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APPENDIX A

Assessment of the Physical Environment of French Creek, South of Union City Dam.

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OBJECTIVE

The objective of this report is to document the physical environment of a small portion of the French Creek watershed, including the geomorphology, sedimentology, and hydrology of the channel. This report documents basic physical parameters of the stream system in order to provide base-line data that may be used as a reference for future stream monitoring efforts.

BACKGROUND

French Creek is a biologically diverse stream, but it is fragile and subject to environmental degradation. One of the first steps in protecting the stream involves documentation of its biological and physical characteristics, in order to establish baseline data against which future changes can be compared. Comparison of the physical environment and associated biota of a healthy stream also allows us to better understand how that ecosystem works.

The typical parameters incorporated in stream monitoring efforts include: channel cross sectional area and shape, flow velocity, discharge characteristics, bedrock geology, river bed substrate (grain size and sorting), and bank stability/riparian zone descriptions (Harrelson *et al.*, 1994). Changes in these parameters through time can be documented and compared with changes in land-use and other environmental controls, in order to better understand how these variables affect local stream ecology.

In addition to the documentation of the physical stream habitat, an understanding of stream hydrology is also important in understanding basic stream functions. This report incorporates a study of flow variability, based on U.S.G.S gauging station data for French Creek. Stream flow variability is an important aspect in the health of natural stream ecosystems. Past and future impacts on flow variability, such as construction of dams like that at Union City in 1970, or the proposed future alteration of that dam (see www.lrp.usace.army.mil/rec/lakes/unioncit.htm) have, and will likely, impact the stream ecology.

The study site described in this report is located approximately 2 miles downstream from the Union City dam (Figures 1 and 2), in Erie County. The study site includes a natural run and riffle sequence, and a disturbed section, chosen to best represent stream environments typical of French Creek.

General Geology

The bedrock of northwest Pennsylvania is made up of predominantly flat-lying to gentle, southeast dipping sedimentary rocks of marine origin. In the study area, all of the bedrock is of Upper Devonian age (Shepps et al., 1959). Exposed rock units include the Chadakoin and Venango Formations. The Chadakoin Formation (shale and sandstone) is exposed at lower elevations such as valley floors (Figure 3). The Venango Formation overlies the Chadakoin, and makes up the valley walls and hilltops. The Venango Formation consists primarily of sandstone and shale, but also contains coarser, conglomeratic beds (Berg, 1981).

The bedrock of the area has been sculpted by multiple glacial advances and retreats. Glacial deposits of the Union City area are primarily composed of ground moraines associated with the Kent Till, of Wisconsin age. Outwash sand and gravel, found underlying the many Pleistocene terraces of French Creek, partially fills valleys that drained glacial margins, such as French Creek.

The post-glacial (Holocene) evolution of French Creek remains poorly understood, but alluvial terraces along French Creek and associated tributaries attest to down-cutting and sediment removal by the stream since deglaciation. Terraces also provide a record of changing channel morphology and sediment load through time, from braided, bed-load (gravelly) dominated systems during glacial episodes, to meandering, mixed (suspended and bedload) load streams during the Holocene. These distinctly different types of river systems can be easily recognized in the field from their respective deposits. Pleistocene outwash is predominantly stratified gravel and sand, while Holocene meandering river deposits typically include poorly to un-stratified gravel overlain by massive fine sand and silt. Major channel changes from braided to meandering systems are often associated with changing environmental conditions (vegetative cover and storm hydrology) that accompany glacial/interglacial conditions (Straffin and Blum, 2002). Human influences can also significantly affect channel morphology.

Soils

Soils within the study area belong to the Howard-Phelps-Fredon-Halsey soil associations (Erie County Soil Survey, 1991). Soils at lower elevations along the French Creek floodplain vary from silt loams to sandy loams. Fine sand loams are prevalent immediately adjacent to the channel, most likely reflecting localized overbank sand deposition by the river. Silt loams are more common away from the channel, on more distal floodplain settings where finer grained sediments have settled in areas of slower moving water.

