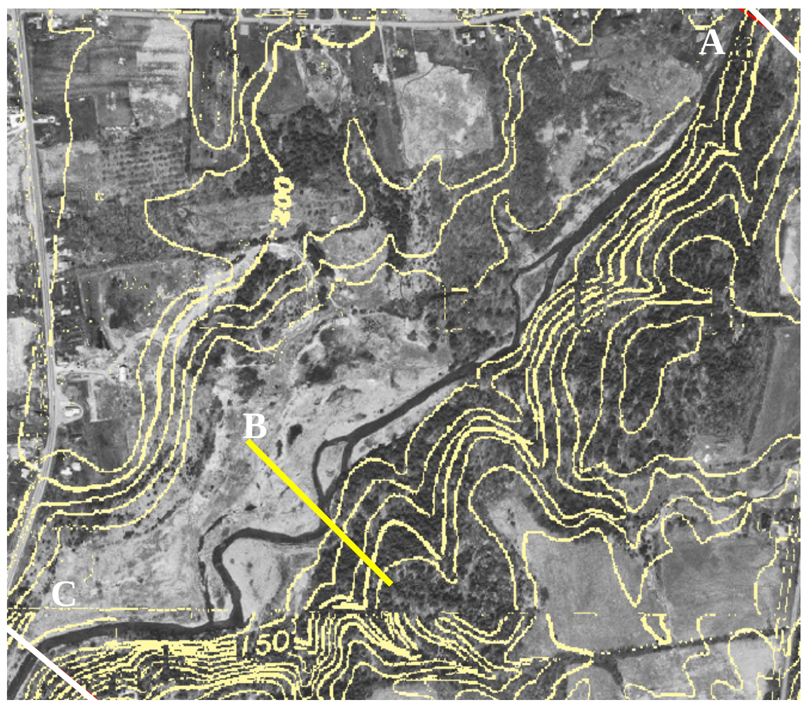
B / W = 715 / 75 = 9.5

Example 2. Three meanders have been bracketed as representative of the reach. Three other bendways are noted with an arrow to show the type of large irregular meander that you may encounter. In this case, these large meanders do not dominate the reach and therefore should not be the basis of your Phase 1 assessment of meander width and wavelength ratios. Had they been the dominant feature, then you would have measured them and determined impact ratings as described in Phase 1, Steps 6.5 and 6.6.



The references below offer excellent reading on the complex subject of meander development and are highly recommended.

Example 3. The reach in this example flows between Lines A and C. Over half of the reach (from Line A to Line B) has been straightened. Therefore, as part of the Phase 1 assessment of wavelength and meander width ratios you would enter the channel width (the value recorded in Step 2.8) into the data base for the wavelength and belt width values. This will generate ratios of "1.0" and impact ratings of "High." The seemingly well formed bendway downstream, from Line B to Line C, may serve as reference during Phase 2 and Phase 3 assessment.



References

1. Leopold, L.B., M.G. Wolman, and J.P. Miller. 1964. Fluvial Processes in Geomorphology. Freeman, San Francisco, 522pp.
2. Knighton, D. 1998. Fluvial Forms and Processes. Oxford University Press, New York.
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4. Thorne, C.R., R.D. Hey, and M.D. Newson. 1997. Applied Fluvial Geomorphholgy for River Engineering and Management. John Wiley and Sons, Chichester, UK.
5. Williams, G.P. 1986. River Meanders and Channel Size. Journal of Hydrology 88:147-164.