Defining River Corridors

FACT SHEET ②

Vermont DEC River Management Program

Overview

A river corridor includes lands adjacent to and including the course of a river. The width of the corridor is defined by the lateral extent of the river meanders, called the **meander belt width** (Figure 1), which is governed by valley landforms, surficial geology, and the length and slope requirements of the river channel. River corridors, defined through ANR Geomorphic Assessments (2004), are intended to provide landowners, land use planners, and river managers with a meander belt width which would accommodate the meanders and slope of a balanced or equilibrium channel, which when achieved, would serve to maximize channel stability and minimize fluvial erosion hazards.

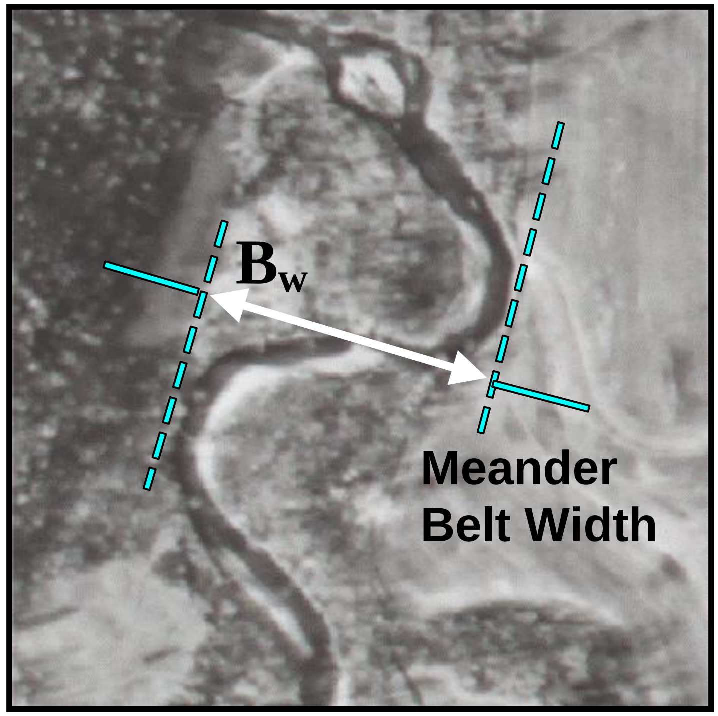

Figure 1. Meander Belt Width (**B_w**) defined by the lateral extent of meanders when the channel slope is in equilibrium with the sediment transport requirements of the river.

Managing for Meanders

Building on the "fundamental principles of river systems" and the diagrams of "floodplain access and channel evolution" laid out in River Corridor Protection and Management, Fact Sheet Q), this section will further explain the components of channel geometry and why understanding their relationship with watershed function is essential to achieving the management objective of sustainable equilibrium river channels and avoidance of fluvial erosion hazards.

Stable, equilibrium river channels erode and move in the landscape, but have the ability, over time and in an unchanging climate, to transport the flow, sediment, and debris of their watersheds in such a manner that they generally maintain their dimension (width and depth), pattern (meander length), and profile (slope) without aggrading (building up) or degrading (scouring down) (Rosgen, 1996; Leopold et. al, 1964). Stable, equilibrium rivers are considered a reasonable and sustainable management objective in consideration of the repeated and catastrophic flood damages experienced in Vermont. Many rivers are in major vertical adjustment due to human imposed changes in the condition of their bed and banks, slope and meander pattern, and/or watershed inputs (see Lane's Balance in Figure 2).

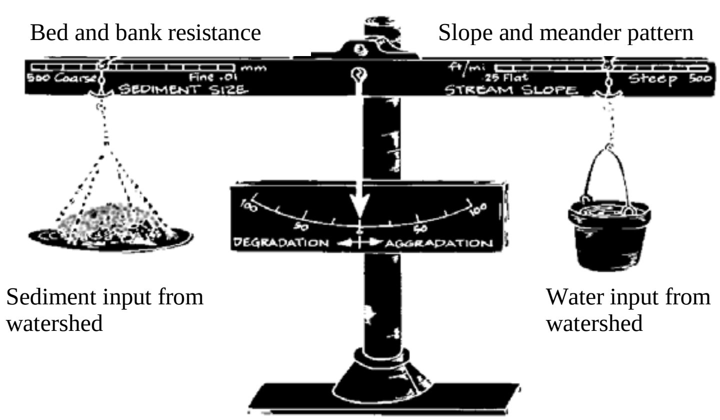

Figure 2. Stable Channel Equilibrium (Lane, 1955)

