of sandstone/conglomeratic bedrock from the Venango Formation, as well as stone rip-rap. Bedrock from the Chadakoin Formation is partially exposed along the channel bottom, and many locally derived boulders are present (see Figure 5). The northern bank of the channel flanks a Holocene terrace and artificial fill around the bridge, which includes gravel and sand. A portion of the bridgeworks and older alluvial deposits are shallowly buried by minor accumulations of recently deposited sand. The natural bank-full elevation is approximately 2 meters above the channel base. Land use surrounding the riparian zone is characterized as urban/row crop, following the classification scheme of Schnier (2002). The riparian/bank zone classification for each channel cross section is summarized in Table 2.

At low flows, water in the channel most resembles a pool, with slow moving water (the average mid-channel velocity at the time of measurement was 0.18 meters per second). The channel width at low flow was 24 meters, and the maximum depth was 0.8 meters (see Figure 6).

The channel geometry is strongly influenced by the constricting nature of the bridge abutments, which are stone, and exposed within the bankfull-stage area of the channel. The channel has a large hydraulic radius, presumably due to flow constriction imposed by the bridgeworks, which promotes channel scouring and sediment removal during high discharges. The bedrock channel base is also resistant to erosion and prevents much scouring during floods.

Cross section #	Riparian Buffer Width	Riparian Vegetation Type	Riparian Vegetation Thickness	Bank Vegetation Type	Bank Vegetation Thickness	Bank Stability
1	Marginal (3)	Good (6)	Excellent (9)	Marginal (3)	Good (6)	Good (7)
2	Marginal (3)	Good (8)	Excellent (9)	Marginal (5)	Excellent (9)	Excellent (9)
3	Marginal (3)	Good (8)	Excellent (9)	Marginal (5)	Excellent (9)	Excellent (9)

Cross section #	Water Pathways	Channel Modification	Shading	In Stream Cover	Embeddedness	Aquatic Vegetation
1	Good (7)	Marginal (4)	Poor (2)	Good (7)	Good (8)	Excellent (8)
2	Excellent (9)	Excellent (10)	Poor (3)	Poor (2)	Good (7)	Good (6)
3	Excellent (9)	Excellent (10)	Poor (3)	Poor (2)	Good (7)	Good (6)

Table 2. Riparian Assessments. Ranking is on a scale of 1-10, following the classification scheme of Schnier (2002).

Figure 5. Photograph of French Creek channel at cross section location #1. View is looking downstream (west).

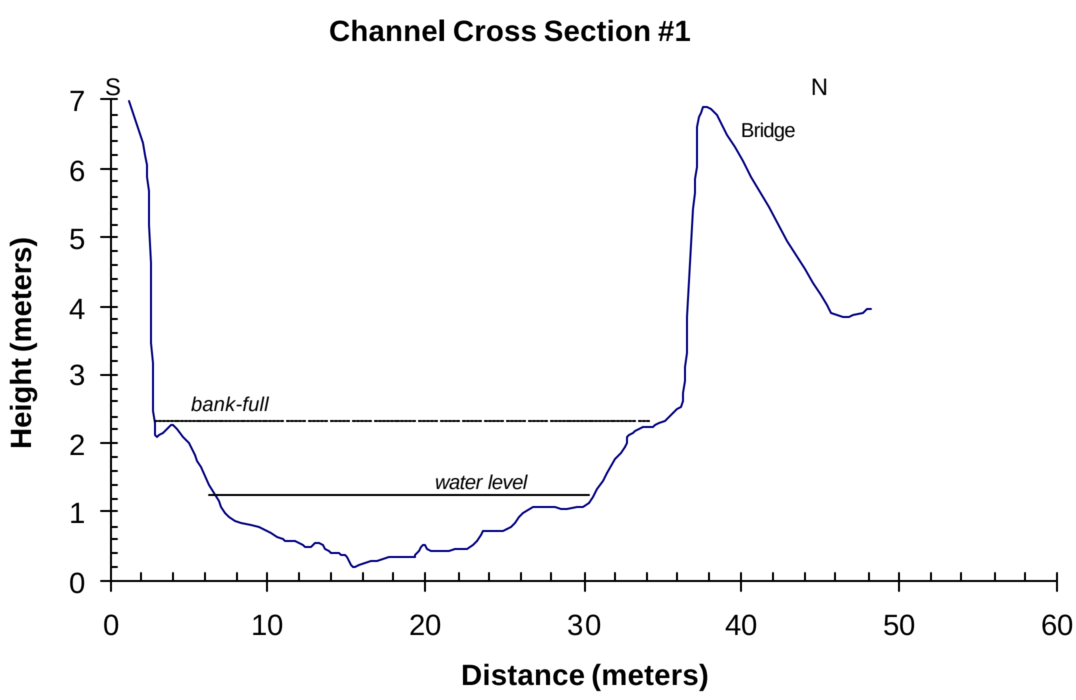


Figure 6. Channel topography at cross section #1.

