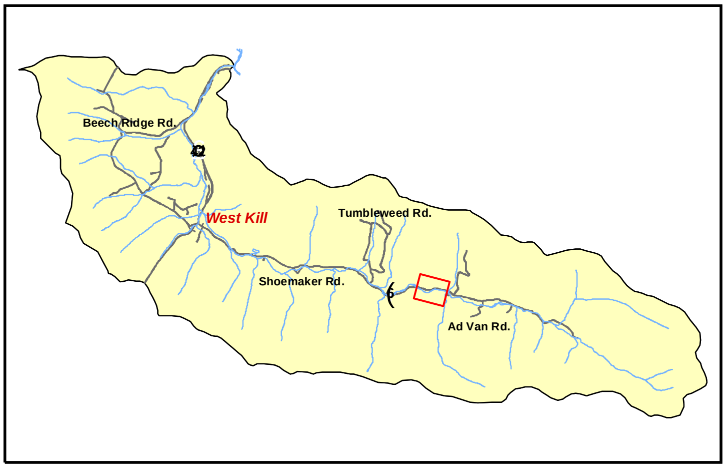


West Kill Management Unit 6

Stream Feature Statistics

23% of stream length is experiencing erosion
30% of stream length has been stabilized
12.2 acres of inadequate vegetation within the 300 ft. buffer
19 ft. of stream is within 50 ft. of the road
3 houses located within the 100-year floodplain boundary

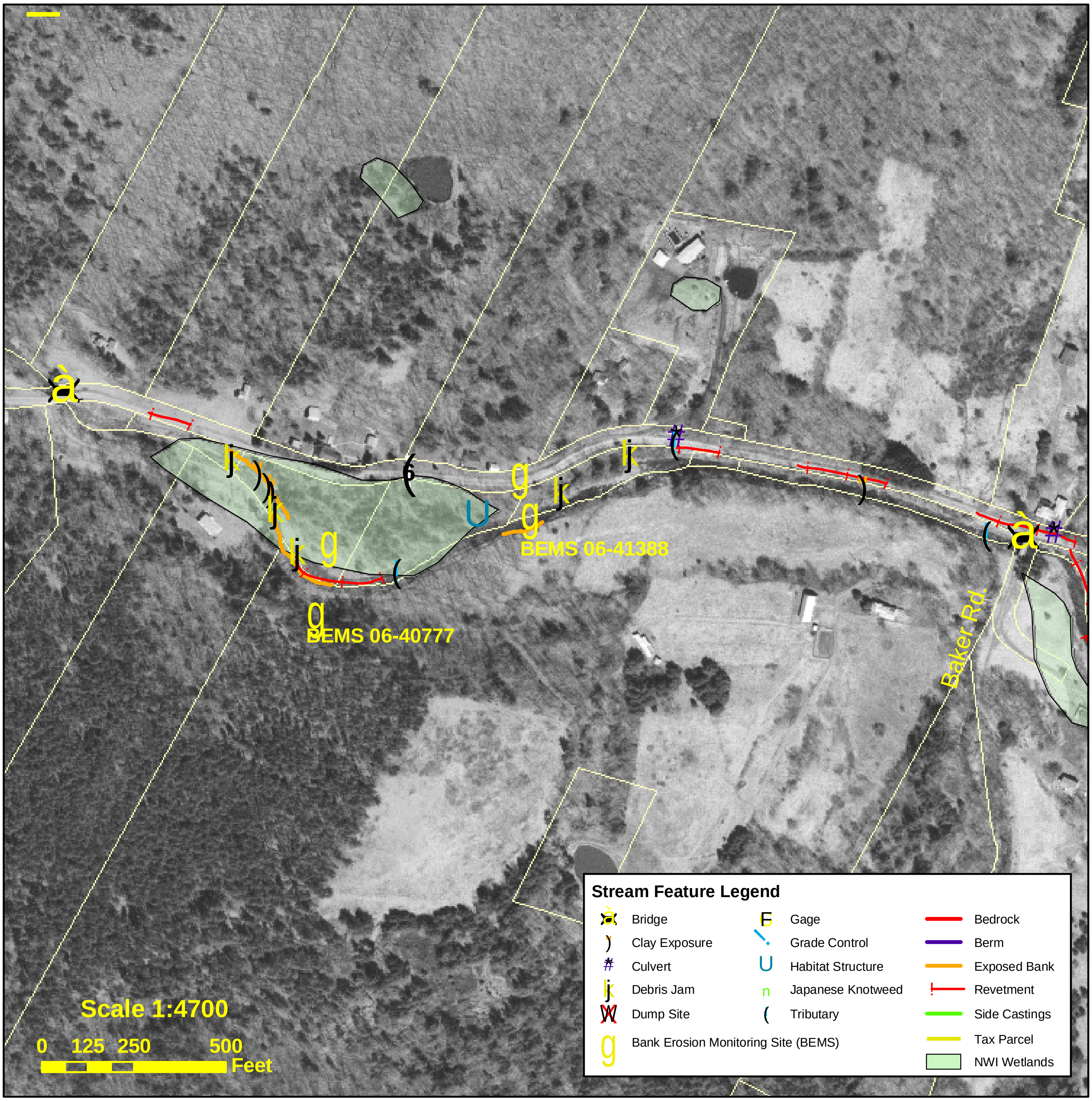


Figure 4.6.1 2004 aerial photography with stream feature inventory and tax parcels