Pleistocene glacial outwash terraces are coarser grained, and contain better drained, more gravelly soils than those in the Holocene floodplain setting.

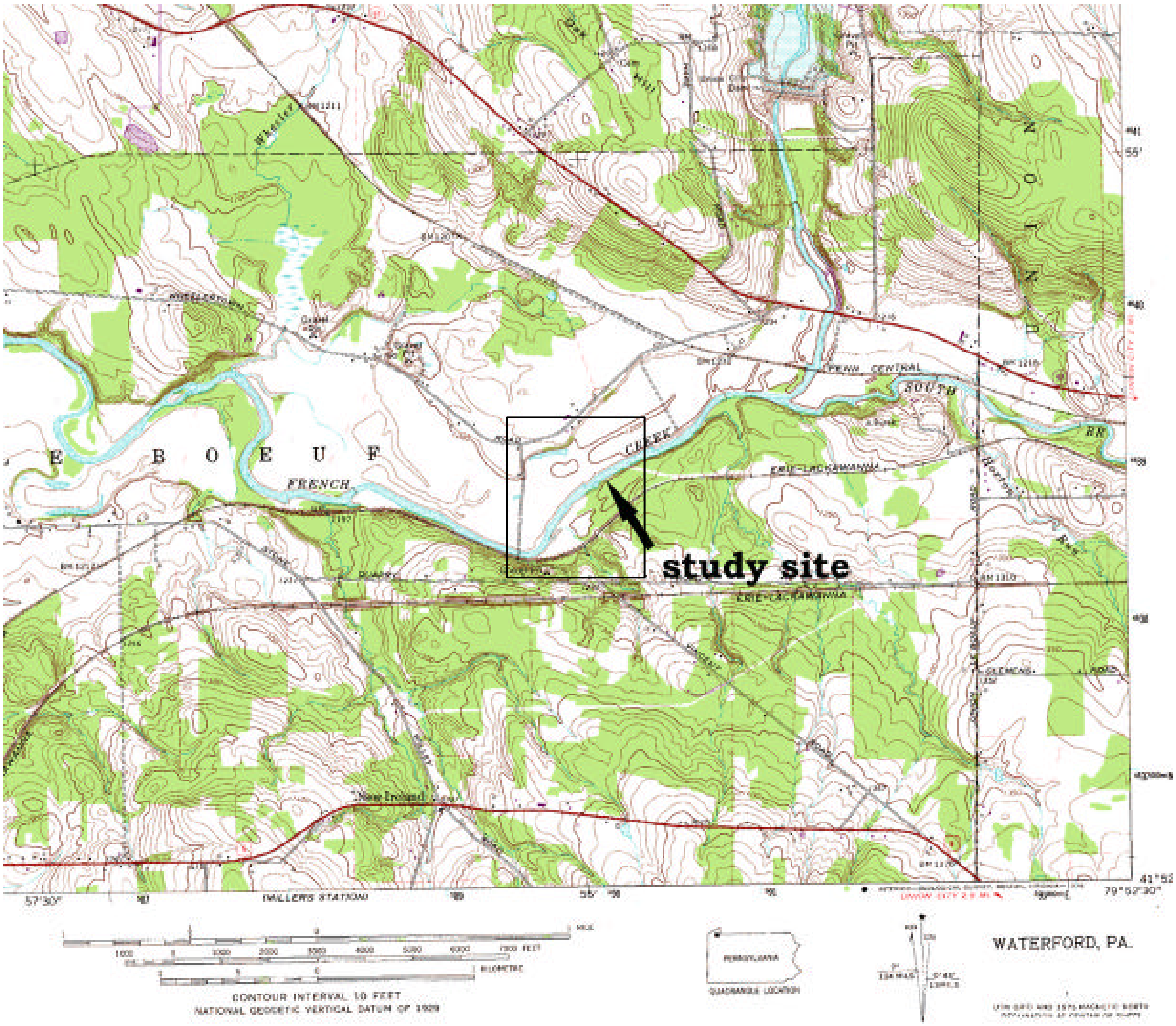


Figure 1. U.S.G.S. topographic map of the study area. Box shows location of aerial photograph shown in Figure 2