Channel Description -Cross Section #2

Cross section #2 was located approximately 300 meters upstream from cross section #1. At this site, the banks are composed of Holocene age meandering stream deposits, which include coarse channel gravel overlain by overbank sand and silt. The natural banks are 3 meters above the channel base, and a well developed soil is present in the upper sediments. Land-use on the surrounding floodplain is primarily agricultural land on the north bank, and mixed scrub/forest vegetation on the south bank. Grass and brambles covers much of the channel banks and exposed bar surfaces (Figure 7).

A riffle is formed at this site, due to the construction of a natural transverse channel bar, composed primarily of gravel and cobbles (see Figure 7). The maximum water depth across the riffle was 0.75 meters, and the average mid-channel velocity was 0.16 meters per second. The low-flow channel was 36 meters wide. The stream has developed a wide, shallow channel here (Figure 8), most likely due to the loose nature of sediment comprising the bed and banks.

At low flows, the slope of the water surface varies significantly along the length of the channel (Figure 9). The average slope of the water surface between cross sections #2 and 3 was 2.62%, but over the bar crest the slope was 11.5%, and upstream at the beginning of the bar the slope of the water surface was 1.9%.

Figure 7. Photograph of channel at cross section locations 2 and 3. View is looking upstream (east). Cross section #2 was measured across the riffle in the foreground, and section 3 upstream where person (for scale) is standing in the background.

Channel Cross Section #2

7 S N

Figure 8. Channel topography at cross section #2.

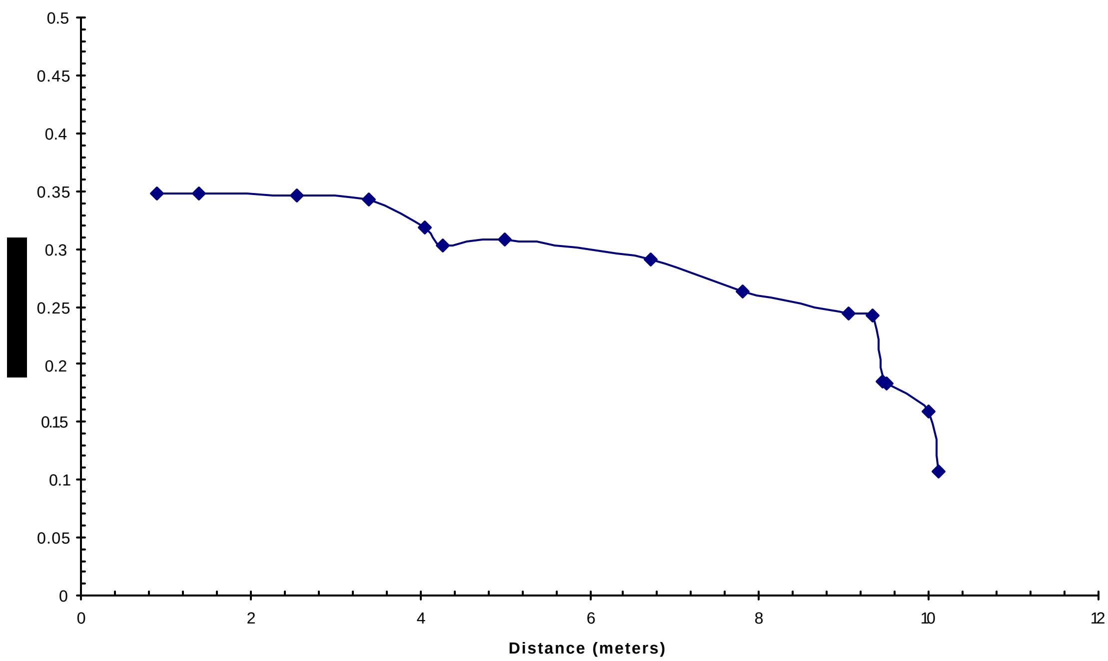


Figure 9. Slope of water surface between cross sections # 2 (downstream) and 3 (upstream). Steepest slope is over the downstream edge of a channel bar.