Management Unit 6

Between Station 42743 and Station 39851

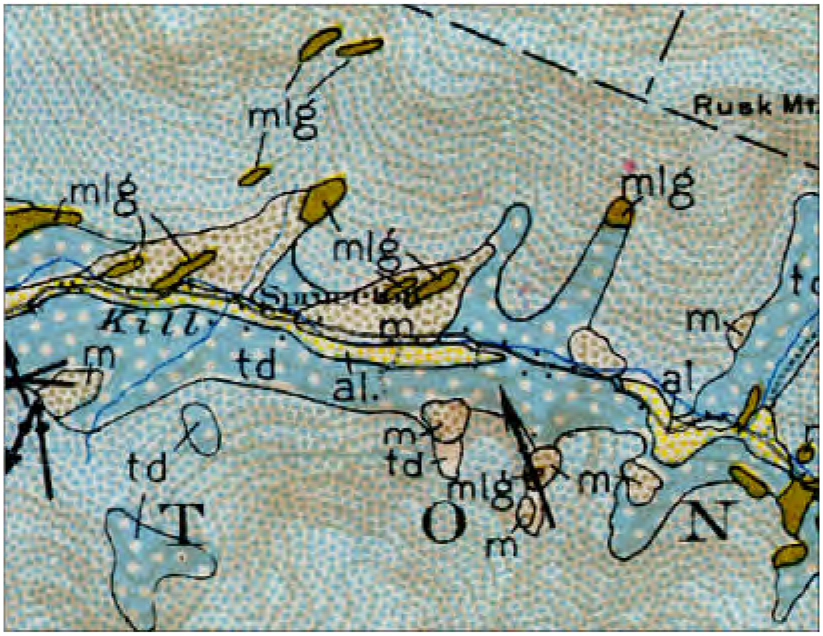
Management Unit Description

This management unit begins just downstream of the Baker Road bridge, continuing approximately 2,892 ft. to the County Route 6 bridge crossing. The drainage area ranges from 8.8 mi^2 at the top of the management unit to 10.8 mi^2 at the bottom of the unit. The valley slope is 1.65%.

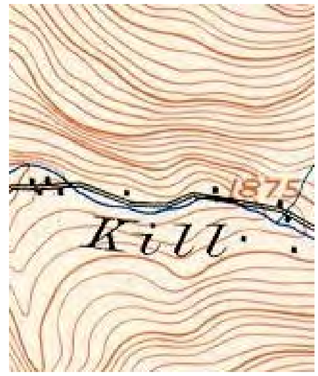
Summary of Recommendations Management Unit 6	
Intervention Level	Full Restoration at BEMS 06-40777 Assisted Self-Recovery at BEMS 06-41388
Stream Morphology	None
Riparian Vegetation	Potential planting sites along road embankments, right and mown field, left, to increase buffer width
Infrastructure	Interplanting of rip-rap on road embankment
Aquatic Habitat	Watershed-wide study
Flood Related Threats	None
Water Quality	Restoration to isolate sources of fine sediment
Further Assessment	Geotechnical assessment of BEMS 06-40777

Historic Conditions

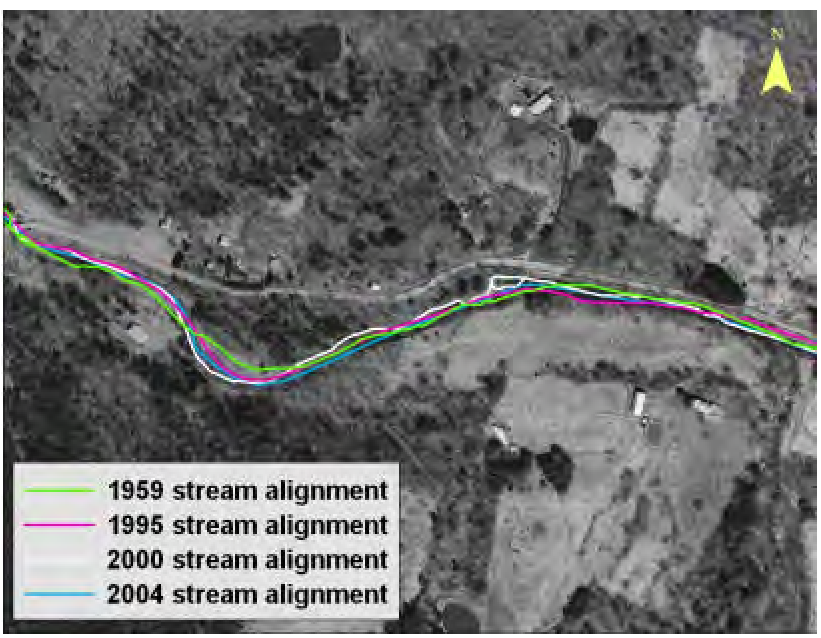
As the glaciers retreated about 12,000 years ago, they left their "tracks" in the Catskills. See Section 2.4, Geology of the West Kill Creek, for a description of these deposits.



