SIXMILE CREEK: A MANAGEMENT OVERVIEW

CONDITION OF SIXMILE CREEK AND WATERSHED

A number of recent studies show that the Sixmile Creek ecosystem is fairly healthy. The watershed remains largely undeveloped and the water quality is rated the best of the local streams by the Community Science Institute. The largest problem in Sixmile Creek is the high load of suspended sediment, a result of erosion along the main channel and tributaries, predominantly from Brooktondale downstream to the dams.

Much or most of this incision (downcutting or degradation) is probably a result of removal of sediment that accumulated in the valley when there was more intensive deforestation and agriculture in the watershed from the mid 19th to early 20th centuries. This activity caused high rates of sediment erosion, primarily in the upland areas, and resulted in deposition of some of this material on the floodplains and in channel aggradation.

However, from the early 20th century to present, the watershed has been reverting to a more forested condition, leading to less erosion in the uplands but to erosion of the sediment that was deposited on the floodplains, as well as some of the underlying clay-rich glacial deposits. This change in channel behavior, together with an increase in channel sinuosity, is a natural attempt of the stream channel to attain equilibrium in response to the reduced sediment yield of the reforested watershed.

The water chemistry of the creek, as measured by the Sixmile Volunteer Monitors and others, shows lower concentrations of nitrate/nitrogen and dissolved phosphorus than do watersheds with more agricultural activity (e.g. Salmon Creek). Chloride concentrations are relatively low but increase downstream. Much of the increase can be attributed to road salt but the sharp increase in chloride concentrations from Slaterville Springs to Brooktondale probably reflects natural discharge of brackish water originating from salt layers in the bedrock. Pathogen (E. coli) levels are usually low but at times exceed some DEC standards.

Channel sinuosity, at least in the reaches between the dams and Brooktondale, has increased since 1936, when the earliest aerial photographs were taken. This increase in sinuosity suggests that the channel is moving toward an equilibrium representing a more "natural" character with the return of a forested watershed.

The riparian corridor along the creek is almost unimpacted by transportation and utility structures and residential and commercial development from Middaugh Road to the City dams, as well as above Slaterville Springs (the Barrile Project). There is significant interaction between the riparian corridor and human activity through Slaterville Springs and Brooktondale and slight to moderate interaction further downstream to Middaugh Rd.

The watershed beyond the riparian corridor has improved greatly because reforestation has stabilized soils and reduced the amount of sediment supplied from the watershed. At present the area devoted to agriculture constitutes only a small fraction of the watershed. Housing and industrial development is not yet a significant factor, but definitely could threaten these improvements, particularly where clay-rich sediments underlie the watershed.

Although many behavioral aspects of Sixmile Creek are now fairly well understood, others are not. Several priorities for future research were identified. These include: 1)

Quantifying the amount and source of bedload sediment moving through the watershed; 2) Describing how channel sinuosity and channel cross-sectional shape has evolved during the 20th century; 3) Quantifying the amount and source of the sediment input to Sixmile Creek from its tributaries, and 4) Determining the effects of road drainage ditches on storm-water runoff and channel erosion.

Bedload is intrinsically very difficult to measure but is a very important factor in stream channel behavior. The silt dam traps all bedload from above that point in the channel, as well as some fraction of the suspended load. Measuring the total amount of sediment removed from the silt dam and of sediment deposited in the City reservoir would permit the calculation of the total sediment load that is transported by Sixmile Creek. An estimation of the ratios of material having different grain size trapped by the silt dam would be necessary to differentiate bedload from suspended load in this trap. Unfortunately, none of this information was obtained when a contractor was excavating the sediment from the silt dam.

Quantification of the bedload above the Barrile project is an important objective because there are questions concerning the role of bedload in the design and function of "Natural Channel Design (NCD)" projects such as Barrile and "Barrile II. Several ideas as to how to constrain, if not quantify this bedload have been discussed, including tracking painted rocks in the bedload and measuring the movement of bedload "waves".

Measurement of channel sinuosity and width over time and along the stream can provide information as to how the channel is evolving as the watershed has returned to a more forested condition. These data could help improve channel design projects. An initial study of sinuosity from the dams to Brooktondale, using imagery from 1936 and 2003 was made for the Status Report, but this should be expanded to include air-photo imagery from intervening dates and also to include channel width data. Analysis of data upstream from Brooktondale would also be useful.