Channel Description -Cross Section #3

Cross section #3 was located at the beginning of a channel bar (described above, see Figure 7), 10 meters upstream from section #2. At this site, the banks are 2 meters above the channel base, and are composed of Holocene age meandering stream deposits, including coarse channel gravel overlain by overbank sand and silt. Within the bankfull area, smaller sandy terraces have developed, presumably due to sediment accumulation during recent, low-magnitude flood events.

The channel at site #3 is wide and shallow (Figure 10). Exposed and vegetated gravel bars line the sides of the channel (Figure 7). The average mid-channel velocity was 0.31 meters per second, maximum depth 0.2 meters, and channel width at low flow was 27 meters.

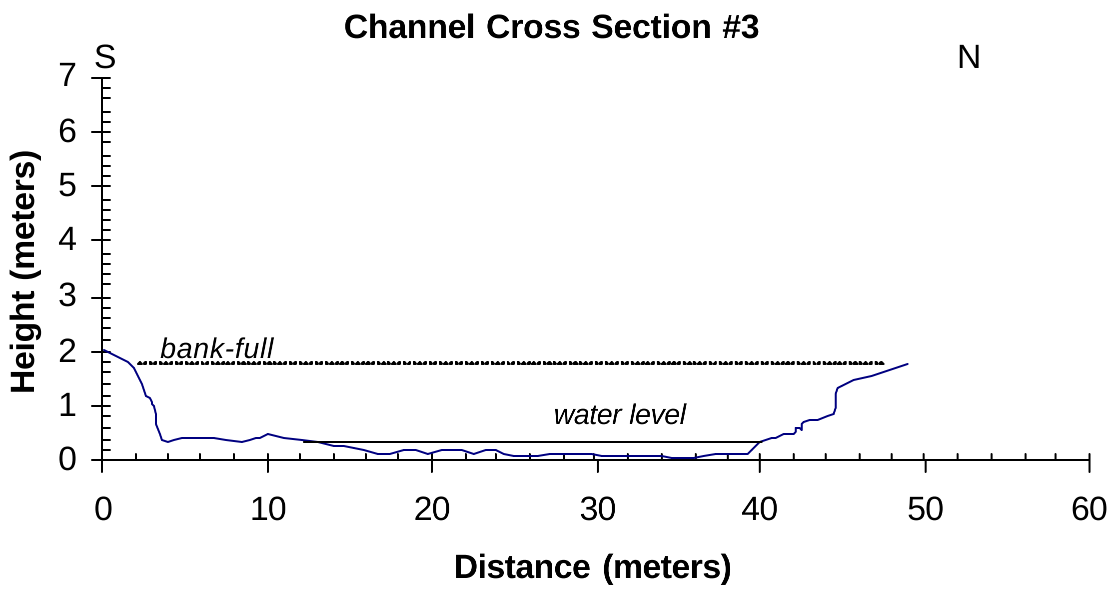


Figure 10 . Channel topography at cross section #2. See Figure 7 for a photograph of this site.

Sedimentology

The nature of sediment in the stream channel plays an important role in stream ecology. Grain size and sorting in the channel are a function of flow dynamics, and the resulting sediment distributions serve as habitat for a variety of aquatic organisms.

The channel substrate was first generally described for clast size, shape, sorting (the range of grain sizes present), and lithology (rock type). At two cross sections, clast sizes were quantified by systematically measuring the diameter of the intermediate axis of gravel clasts exposed along the bed of the channel.

The channel at cross section #1 contains boulders scattered throughout gravel and cobbles, overlying sandstone bedrock, which is exposed in the center of the channel. Most sediments were well rounded, generally poorly sorted, and clast supported with minor amounts of sand and silt between larger clasts. Much of the gravel is composed of quartzose lithologies, derived from reworking of older glacial outwash. The remaining sediments are composed of sandstone and shale derived locally from erosion of Devonian strata. Detailed grain size analyses were not conducted at this stretch, due to the large, predominantly boulder sized material, and bedrock, that made up the channel bed.

The grain size distribution of sediments along the channel bottom at cross sections #2 and 3 (a riffle and run, respectively) were measured by systematically sampling materials lining the channel bottom (675 clasts at cross section #2, and 495 clasts at section #3). Both channel cross sections contained poorly sorted, moderately well rounded gravel and minor amounts of sand and silt (Figure 11). A pebble count across both cross sections yielded an average intermediate diameter gravel size of 40 cm. Gravel lithologies were similar to those described for section #1, above.