Excerpt from Rich, 1935



Excerpt of 1903 USGS topographic map MU6



Historic Stream Channel Alignments in MU6

As seen from the historical stream alignments, the channel alignment has not changed significantly over the years, although a debris jam appears to have created a cutoff channel in response to the 1996 flood.

According to available NYS DEC records there were two stream disturbance permits issued in this management unit following the flood of 1996. The first was to Joyce Becker, to remove 300 yards of gravel, over approximately 800 ft. of stream, obstructing the County Route 6 bridge. The second was to Ronald Haring; no documentation of the scope of the permit was available from NYSDEC records.

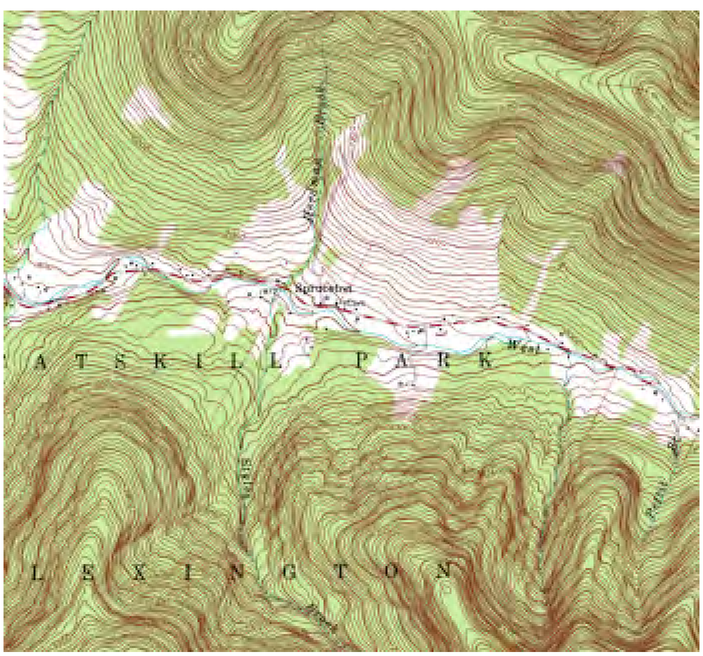
Stream Channel and Floodplain Current Conditions

Revetment, Berms and Erosion

The 2004 stream feature inventory revealed that 23% (659 ft.) of the stream banks exhibited signs of active erosion along 2,892 ft. of total channel length (Fig. 4.6.1). Revetment has been installed on 30 % (873 ft.) of the stream length. No berms were identified in this management unit at the time of the stream feature inventory.

Stream Morphology

The following description of stream morphology references insets in the foldout Figure 4.6.2. "Left" and "right" references are oriented looking downstream. Stationing references proceed upstream, in feet, from an origin (Station 0) at the confluence with the Schoharie Creek at Lexington. Italicized terms are defined in the glossary. This characterization is the result of surveys conducted in 2004 and 2005.



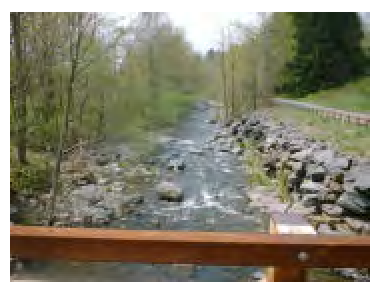
Excerpt of 1980 USGS topographic map

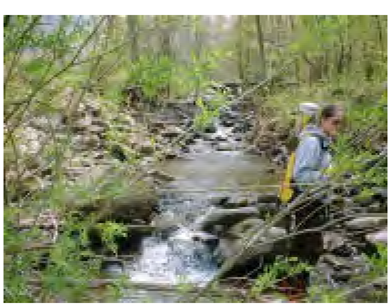
In Management Unit 6, the West Kill bends back toward, and again becomes influenced by, Spruceton Road. The valley slope here remains 1.65%, which in a wild river one would expect to result in more channel sinuosity, a wider beltwidth and consequently, greater tendency and capacity for sediment storage, than one finds in MU6, in contrast, for example, to the reaches just upstream. These conditions may be the result of historic channelization to create conditions more favorable for agriculture. The low *sinuosity*, or curviness, and *beltwidth*, or the width of the stream corridor from outside-to-outside of meanders, are uncharacteristic of this valley slope, and judging by the extensive revetment, the reach may be incising. Streams in valleys of this gradient tend to dissipate stream power laterally during high flows, with excess *shear stress*, or the force the stream exerts in the direction of its flow, often producing erosion of streambanks when the flows are confined by historic incision or berming. Often channels are widened to reduce flood elevations and associated erosive shear stress, as well as to increase their ability to convey larger flows. Channel widening, however, usually leads to *aggradation*, or a raising of the streambed due to the deposition of sediment that cannot be moved by the shallower flows at these greater widths. Aggradation can lead to channel instability and the necessity for unnecessary ongoing maintenance.