Indirect evidence indicates that most of the suspended sediment load in the Sixmile channel is derived from tributaries below Brooktondale that are actively eroding glacial deposits, but it would be valuable to document this with data collected in the field. This could be done by a synoptic collection of suspended sediment samples and flow measurements from all these tributaries, but the logistics behind such an effort are daunting. However, even selective measurements of suspended sediments in selected tributaries would be valuable for comparison with samples collected at the same time by the Sixmile Volunteer Monitors.

Rebecca Schneider (Cornell) has been investigating the role of road ditches on watershed behavior, with some data collected in the Sixmile drainage. These data should be acquired and analyzed.

Another factor with largely unknown effects on the Sixmile system is climate change. This is predicted to increase annual precipitation in this region, which has already been recognized. There might also be a change in the intensity of rainfall events. Both effects might change the character of the stream channel through changes in the size of the mean annual flood.

Although some aspects of the Sixmile system remain relatively unknown or debatable, a number of watershed/ stream channel management recommendations can be made with some confidence based on the information at hand.

MANAGEMENT RECOMMENDATIONS

Management in the Sixmile system must be integrated among its various hydrologic components: channel, riparian zone and off-channel watershed. This is a well-recognized paradigm and was explicitly recommended in the Milone and MacBroom report.

CHANNEL

The reach between Middaugh Rd. and the silt dam is largely without structures or streamside development and seem to be returning to an equilibrium state of moderate sinuosity with pools and riffles. Measurements at German Crossroad since 1976 indicate a history of decreasing channel degradation rate with time, but one punctuated by a recent pulse of degradation caused by upstream migration of a zone of active incision (a knick zone). Future degradation will be inhibited by the massive structures at the pipeline crossings, which act as local base levels. **As long as the channel doesn't threaten homes and critical structures such as pipelines and bridges**, **there is no reason to interfere with this natural process and it is obviously the least expensive approach.**

However, this do-nothing approach will not address the problem of the large suspended load in this section of the creek. If channel erosion work were done only in the main channel, it would probably not significantly reduce the sediment load carried by Sixmile creek since most of this sediment is derived from the tributarie. Remedial efforts in these tributaries might be possible but would be a daunting and very expensive task. Continued incision of and slumping along these channels will follow the equilibrium trend now occurring in the main channel and will lead naturally to a reduction in sediment supply, although the time frame is uncertain.

Reaches between and below the dams are highly erosive. This "clear water erosion" occurs when sediment, especially bedload, is removed from the stream, which becomes sediment-starved. Degradation is impeded by bedrock exposures in much of the streambed along these reaches of Sixmile Creek and the channel response has been lateral erosion and avulsion (sudden shifts in channel position). The channel will remain in this condition as long as bedload continues to be trapped behind the dams. **The most reasonable solution to erosional problems in these reaches is the use of hard engineering structures to control the channel location.**

An alternative scenario, if the City of Ithaca abandons Sixmile Creek as a water supply, would be dam removal. This alternative would result in the transport of several hundred thousand cubic yards of sediment stored behind the dams downstream into the Cayuga Inlet, where efforts are underway to dredge sediment already accumulated there. **If abandoned for water supply and not removed, the dams must still be maintained, although they could be allowed to fill. Once the dam is filled with sediment, the sediment load transported by Sixmile Creek will pass through the dam infill and ultimately be deposited into Cayuga Inlet. If the Inlet is to remain navigable, a decision will have to be made whether to remove sediment from behind the dams or from the Inlet.**

The reaches above the Barrile Project at Slaterville Springs are also nearly “pristine” and **here again the best management seems to be to allow the stream to continue to equilibrate with watershed conditions without engineered interference.** Only along the headwaters of the east branch (Irish Settlement Rd) has there been disturbance of and encroachment toward the channel, but management of this reach is better described in the recommendations for management of riparian corridors.

The most intensive interaction between the channel and human activity occurs along the reaches through Slaterville Springs and Brooktondale. It is in these reaches that pressure for channel manipulation is and will be the greatest because the processes of channel equilibration now and for the foreseeable future will cause bank erosion.

Channel erosion control projects such as Natural Channel Design (NCD) projects, in particular those following the Rosgen protocol have been implemented (Barrile project), and are being planned for other reaches of Sixmile Creek, but several issues should be evaluated before embarking on these projects..