Hydrology

River flow regimes are an important aspect of stream ecology (Harris *et al.*, 2000; Wood *et al.*, 2000). Peak stream discharges of French Creek are controlled by the Union City dam, built in 1970. Gauging stations throughout the French Creek watershed permit an examination of pre- and post-dam hydrologic conditions. The longest continuous records of discharge in the French Creek watershed were recorded downstream from the study area, at the confluence of French Creek and the Allegheny River (88 years), and at Utica (69 years) (Table 3). Shorter records are also available, however most either only predate or post-date dam construction.

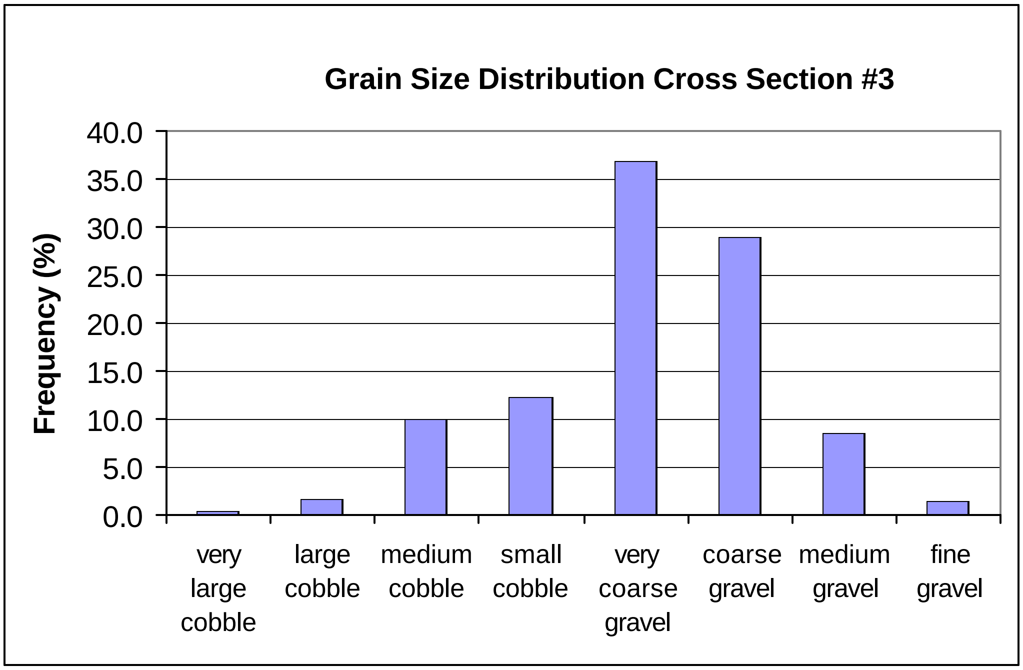
					Discharges		
Location	Years of record	Drainage area	Maximum	Minimum	Average annual peak	Pre-dam average	Post-dam average
		(sq miles)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
Franklin	88	5982	196000	31600	72143	80738	57203
Utica	69	1028	35600	9140	13453	14611	12114
Carelton	17	998	38000	14800	17288	17288	-
Saegertown	19	629	26300	12600	11797	11797	-
Union City	20	221	4430	1250	2468	-	2468
Carters Corners	61	208	20000	2350	7695	7788	-
Wattsburg	27	92	6350	1860	4015	-	4015
Sugar Creek	47	166	10000	2060	5600	not dammed	not dammed

Table 3. Discharge statistics for selected gauging stations along French Creek. Cfs = cubic feet per second.

Analysis of annual series discharge data collected by the U.S.G.S. clearly shows differences in peak discharges through time (Figure 12). Annual series discharges include only the largest discharge for each year of record (Dunne and Leopold, 1978). It is generally accepted that larger peak discharges are most responsible for the greatest morphological adjustment of floodplains, including mobilization and redistribution of sediment, organic matter, and landform creation. Discharges smaller than bankfull capacity, while more frequent than overbank flows, have less potential to alter the riverine landscape, and do nothing to impact the floodplain proper.

Figure 12 clearly shows not only a decrease in average peak discharges, but also decreased peak flow variability from the pre- to post dam period. Total variability in discharge can be expressed by the standard deviation of discharges in each period. (The standard deviation is a measure of how widely values are dispersed from the average value, the mean). The pre-dam standard deviation at Utica was 3961 cfs, where as the post dam standard deviation was 2948 cfs. The difference between these values demonstrates that there has been a 25.6 % decrease in annual series flow variability since dam construction at Union City. Flow variability measured on French Creek at the confluence with the Allegheny River at Franklin has decreased by 54 %.