Stream morphology, or shape (i.e., slope, width and depth) changes several times in this unit, creating small reaches with differing morphologic characteristics, which are classified as different *stream types* (See Section 3.2, Introduction to Stream Processes, for description of stream types).

Cross-sections and Rosgen stream types in Management Unit 6

Management Unit 6 (MU6) begins with a relatively straight, 943 ft. reach of B3c streamtype, a continuation of the same reach type upstream of the Baker Road bridge (see Inset D, Fig. 4.6.2). A monumented cross-section (Station 42467) documents a moderately *entrenched*, cobble-dominated channel with a slope of 1.49%. Moderate entrenchment means that as flows increase, access to the floodplain increases. In this reach of stream, the West Kill accesses its floodplain on the left. On the right, a 287 ft. stacked rock embankment protects Spruceton Road upstream and downstream of the bridge. The addition of trees and shrubs here would help buffer the stream from the road, and add stability to the bank. The stability of the left bank would also benefit from the improvement of the riparian buffer, although willows are growing on the bank, adding cohesiveness here. Beyond a narrow line of trees on the left is a large mown field.





Styles Brook confluence, left bank

Styles Brook (1.5 mi.^{2}), a significant tributary, enters on the left at a well-connected confluence. Continuing downstream, on the right, the stacked rock wall transitions to dumped rock. There is evidence of grading and associated aggradation throughout this reach.

Continuing downstream, a 251 ft. installation dumped riprap protects the County Rte. 6 road embankment on the right (see Inset G, Fig. 4.6.2). Lacustrine clay is exposed in the bed at the toe of the left bank, and groundwater seeps from the bank over these exposures.

Clay exposure, left

Aggradation adjacent to stacked rock wall

Continuing downstream, the channel is aggrading, an artifact of backwater resulting from a debris jam further downstream that has since been moved to block an overflow channel (see Inset C, Fig. 4.6.2).. Near the downstream end of the straight reach, another 121 ft. section of stacked rock protects the road embankment. An 18" culvert enters on the right carrying road drainage and flow off the hillslope to the north under Spruceton Road (County Route 6). The culvert is without outfall protection, the headwall is in poor condition, and the confluence with the West Kill is perched, also without outfall protection, creating a high potential for headcutting. Vegetative stabilization is recommended here.

Culvert outfall

At the downstream end of the stacked rock, the channel bends to the left, where a large woody debris jam blocks what had been a cutoff channel on the right. Historical channel alignments indicate that this overflow channel was created during the flood event of 1996. The split flow created ineffective sediment transport and aggradation. There is evidence of efforts to fill the overflow channel with debris and direct flow to the left.

Debris jam, aggradation at head of overflow channel, right

Headcut at divergence of overflow channel and debris jam

This aggradation creates a hydraulic drop at its downstream end, resulting in a *head cut*. Headcuts are short, steep sections that migrate upstream as they progressively erode the bed. However, there is abundant large, native rock present at the headcut, apparently placed, as well as in the channel downstream, and the site exhibits high potential for self recovery. This was confirmed during the 2005 inventory. A short, steep riffle is developing here. It is recommended that the site be monitored to ensure that recovery continues. Entrenchment increases at the downstream end of the headcut, but lessens as access progressively increases to the floodplain on the right.

Lateral debris jam, right

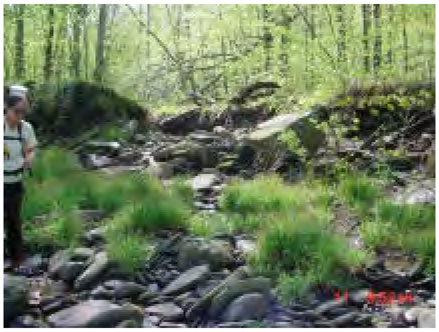
Entrenchment continues to diminish downstream, where a debris jam and associated lateral bar on the right were documented, as the stream transitions to a 1500 ft. reach of C3 stream, documented by a surveyed cross-section at Station 41139. The debris jam presents no obstruction at low flow, and may provide some bank protection at high flow. Dense sedges stabilize this bar.

Bank Erosion, left bank

As the treeline on the left bank narrows to nothing along the mown field, the bank becomes undercut. Plantings of trees and shrubs along the streambank are recommended to help stabilize the bank and buffer the stream from the horse pasture. The reach appears overwide, and aggradation was observed downstream. Erosion of this bank has been monumented as a Bank Erosion Monitoring Site (BEMS Station 06-41388). In a prioritization of twenty-one BEMS sites throughout the West Kill watershed (see Section 3.3, Watershed Inventory and Assessment), this site ranked Low Priority. The *thalweg*, or deepest part of the stream channel flows up against the left bank here, undercutting the adjacent mown field. As there is no serious threat to infrastructure or water quality, and as the pressure on the bank may be mitigated if the debris jam on the right upstream is gradually cleared through deterioration and higher flows, the recommendation here is to continue monitoring the bank.