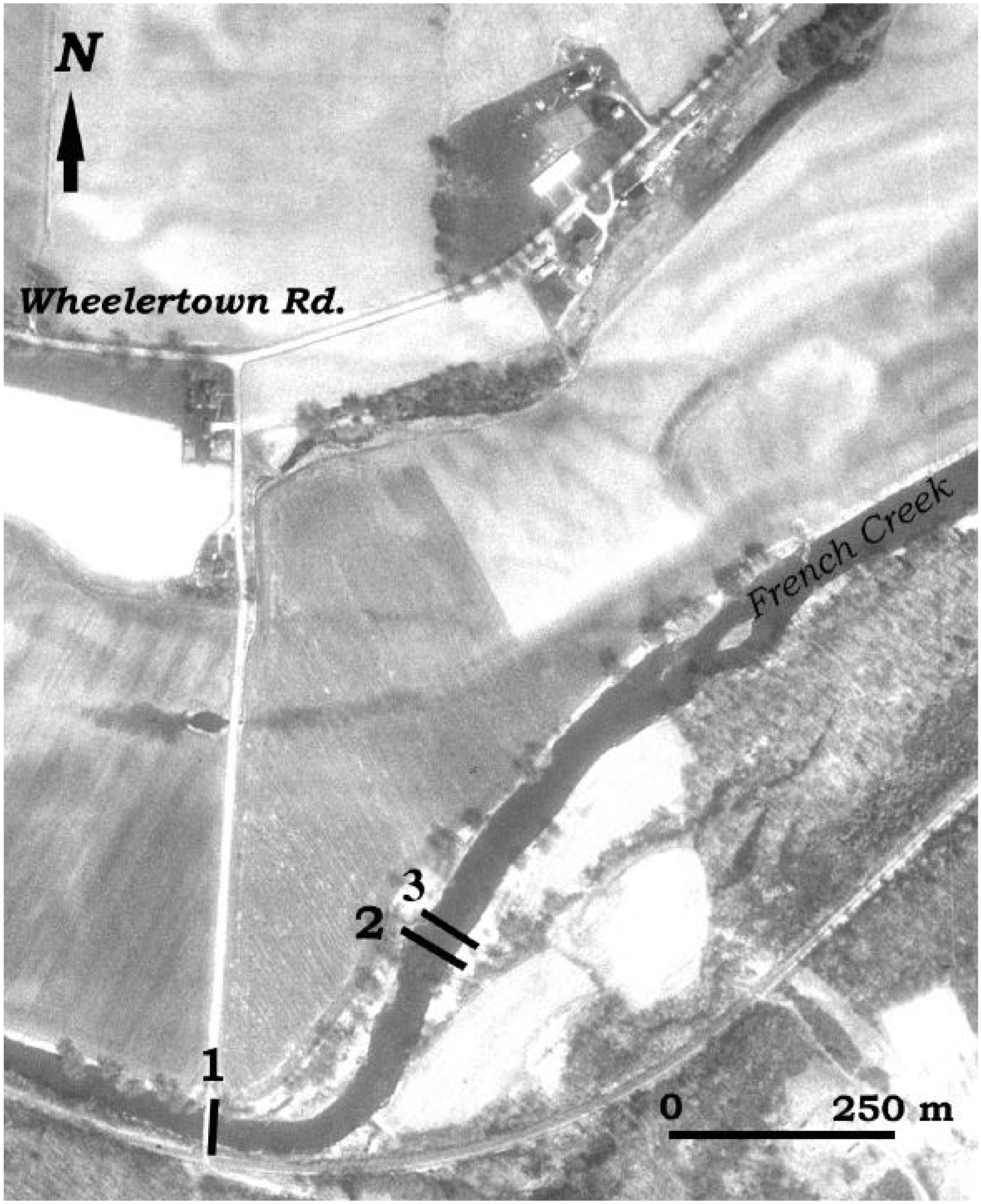


Figure 2. Portion of U.S.G.S. panchromatic aerial orthophotograph showing study site and channel cross section locations.

