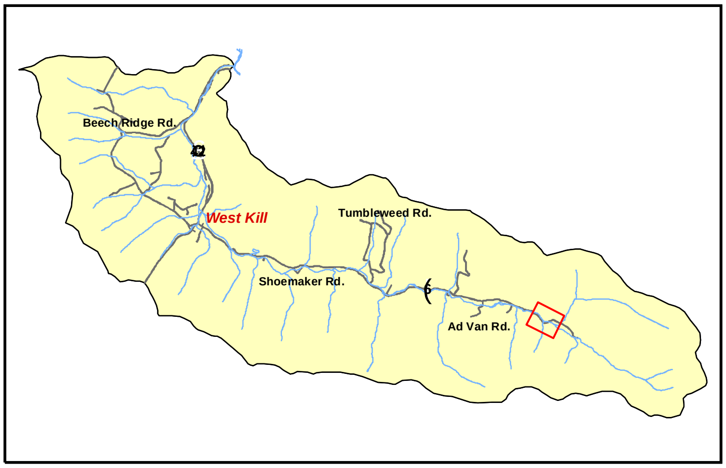


West Kill Management Unit 2

Stream Feature Statistics

11% of stream length is experiencing erosion
9% of stream length has been stabilized
12.8 acres of inadequate vegetation within the 300 ft. buffer
140 ft. of stream is within 50 ft. of the road
0 houses located within the 100-year floodplain boundary

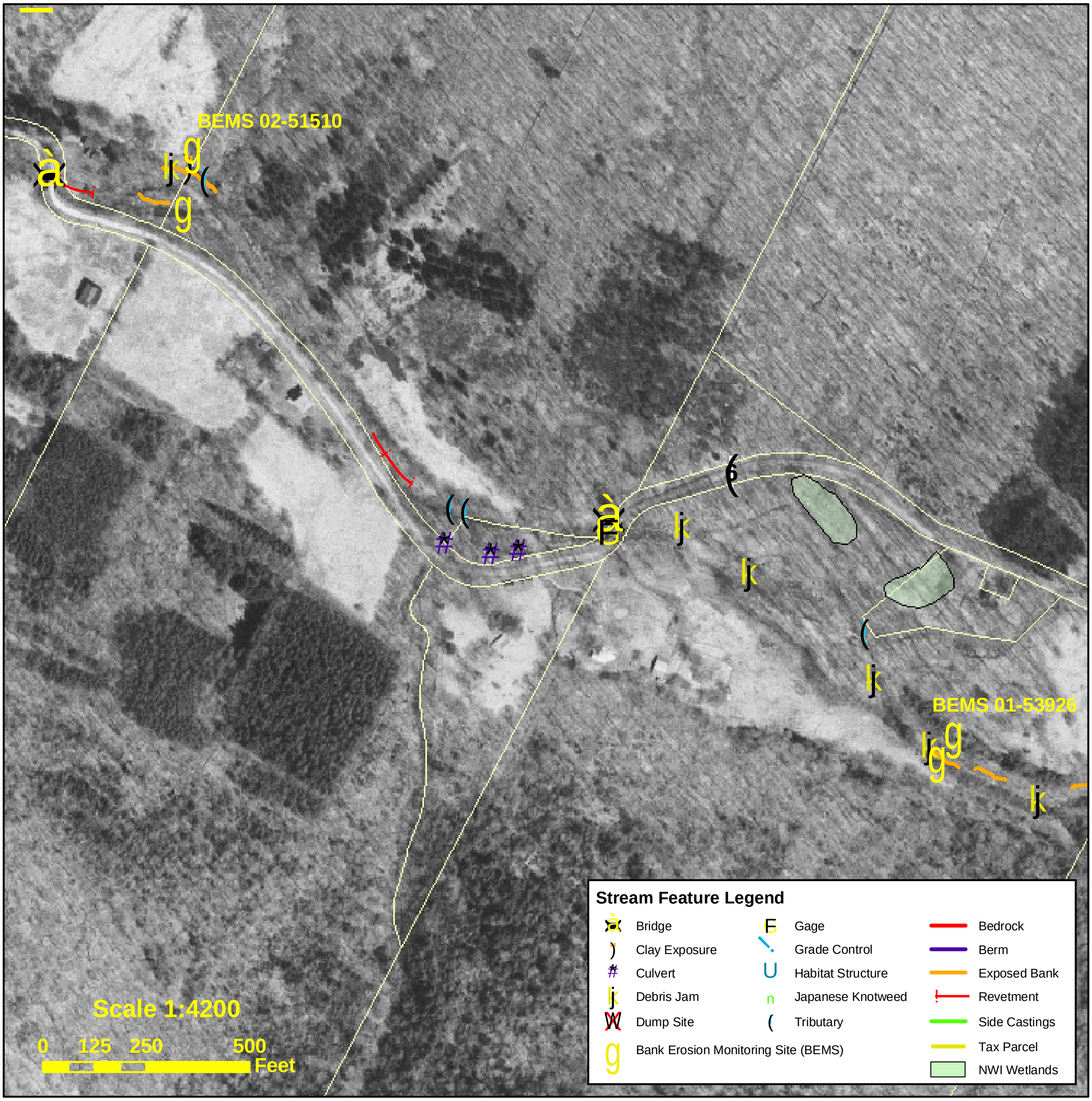


Figure 4.2.1 2004 aerial photography with stream feature inventory and tax parcels