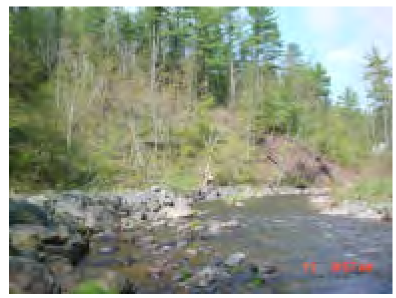
Remnants of habitat structure, right

As the riparian buffer improves on the left, the remnants of a NYSDEC habitat structure (Station 41250) are observed on the right, with associated aggradation just upstream. Habitat structures were historically installed throughout the West Kill mainstem by the New York State Department of Environmental Conservation (NYSDEC), often to create scour pools. These scour pools offer deeper holding habitat, sometimes with associated cover, and the spillways raise the level of dissolved oxygen in the water. The structures, often in the form of a log weir perpendicular to the channel, also provided grade control. Because they provide only minimal lateral control, however, higher flows frequently flank these structures. In some settings, this can promote lateral channel migration, increase width-to-depth ratios and result in bank erosion up- or downstream, as is seen here. In wild streams, these functions – both positive and negative – are performed to a large extent by large woody debris.



Tributary, left bank

A small unnamed tributary enters from the left, with the confluence somewhat perched, just upstream of the head of a 258 ft., low installation of rip-rap on the left, intended to protect a large slope failure on the outside of a meander bed to the right. Some channel aggradation is evident here (see Inset F, Fig. 4.6.2).



Rip-rap toe protection of slope failure, left bank

The channel is being turned here by the clay-rich, morrainal till of the terrace wall, and the toe of this bank is being scoured, with deep pools resulting, and causing the rip-rap to fail in places. The large structural failure is being exacerbated by the deposition of slash and timber from forest clearing and road development taking place on the terrace slope. The resulting slide is introducing considerable woody material into the stream. This erosion has been monumented as a Bank Erosion Monitoring Site (BEMS Station 06-40777). In a prioritization of twenty-one BEMS sites throughout the West Kill watershed (see Section 3.3, Watershed Inventory and Assessment), this site ranked at the top of the Medium Priority class, due in part to its size, potential threat to the road above and the quantity of woody material it is introducing to the stream. The *thalweg*, or deepest part of the stream channel flows up against the terrace here. The hillslope is being undermined by toe erosion, leaving sections of the stream bank unvegetated. The *glacial till deposits* have a high silt and clay content, contributing sediment through both *wet and dry ravel* and yielding a significant suspended sediment load during high flows. Clay inputs into a stream are a serious water quality concern because they increase *turbidity*, degrade fish habitat, and can act as a carrier for other pollutants and pathogens.

Debris jam

At the toe of the slope failure, a debris jam delivered off the slope obstructs the flow. This obstruction may encourage the development of a bench at the toe of the failure; there is good conveyance around the right of the jam, and access to the floodplain on the right. Alternatively, this material may accentuate scour at the toe. Which scenario occurs will depend on the sequence and magnitude of the flows over the next few years, as well as chaotic dynamics like additional collection of large woody debris and the size of material slumping out of the bank.

Debris jam

Another fallen tree downstream presents a more significant problem for conveyance across the point bar on the right, and directs flow toward the eroding bank (see Inset B, Fig. 4.6.2).

Clay Exposure in bed, right

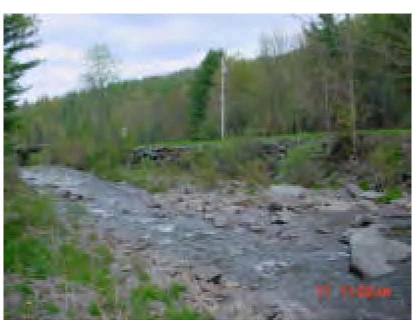
As the channel meanders back to the left, 260 ft. of bank cutting along the floodplain on the right was observed, exposing a deposit of clay till in the bed and bank in several locations. Groundwater seeps across the top of this clay deposit. This erosion is associated with, and would be included as part of any treatment of the BEMS 06-40777 site.

Bank Erosion, right bank

Continuing downstream, a monumented cross-section (Station 40175) documents the transition to a 449 ft. reach of B4c stream type. Entrenchment increases as the channel becomes confined by the County Route 6 embankment on the right, the dominant bed material changes to gravel, and the slope drops to 0.9%. A single line of trees buffers the stream from the road on the right, and erosion is undermining these as well. One tree is deposited here in the middle of the channel (see Inset E, Fig. 4.6.2).