Establishing channel equilibrium as a river management objective, however, demands a recognition that the geometry of certain river channels, due to their location in the watershed, may be influenced by a net storage or net export of sediment in the reach. In such cases, the inherent vertical "instability" should be assessed and potentially managed differently than the river that is aggrading or degrading as a result of one or more human imposed changes. For instance, it may not be prudent to use the definition of stability and manage against the aggradation which occurs on an active alluvial fan, i.e. where streams transition between steep mountain and gentle valley locations. Also recognize that the potential level of achievement of this objective may frequently be tempered by the constraints of human investments on the landscape.

Protecting river corridors as defined by the meander belt width of the equilibrium channel avoids conflicts with human land uses and minimizes investments and the need to conduct expensive channel management or stabilization activities. Failure to recognize the physical imperatives of river systems and the land area that rivers **will** occupy over time will demand large, on-going private and public expenditures to maintain an unsustainable condition of dis-equilibrium which will ultimately fail.

Some Vermont rivers are presently in balance. The power produced by flood flows and channel slope (a function of meander length) is not so great as to cause significant scour (degradation) of the river bed, or so diminished as to cause a loss of sediment transport capacity and a build up of sediment (aggradation) in the channel.

In these cases, it is cost effective to simply keep investments out of the river corridor and avoid the eventual use of channel management practices, which become necessary to protect investments, but ultimately change the river's length and slope, lead to channel adjustments, and increase erosion hazards.

For many Vermont rivers and streams, a combination of watershed, floodplain, and channel modifications over the past 150 years, has led to the major vertical channel adjustments that are ongoing today. The initial stage of adjustment typically involved the bed scour and head-cutting associated with channel straightening and degradation. Steeper, straightened channels are now adjusting or "evolving" back into more gentle gradient, more sinuous channels through an aggradation process (Figure 3). The narrower belt widths observed during Stages II and III of channel evolution, which held for decades and encouraged human encroachment, have now begun to widen during recent floods as new sediments deposit and longer meanders develop putting human encroachments at risk.

The practice of dredging sediment to avoid flood hazards has typically worked until there is another flood. Berming and armoring may hold longer, but tend to cause the unbalanced condition to extend upstream and downstream. Such practices are unsustainable and will eventually unravel requiring extensive maintenance operations. A cost-effective, geomorphic approach would involve avoiding or minimizing encroachments and investments in river corridors. Corridors can be defined by applying fluvial geomorphic principles to calculate and predict the belt widths which would accommodate the meanders and slope of equilibrium river channels.

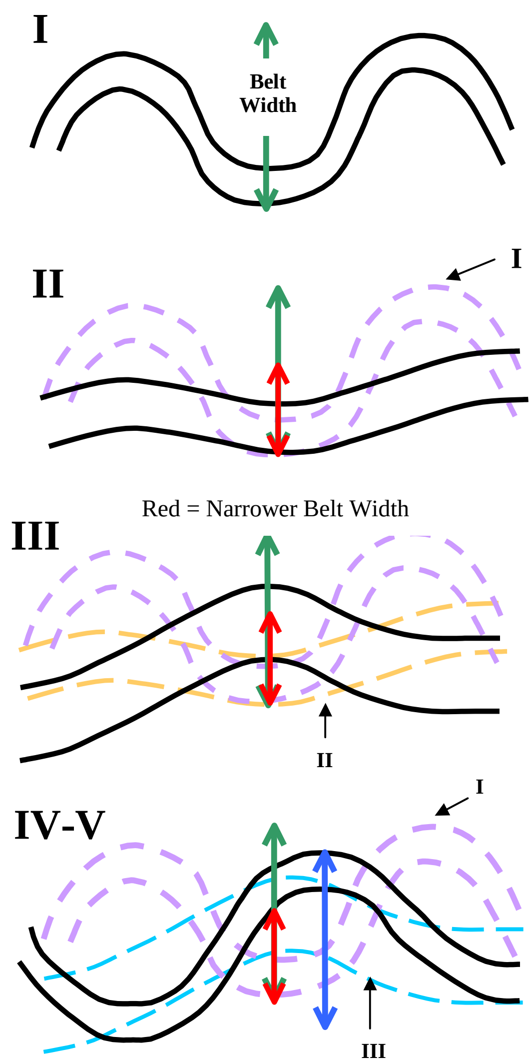

Figure 3. A planform view of the Schumm (1984) channel evolution model showing how adjustment processes lead to a narrowing and then widening of the meander **belt width** as the channel equilibrium re-establishes at a more gentle slope.