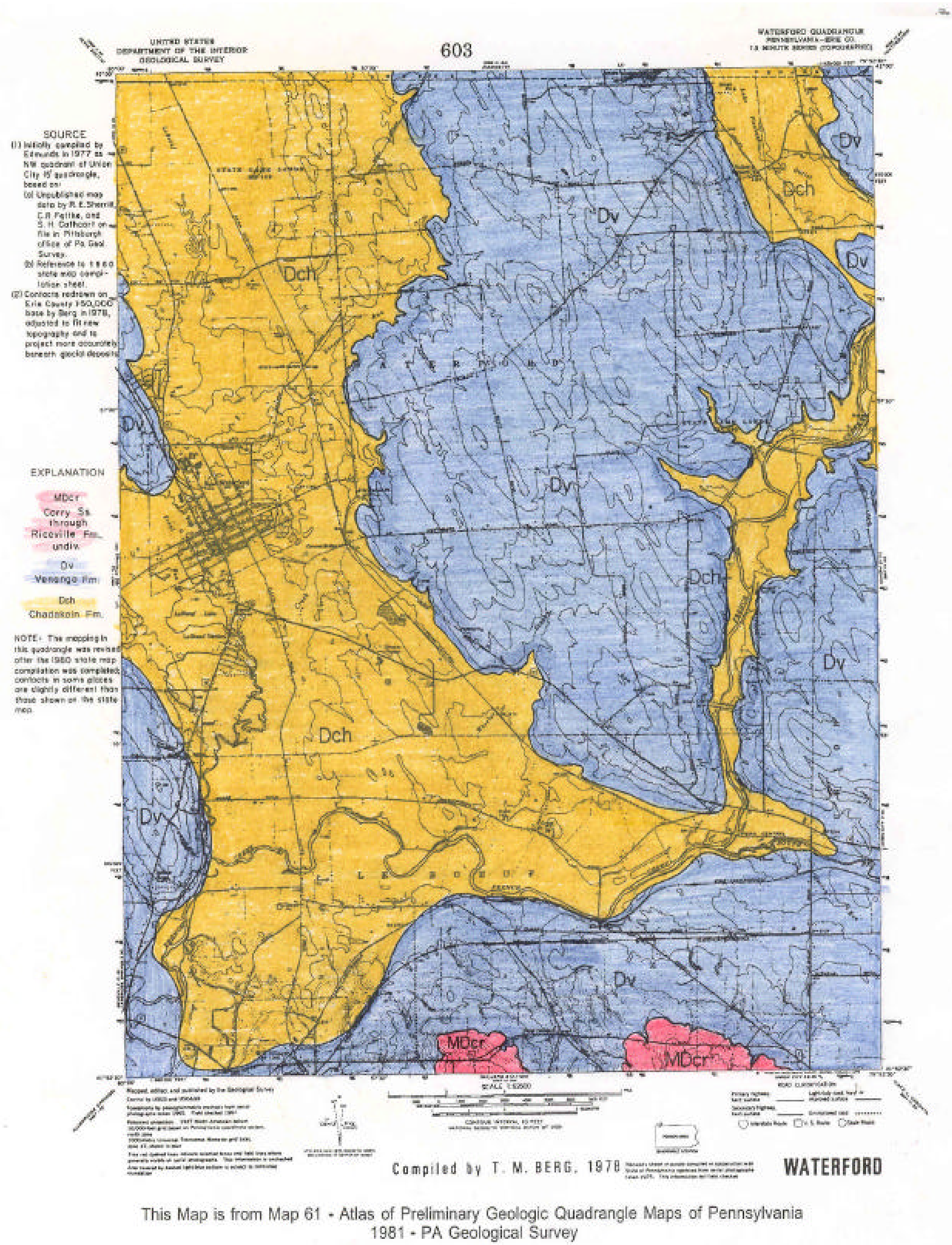