Debris Jam

Full Restoration is recommended for this site. This would likely involve establishment of a well-vegetated bench on the outside of each meander, with rock vanes to direct stream flows away from the banks and to establish grade control, and revegetation of the bank faces. In-depth survey and design would be required to plan a stream restoration project at this site.



Stacked Rock Wall, right

Further downstream, the embankment of CR6 bar has been stabilized with a 122 ft. section of stacked rock wall on the right. A lateral bar has developed at its toe, and willows are colonizing it.


County Route 6 Bridge

At the County Route 6 bridge, the road turns to the left and the West Kill bends to the right, but the alignment remains diagonal, requiring a long wing wall upstream left, and significant scour protection, which includes a flow directing rock structure. Despite this design, the left bridge abutment is severely scoured. There is aggradation upstream, likely due to backwatering exacerbated by the poor alignment.

Sediment Transport

Streams move sediment as well as water. Channel and floodplain conditions determine whether the reach aggrades, degrades, or remains in balance over time. If more sediment enters than leaves, the reach aggrades. If more leaves than enters, the stream degrades (See Section 3.1 for more details on Stream Processes).

Sediment transport processes in Management Unit 6 are not straightforward. Several reaches appear to be overwidened. Where the entrenchment is moderate to high, the result is an oscillation between aggradation at lower flows (when sediment is being delivered by more effective reaches upstream, but is incapable of being transported through the reach) and degradation at higher flows (when disconnection of floodwaters from the floodplain results in overly effective transport, and incision). Where the entrenchment is low, the result is a positive feedback loop driving the reach toward aggradation, avulsion or bank cutting and, eventually, braiding.

Several short steep sections appear to be headcuts, which often start at the downstream end of aggradation, where a hydraulic drop creates excess shear stress locally. The result of headcuts moving through a stream is a lowering of base elevation and an increase of sediment loading downstream as a result of entrainment of material from the bed and oversteepened banks. The resulting entrenched conditions lead to additional stability problems.

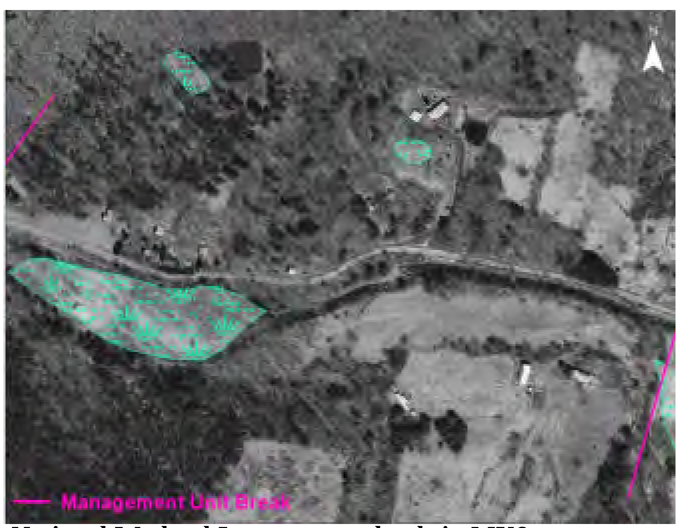
Riparian Vegetation

One of the most cost-effective methods for landowners to protect streamside property is to maintain or replant a healthy buffer of trees and shrubs along the bank, especially within the first 30 to 50 ft. of the stream. A dense mat of roots under trees and shrubs bind the soil together, and makes it much less susceptible to erosion under flood flows. Mowed lawn does not provide adequate erosion protection on stream banks because it typically has a very shallow rooting system. Interplanting with native trees and shrubs can significantly increase the working life of existing rock rip-rap placed on streambanks for erosion protection. *Riparian*, or streamside, forest can buffer and filter contaminants coming from upland sources or overbank flows. Riparian plantings can include a great variety of flowering trees and shrubs, native to the Catskills, which are adapted to our regional climate and soil conditions and typically require less maintenance following planting and establishment.

Some plant species that are not native can create difficulties for stream management, particularly if they are invasive. Japanese knotweed (*Fallopia japonica*), for example, has become a widespread problem in recent years. Knotweed shades out other species with it's dense canopy structure (many large, overlapping leaves), but stands are sparse at ground level, with much bare space between narrow stems, and without adequate root structure to hold the soil of streambanks. The result can include rapid streambank erosion and increased surface runoff impacts.

An analysis of vegetation was conducted using aerial photography from 2005 and field inventories (Fig. 4.6.3). Japanese knotweed occurrences were documented as part of the stream feature inventory conducted during the summer of 2004, with additional occurrences identified in 2005.

In this management unit, the predominant vegetation type within the 300 ft. riparian buffer is Forest (57%) followed by Herbaceous (27%). *Impervious* area (5%) within this unit's buffer is primarily the Greene County Route 6, along with private residences and associated roads. No occurrences of Japanese knotweed were documented in this management unit during the 2004 or 2005 inventory. However, Japanese knotweed does occur downstream, and a program for eradication of Japanese knotweed throughout the West Kill valley is recommended.