Defining the River Corridor

When rivers are in dynamic equilibrium, a sustainable meander geometry provides for the dissipation of the energy of moving water and the transportation of sediment. The fact that unconfined, single thread streams tend to follow a sinuous or meandering course is related to the vertical (up and down) oscillations of the stream bed. Flow characteristics (turbulence and secondary or lateral currents) cause the selective entrainment, transport, and deposition of bed materials which produces systematic sorting of sediment sizes between scour pools and riffle deposits. Riffles are the topographic high points in the undulating profile and pools are the intervening low points. The combination and sequence of bed features results in converging and diverging flows and leads to the development of a sinuous channel, with riffles becoming points of inflection (crossovers), where the flow switches from one side of the channel to the other (Thorne, 1997).

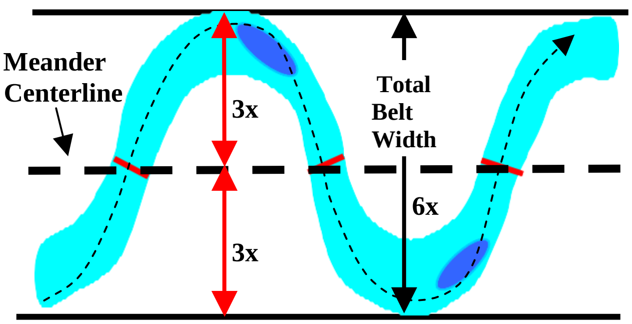

Figure 4. Idealized representation of a river corridor drawn to accommodate the meander belt width, measured out as parallel lines "3 x channel width" either side a meander centerline drawn down valley through the cross-over or inflection points of the river (dotted line).

Researchers have developed meander geometry formulas to relate channel dimensions with planform measurements. Williams (1986) using data collected from 153 alluvial rivers around the world found that the relationship between channel width and the meander belt width is expressed by the formula $B=3.7W^{1.12}$ (where B is the belt width and W is the channel width in feet 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). Corridors for gentle gradient rivers and streams (slope $< 2\%$) in narrow to broad alluvial valleys are calculated and drawn to accommodate a meander belt width that is equal to 6 times the width of the river channel.

Where rivers are assessed as being in equilibrium and the lateral extent of their meanders create a belt width that is at or near the "6 times channel width" relationship, then corridors are drawn as two roughly parallel lines, following down the valley and capturing the extent of existing meanders (Figure 4). If the river slope and sinuosity have been modified, the corridor is drawn using 3 channel widths either side of a meander centerline or 6 channel widths out from the toe of the valley if the river is presently flowing less than 3 channel widths from the toe (Figure 5)

Rarely does one find the idealized sinuosity shown in Figure 4. Rivers and streams in Vermont are usually less sinuous, many having been straightened against a valley side slope. In these cases, the river corridor (still "6 times channel width") is drawn so that the belt width extends laterally out from the valley toe (see Figure 5). These corridors are not established with the expectation that river adjustments will occur and result in a perfect sine wave pattern which conforms to the calculated belt width. Rather, they provide an area within which channel adjustments may occur, in order to re-establish an equilibrium condition, and there can be a reasonable expectation that fluvial erosion hazards will be minimized.