First, there are many benefits in living along a stream but it should be recognized that this is a hazardous environment. The consequences of living by the creek, with both its beneficial and hazardous aspects, are primarily the responsibility of those living there, rather than that of the public.

Second, it must also be pointed out that the effectiveness and cost benefit of the channel projects, even the NCD projects, are still debatable. A NCD project may have the geometries of a natural channel but differ in one very important aspect: it is designed not to migrate or change its geometry, as do natural channels because of the fixed constraining structures in the former. Both natural channels and NCD’s have geometries that reflect the flow at bankfull conditions because this condition reflects the maximum work done on the channel over time. Although NDC structures are constructed so as to remain stable during floods, their track record in larger floods (e.g. FFI of >30 years) is not great. They often fail under these conditions. This may be due to the fact that an NDC cannot dynamically change its position, as a natural channel often does.

Third, owners and developers of streamside properties should be aware of the limitations of NCD and other channel remediation projects. There are many cautionary anecdotes about municipalities developing land adjacent to a “restored” channel and subsequently suffering financial and even human loss when a large flood event occurs. At the very least, some sort of riparian buffer or “setback” should be incorporated into stream channel “restoration” projects. Finally, although seldom done, cost-benefit studies might be considered for these projects. The costs involved in NCD projects usually run several hundred dollars per foot of channel.

A significant fraction of **channel management** occurs **in the sections adjacent to public bridges.** This work is unavoidable but **should maintain the natural channel parameters as much as possible.**

Several past and existing management techniques are counterproductive and are to be avoided in the Sixmile Creek channel. These include removing gravel from the

channel system, reducing the channel sinuosity, reducing channel roughness, or other practices that increase water velocity in the channel.

Removal of bedload(aka “gravel”) from the channel and floodplain only increases the incision (downcutting and bank erosion) downstream of the removal point because Sixmile already has insufficient bedload for its energy. This energy depends upon several factors, but the most controllable is the water velocity. The quantity of sediment increases exponentially as velocity increases. Velocity increases as the channel slope increases (sinuosity decreases) and as channel roughness decreases. The procedure of bulldozing a smooth straight channel both increases slope and decreases roughness and should definitely be abandoned.

RIPARIAN ZONE

Stream systems include more than the channel at normal (low flow) conditions. They include the floodplain, which is that area flooded by an event of some chosen Flood Frequency Interval (e.g. the 50 yr floodplain is that area covered by a flood that statistically occurs once in 50 years). Therefore, the entire stream valley, not just the channel, comprises the naturally functioning river ecosystem. For the health of the stream and for the safety and welfare of those living along the stream, it is important to control development on the floodplain. This can be most logically done by creating a riparian buffer or setback. This is an area adjacent to the channel within which certain forms of development should not be undertaken. The widths of such zones must be discussed and legislated, but certainly should include the flood plain of some fairly large flood event (Flood Frequency Interval of 50 to 100yr).

There are many positive advantages (aspects) of riparian buffers, not the least of which is financial. Often the long period between major floods, especially when channel restoration projects have been completed, leads to complacency and to development too close to the channel. There are abundant data showing the constantly increasing financial loss resulting from flooding in the US, much of which is due to unwise construction too close to the channel. From a cost-benefit perspective, it is usually cheaper to allow a stream channel to have an undeveloped floodplain in which to expand and to move. Other positive aspects include improved water quality, enhanced ecological conditions, increased flood amelioration, and a more aesthetically appealing river environment.

Creation of a riparian buffer does not mean that nothing at all can be done in that area. There has been much discussion concerning the things that should and shouldn’t be in riparian buffers but some of these are commonly agreed upon. Inhabited structures and impermeable surfaces, as well as potentially polluting activities (e.g., manure spreading) should definitely be avoided in the flood plain. Fill material and other obstructions on the flood plain should also be avoided. Vegetation adjacent to the channel resists erosion and trees provide shade, which reduces water temperatures. Natural flora is preferred, but even untilled land and lawns are better than unvegetated surfaces. Of course, wider is better, but even a narrow strip of bankside trees offers significant ecological benefits.

WATERSHED

At present, the Sixmile watershed is in fairly good shape, with a large percentage in woodland or abandoned agricultural land. Future development poses great challenges but some current practices can be addressed.