National Wetland Inventory wetlands in MU6

There are two wetlands within this management unit mapped in the National Wetland Inventory (see Section 2.5, Wetlands and Floodplains for more information on the National Wetland Inventory and wetlands in the West Kill watershed). Wetlands are important features in the landscape that provide numerous beneficial functions including protecting and improving water quality, providing fish and wildlife habitats, storing floodwaters, and maintaining surface water flow during dry periods (See Section 2.6 for wetland type descriptions and regulations). The smaller wetland, a pond across County Route 6, is 0.2 acres in size, and is classified as *palustrine unconsolidated bottom, permanently flooded, diked impounded* (PUBHh). The larger wetland, in the floodplain on the right near the end of the unit, is 4.2 acres in size, and is classified as *palustrine forested, broad-leaved deciduous, and temporarily flooded* (PFO1A).

Areas of herbaceous (non-woody) cover present opportunities to improve the riparian buffer with tree plantings, to promote a more mature vegetation community along the streambank and in the floodplain. In November 2005, suitable riparian improvement planting sites were identified through a watershed-wide remote evaluation of current riparian buffer conditions. These locations indicate where plantings of trees and shrubs on and near stream banks can help reduce the threat of serious bank erosion, and can help improve aquatic habitat as well. In some cases, eligible locations include stream banks where rock rip-rap has already been placed, but where additional plantings could significantly improve long-term stream channel stability, as well as biological integrity of the stream and floodplain. Areas with serious erosion problems where the stream channel requires extensive reconstruction to restore long-term stability have been eliminated from this effort. In many cases, these sites can not be effectively treated with riparian enhancement alone, and full restoration efforts would include channel restoration components in addition to vegetative treatments. Twenty-three potential planting sites were documented within this management unit (Figure 4.6.4).

Flood Threats

Inundation

As part of its National Flood Insurance Program (NFIP), the Federal Emergency Management Agency (FEMA) performs hydrologic and hydraulic studies to produce Flood Insurance Rate Maps (FIRM), which identify areas prone to flooding. The NYS DEC Bureau of Flood Protection is currently developing new floodplain maps for the West Kill on the basis of recent surveys. These maps should be completed for the West Kill watershed in 2006.

The 100-year floodplain is that area predicted to be inundated by floods of a magnitude that is expected to occur once in any 100 year period, on the basis of a statistical analysis of the local flood record. Most communities regulate the type of development that can occur in areas subject to these flood risks. There are three houses in this management unit in the 100-year floodplain. The current NFIP maps are available for review at the Greene County Soil & Water Conservation District office.

Bank Erosion

Many of the stream banks within the management unit are unstable, although 23% (659 ft.) of the stream length is experiencing major erosion, and 30% (873 ft.) has been stabilized, indicating historical stability problems as well.

There are two Bank Erosion Monitoring site in MU6, and one (BEMS #06-40777) is a relatively large failure contributing significant amounts of fine soil and clay, as well as mature trees, to the creek. This failure could constitute a severe flood hazard for downstream reaches due to the potential for uprooted trees to be introduced into the stream from the eroding stream bank during large floods. These trees could create a debris jam at mid-channel bars or the County Route 6 bridge just downstream, and may shift the flow pattern of the stream, threatening roads and residential properties. BEMS #06-40777 ranked at the top of the Medium Priority class.

Infrastructure

Thirty percent of the stream length in this management unit has been treated with some form of revetment. While there are no immediate threats to roadways or bridges in this management unit, both the drive at the top of the structural hillslope failure at Bank Erosion Monitoring Site 06-40777 and the County Route 6 road embankment just downstream may be at risk in the future if the problem remains unchecked. Full restoration is recommended.

Aquatic Habitat

It is recommended that a habitat study be conducted on the West Kill Creek, with particular attention paid to possible physical and temperature barriers in aggrading sections, to the frequency of disturbance of the bed due to incision and aggradation at numerous points in the system, and to embeddedness resulting from excessive entrainment of fine sediment.

The continued deterioration of the NYSDEC habitat structure will reduce erosion threats in their vicinity, and is unlikely to meaningfully reduce the quality of the habitat in the unit.

Water Quality

Clay exposures and sediment from stream bank and channel erosion pose a potential threat to water quality in West Kill Creek. Clay and sediment inputs into a stream may increase *turbidity* and act as a carrier for other pollutants and pathogens. There were four significant clay exposures documented in this management unit in 2004. The upstream exposure should be addressed through *Assisted Self-Recovery*. The downstream exposures, associated with Erosion Monitoring Site #06-40777, will require *Full Restoration* to address the major slope failure and isolate exposures in the bed.

Stormwater runoff can also have a considerable impact on water quality. When it rains, water falls on roadways and flows untreated directly into West Kill Creek. The cumulative impact of oil, grease, sediment, salt, litter and other unseen pollutants found in road runoff can significantly degrade water quality. There is one stormwater culvert in this management unit. Less than 1% of the stream lies within 50 ft. of a road.