Decreased flow variability corresponds with fewer, and smaller, overbank flow events. The net result is less interconnectedness between in-channel stream environments and the floodplain setting, which impacts the mobilization of organic matter and nutrients that sustain healthy ecosystems. For example, a large statistical analysis investigating the distribution of fish species as a function of environmental variables indicated that species diversity decreases with decreasing stream flow variability (Koel, 1997). And, recent significant stream management programs recognize that peak flow variability is one of the most important aspects of maintaining a healthy stream ecosystem and restoring habitat diversity (Gosford-Wyong Councils, 2001).



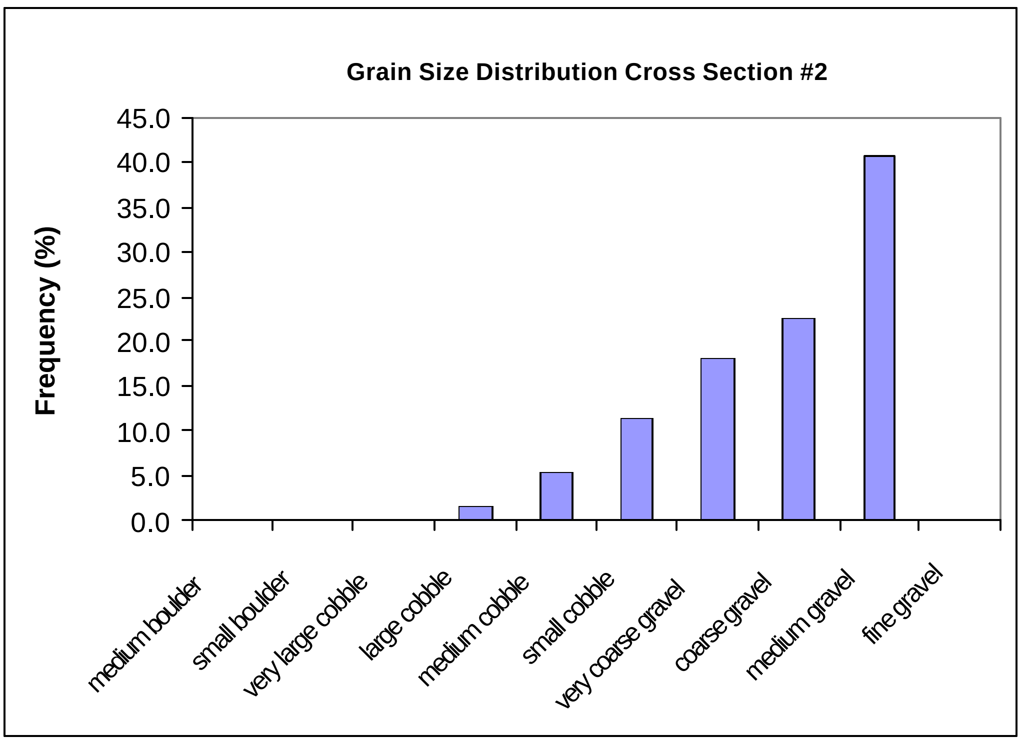
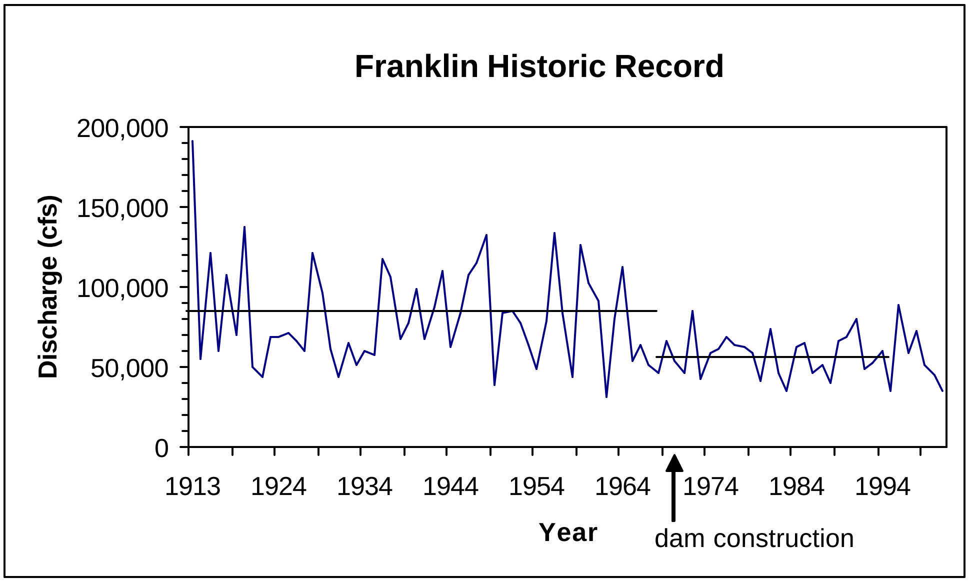