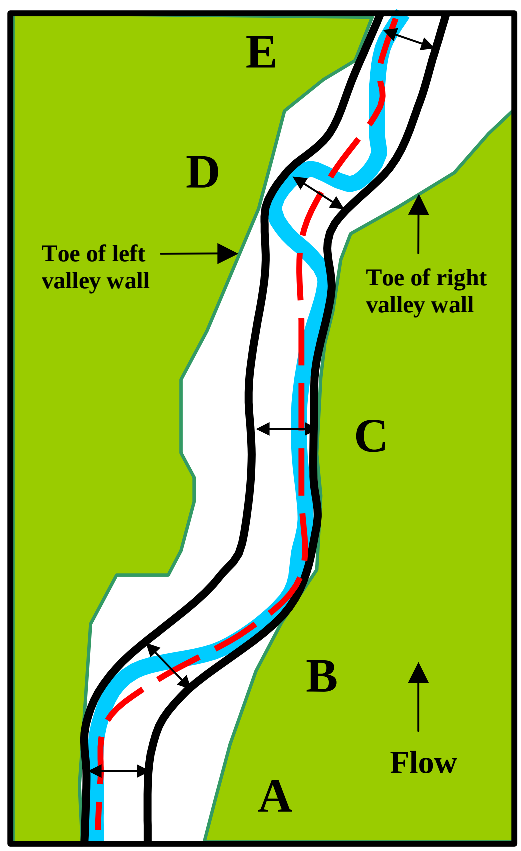

Figure 5. River corridor drawn for a reach of river straightened against the toe of the valley.

Figure 5 illustrates a river corridor, in a broad gentle gradient valley, which was drawn using a combination of river and valley features. The river starts out against the left valley wall (Segment A), flows across the valley (B), returns to the right valley wall (C), flows through a set of meanders (D), and then again along the left valley wall (E). All but Segment D represent the planform of a river reach which has been historically straightened. The meander centerline (red dashed line) travels between meander crossovers where they exist but otherwise, follows the path of the river. The river corridor is a belt width (solid black lines) equal to 6 times the channel width; 3 widths either side of the centerline in Segments B and D, and 6 widths out from the toe of the valley in Segments A, C, and E.

The River Management Program has developed GIS extension software, called the Stream Geomorphic Assessment Tool (SGAT), to automate the process of creating river corridors, once the geographical features: streams, valley walls, and meander centerlines are defined.

Adjusting Corridor Widths

Belt widths "6 times the channel width" develop on rivers which are gentle-sloped, unconstrained, and have erodible boundaries. Obviously, these conditions do not prevail in all Vermont valleys and there are both geographical and human constraints that may justify changing river corridor widths and locations, including:

- **Existing private investments and public infrastructure** for which there is a longer-term public commitment to protect (armor) against fluvial erosion hazards (e.g., town and state roadways);
- **Steeper, confined to narrow valleys with less erodible boundaries**, where corridors of "1 to 4 times channel width" are recommended based on stream type and specific valley characteristics; and
- **Extremely sensitive stream types or landslide areas** that may require corridors > 6 channel widths.

Refer to the "Technical Guidance for Determining Floodway Limits" (ANR, 2003) for more information on adjusting river corridors by stream and valley type and accommodating human developments and infrastructure.

Practical Planning and Management Tool

Defining river corridors is essential to the development and implementation of river corridor plans. Such plans should include a process for selecting and implementing river corridor management alternatives and providing a basis for corridor protection through various land use planning and incentives programs. River corridors can define flood hazard zones or overlay districts thereby supporting implementation of town pre-disaster mitigation plans, or be incorporated into the watershed (basin) plans developed by regional, state, and federal agencies. River corridors defined and "adopted" as part of a public process become a practical, science-based planning tool for directing the use of public funds to reduce fluvial erosion hazards.

River corridor plans, while setting objectives for managing toward a geomorphically-stable river and reducing fluvial erosion hazards, should also recognize that nearly all landowners have made some investment in their lands along a river. Adopting a river corridor plan would not necessarily require the removal of existing investments, but rather would work to avoid future encroachments within the meander belt width which eventually require long-term commitments to bank armoring and other channelization practices for their protection. To deal with conflict areas, for instance when the channel lengthening process threatens an existing investment either within or at the bounds of the corridor, the plan would spell out a range of alternatives and a process for resolving conflicts. At one end of the range, the plan would create the opportunity for willing landowners to be appropriately compensated for removing investments and changing land uses within the corridor. On the other end, the plan may recognize certain reaches where, for example, transportation infrastructure is located and keeping the river channelized is in the public interest.

Implementing river corridor plans will require a long-term commitment to reducing fluvial erosion hazards and restoring the natural and recreational values of rivers, while respecting traditional settlement patterns and the importance of a prosperous agriculture in Vermont. From one decade to the next, opportunities arise to work with landowners in a cooperative fashion, increasingly if not gradually giving the river more space to achieve equilibrium. Without a corridor plan, encroachments will continue, compounding the cost of flood recovery, and necessitating river management that is both economically and ecologically unsustainable.

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