Nutrient loading from failing septic systems is another potential source of water pollution. Leaking septic systems can contaminate water making it unhealthy for swimming or wading. There are numerous houses located in close proximity to the stream channel in this management unit. These homeowners should inspect their septic systems annually to make sure they are functioning properly. Each household should be on a regular septic service schedule to prevent over-accumulation of solids in their system. Servicing frequency varies per household and is determined by the following factors: household size, tank size, and presence of a garbage disposal. Pumping the septic system out every three to five years is recommended for a three-bedroom house with a 1,000-gallon tank; smaller tanks should be pumped more often.

The New York City Watershed Memorandum of Agreement (MOA) allocated 13.6 million dollars for residential septic system repair and replacement in the West-of-Hudson Watershed through 2002. Eligible systems included those that were less than 1,000-gallon capacity serving one- or two-family residences, or home and business combinations. No homeowners in this management unit made use of this program to replace or repair a septic system.

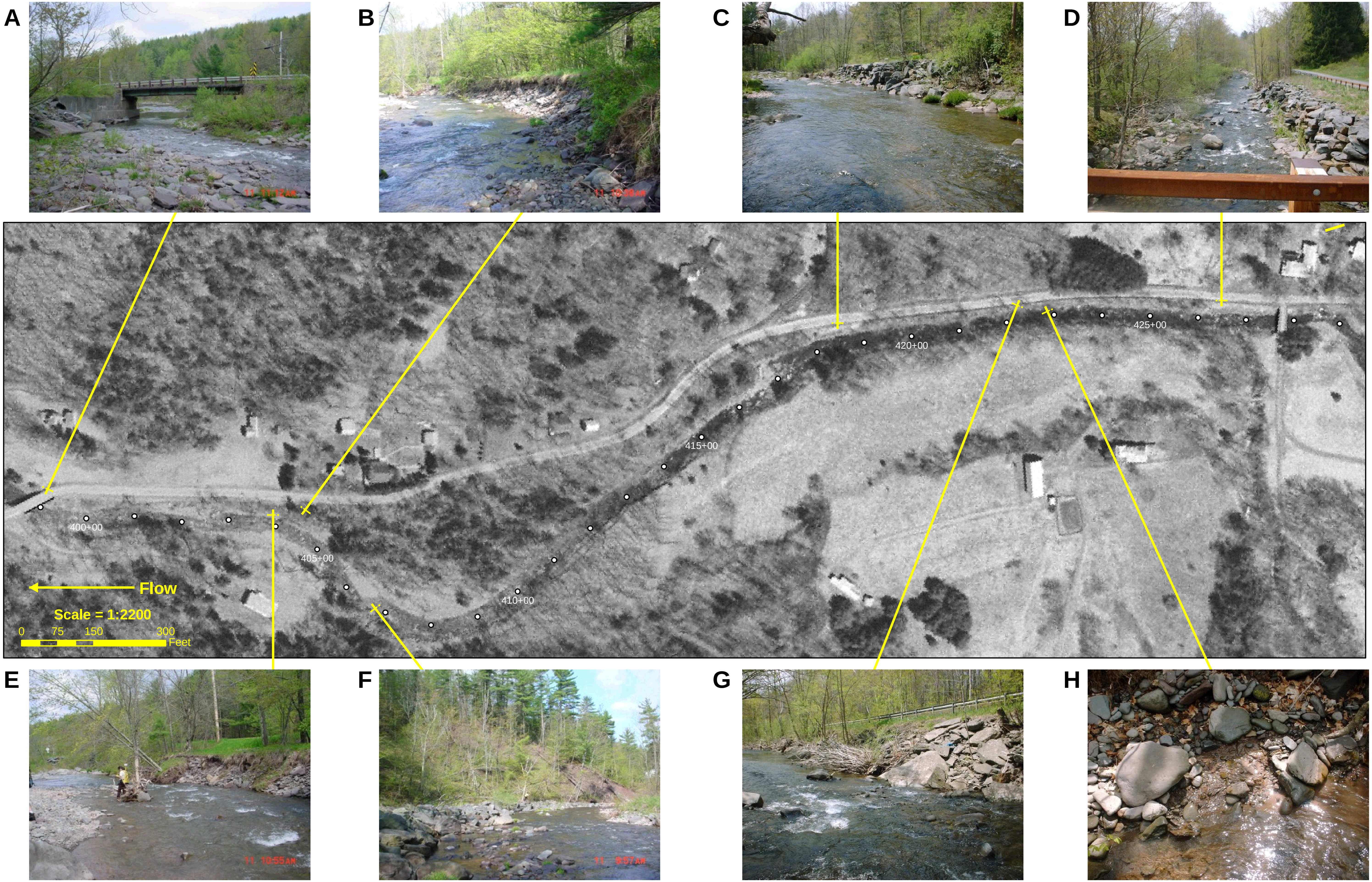


Figure 4.6.2 Management Unit 6 - 2004 aerial photography