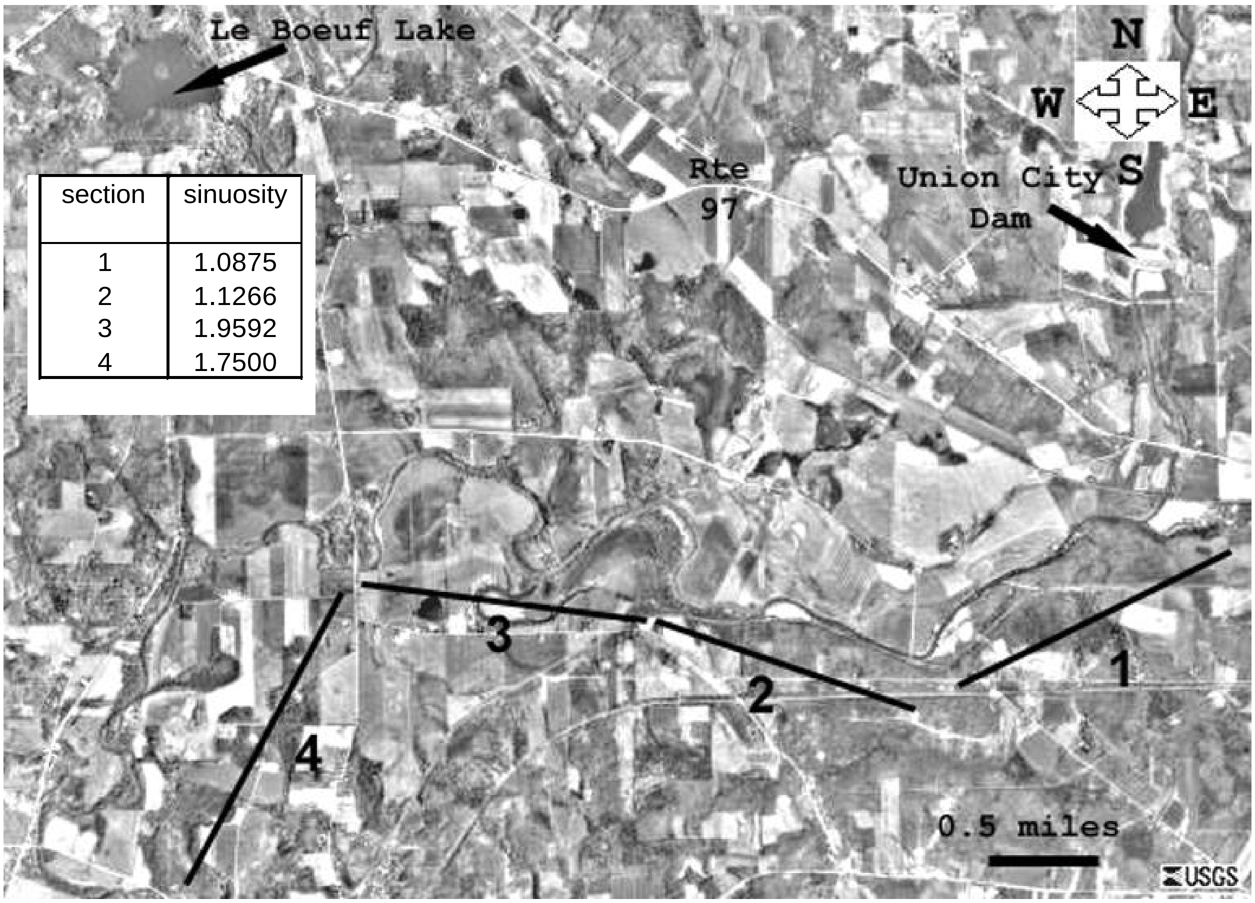