Figure 11. Grain size distribution of clasts exposed along the channel bed. Grains sizes measured from the intermediate axis of clasts.



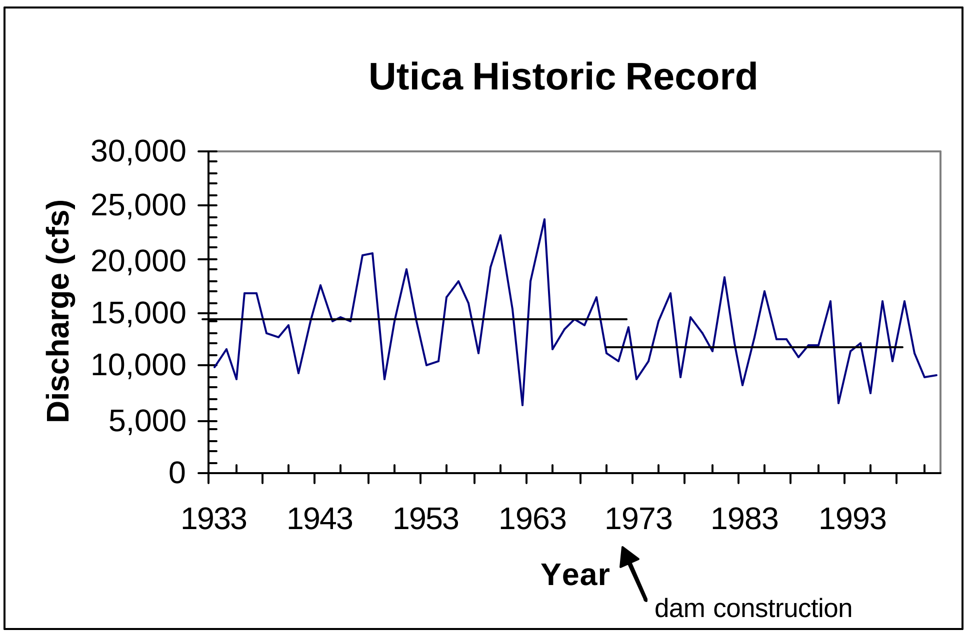


Figure 12. Annual series discharges on French Creek at the confluence with the Allegheny River (A), and at Utica (B). Horizontal lines indicate average annual series discharges for the pre-and post-dam periods.

Summary

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

The study site includes a natural run and riffle sequence and a disturbed section south of the Union City dam, chosen to best represent stream environments typical of French Creek. Physical parameters documented here include: channel cross sectional area and shape, flow velocity and discharge at low flow, bedrock geology, river bed substrate (grain size and sorting), bank stability and riparian zone descriptions. 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.

Based on the limited observations described above, stream morphology does not appear to have changed radically over the last several hundred years or so, with a few exceptions. For example, French Creek had been an actively meandering stream in the past, as indicated by the occurrence of many abandoned channels (visible in aerial photographs, and recorded in the sedimentary record) that are most likely late Holocene in age. However, localized revetments have restricted channel migration, resulting in channel scouring and deepening. Coarse grained sediments scoured from those locations are deposited downstream as channel bars, which fill the channel and force floodwaters to further scour banks opposing those revetments.

This report also incorporates a study of flow variability, which is an important aspect in the health of natural stream ecosystems. Natural peak flow variability has decreased since the construction of the dam at Union City, however the impact of that change in flow regime on local species diversity is not known. In many other watersheds, a decline in flow variability is tied to decreased stream biodiversity, as the linkages between floodplain and channel are reduced through peak flow reduction. A reduction in overbank floods and the fine-grained sedimentation that accompanies those events requires that that fine material must still be in the channel. Increased fine grained material in the channel decreases habitat for aquatic insects and some fish. Future impacts on flow variability through the proposed alteration of the Union City dam will likely reduce peak flow variability even further. The result, based on comparisons of other streams, will be reduced biodiversity.

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