Even though agriculture is now a minor land use, agricultural practices have an effect on sediment erosion. Tillage methods are important. Contour plowing reduces runoff and erosion, but this practice appears to be much less prevalent than in surrounding areas (e.g., Cayuga Co.). If there are cogent reasons to resist contour plowing, reduced till methods should be considered. **Current and future agricultural practices should specifically protect riparian and wet areas, soil loss should be minimized from working fields, and working fields should be buffered by permanent vegetated areas.**

Road ditches and field drainage systems have been cited as responsible for disruption of surface flow and for reduction in infiltration. **Local highway departments should be appraised of the studies on the effects of ditching and trained in practices that minimize their negative effects.**

Perhaps the most threatening practices are residential and commercial construction, during which the unvegetated surfaces can temporarily supply large amounts of runoff and soil to the channel system. To some degree this may be mitigated by the stormwater regulations now being developed in the town legislatures.

After completion of construction projects, the increase in impermeable surfaces leads to increased runoff and higher peak flows. Parking lots are perhaps the single largest type of impermeable surface, but **that effect can be reduced by permeable surfaces and retention basins. These and other means of minimizing degradation of the watershed should be pursued through cooperation with the Intermunicipal Organization (IO) and municipal planners.**

WATER QUALITY

Analyses at the City of Ithaca Water Treatment Plant have shown that sodium concentrations have increased from 2005 to 2007 (Averages; 15 to 19mg/L). Public notification is required for values >20 mg/L. Sodium concentrations are strongly correlated with chloride concentrations, which have also been rising in local streams. Increases in these chemicals have been regionally linked to road de-icers, usually sodium chloride. **Highway departments should minimize the negative effects of de-icing compounds through product choice (favoring chemicals that require lower application rates), changes in practices (anti-icing instead of de-icing) and public service announcements reminding drivers to anticipate compromised road surfaces.**

BACKGROUND READING

Support for and details concerning material in the preceding text can be found in the following resources.

Milone and MacBroom, Inc. , 2003, Flood Mitigation Needs Assessment; Six Mile Creek, Tompkins County, New York.

This a report commissioned by the Tompkins County Planning Department that outlines the hydrology of Sixmile creek. It was written by professional hydrologist and reflects that perspective. Copies are available from the Tompkins County Planning Department.

Sixmile Creek: A Status Report. 2007. 35 p.

This report was written by a number of local people with scientific or technical backgrounds in stream related issues under the auspices of the Sixmile Creek Partners. The report includes extensive information concerning the geologic infrastructure, sediment transport and aspects of aquatic health (e.g. biological diversity and water quality). Integrating this report with the MMI report provides a useful background to Sixmile Creek as of 2007. It is available online for review at the Tompkins County Planning Department or online at the following sites;
http://ecommons.library.cornell.edu/handle/1813/8354

http://www.ci.ithaca.ny.us/vertical/Sites/%7B5DCEB23D-5BF8-4AFF-806D-68E7C14DEB0D%7D/uploads/%7BE7D21826-A480-4E0C-B601-26071B17437A%7D.PDF

Leopold, Luna, 1994, A View of the River, Harvard University Press

This book is one of many on Stream behavior, but one of the best. It covers most aspects of stream behavior (fluvial geomorphology) in a complete and moderately technical manner, but is quite readable by most people.

Keller, E. A, 2001. Environmental Geology, Upper Saddle River, New Jersey, Prentice Hall.

This is one of the better texts on environmental geology that covers the human interactions with streams as well as presenting stream behavior at an elementary level. This and many other such texts are available at local libraries

Rosgen, Dave, 1996, Applied River Morphology, Wildland Hydrology, Pagosa Springs, Colorado.

This book covers the Rosgen approach to channel management as well as providing underlying hydrologic principals to that approach. An extensive list of websites related to the Rosgen methodology can be found at:
http://www.wildlandhydrology.com/html/references_.html

Community Science Institute website;
http://www.communityscience.org/SixMile/SixMileCreek.html
See pages at this site concerning water quality and flow. Profiles of various chemical and physical parameters along Sixmile Creek are posted here. The page on ***summary of results*** *gives a brief analysis of most of these data.*

Langen, et. al., 2006. Environmental Impacts of Winter Road Management at the Cascade Lakes and Chapel Pond. Clarkson Center for the Environment, Report #1.
This is a recommended resource for the effects of road salt on the environment and on methods to manage the problem.