Figure 3. Bedrock geology of the Waterford area. Study area is indicated by the box.

PHYSICAL CHARACTERIZATION

Channel Morphology

French Creek is generally a single channel, meandering stream. However, the river's morphology varies considerably along its length. For example, sinuosity varies between straight and highly sinuous. The study area documented in this report occurs within a relatively straight reach (section 1, Figure 4).



section	sinuosity
1	1.0875
2	1.1266
3	1.9592
4	1.7500

Figure 4. Variation in sinuosity along French Creek downstream from the Union City Dam. Sinuosity is calculated as channel length divided by reach length (Richards, 1982).

Channel and bank stability is also variable, being in part dependent on the sedimentology of the channel perimeter (Richards, 1982). For example, mixed-load streams such as French Creek typically have floodplains containing predominantly non-cohesive sediments (gravel and sand). These loose sediments do not maintain steep banks, and are easily mobilized during floods, resulting in wide, shallow channels that are prone to lateral migration. Natural zones of bank instability should thus be expected in areas of the valley where there is abundant sand and gravel (such as where the river is cutting through older glacial outwash). Rip-rap or revetment along one side of a channel bank has a similar effect, by armoring the bank and preventing channel widening during floods. During floods, higher flood stages and velocities result from these bank protection efforts, because the channel cannot expand to accommodate the increased discharge. As a result, there is an increased potential for erosion on unprotected banks opposing revetments. When flood waters recede, areas with gravelly banks will often have wide channels with many channel bars and corresponding riffle sequences.

Areas underlain by glacial till or lacustrine sediments, which have finer, more cohesive sediments, may have more stable channel and bank configurations. As a result, these areas are often the sites of deeper pools.

It is interesting to note the change in sinuosity of French Creek, from a relatively straight channel in the narrow, confined valley below the Union City dam, to the very sinuous channel that meanders through the wide, glacial outwash-filled valley south of Le Boeuf (Figure 4).

Channel Topography and Hydraulic Data

Channel topography was measured with a *Topcon TOTAL* laser transit system, to establish channel geometry at three locations. Channel dimensions were then used to calculate the hydraulic radius for each cross section. Hydraulic radius is a measure of channel efficiency at routing water through the channel. Stream channel cross sections that most closely approximate circular channels are most efficient (larger values), where as wide, shallow streams or deep, narrow channels are less efficient (smaller values). Hydraulic radius thus has important implications for how water interacts with the channel bed and banks.

Flow velocities were measured incrementally at each channel cross section with a *Flow Mate* 2000 flow meter. At the time of measurement (July 2002), river stages (and flow velocities) were very low.

Discharges for the channel were then calculated in a spread sheet, by multiplying velocity by the incremental area of the channel, following the procedures set out by Harellson *et al.,* 1994. Table 1 summarizes the calculated channel dimensions for each of the three cross sections, as measured in July 2002.

Cross section	Low flow channel area (m2)	Calculated discharge (m3/s)	Wetted perimeter (m)	Hydraulic radius (m)
1	16.2	2.8	37.6	0.43
2	22.5	3.1	61.3	0.37
3	14	3.8	51.5	0.27

Table 1. Channel dimensions at three cross section locations. Hydraulic Radius = cross sectional area/wetted perimeter.

Channel Description -Cross Section #1

Cross section #1 was measured at the upstream side of the bridge connecting Wheelertown and Stone Quarry Roads. At this site, the stream hugs the southern valley wall, which is composed