Management Unit 2

Between Station 53971 and Station 51153

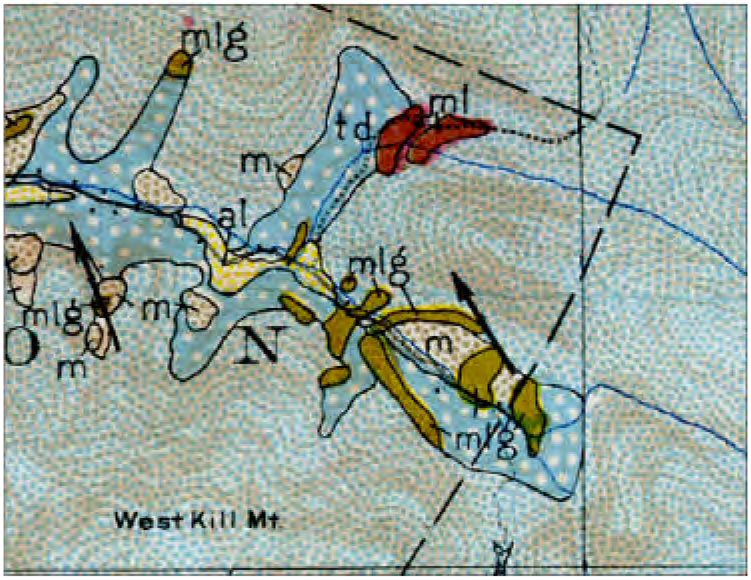
Management Unit Description

This management unit begins upstream of the confluence of Hunter Brook, continuing approximately 2818 ft. to the County Route 6 bridge #3201250. The drainage area ranges from 2.85 mi^2 at the top of the management unit to 5.49 mi^2 at the bottom of the unit. The valley slope is 2.19%.

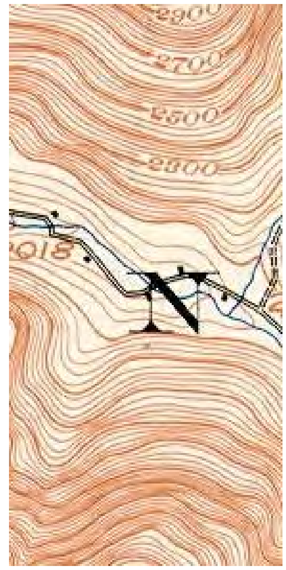
Summary of Recommendations Management Unit 2	
Intervention Level	Assisted Self-Recovery.
Stream Morphology	Allow channelized reach to re-develop bedform diversity and sinuosity within its existing confines.
Riparian Vegetation	Increase buffer width at several locations; interplant rip-rap installations.
Infrastructure	Design bridge replacement to include floodplain drainage and adequate bankfull width.
Aquatic Habitat	Allow channelized reach to re-develop bedform diversity, improve canopy cover, arrest fine sediment sources.
Flood Related Threats	Reduce risk of damage to bridges by addressing flood conveyance.
Water Quality	Isolate fine sediment sources through redirection of channel pattern; investigate source of nutrient enrichment.
Further Assessment	Continue monitoring of Bank Erosion Monitoring Sites; investigate Hunter Brook sediment load.

Historic Conditions

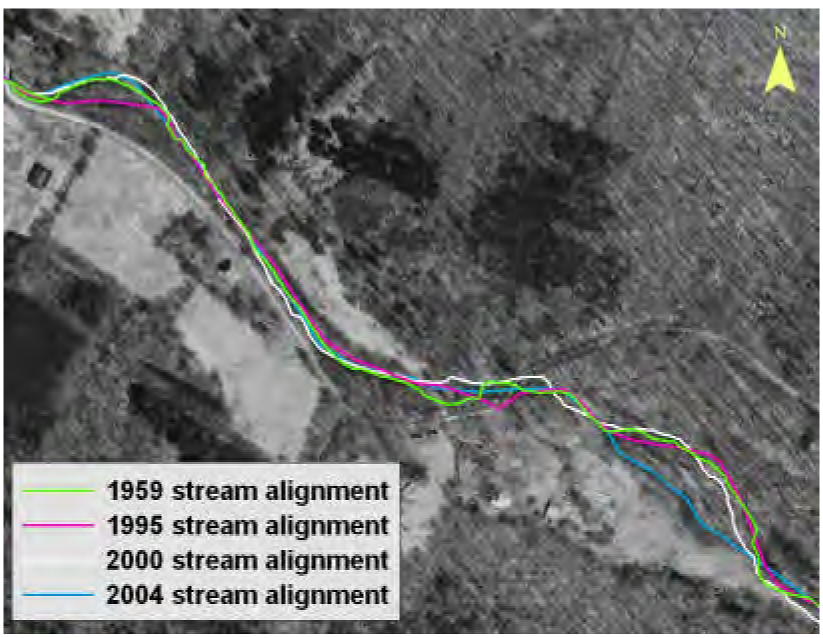
As the glaciers retreated about 12,000 years ago, they left their "tracks" in the Catskills. See Section 2.4, Geology of the West Kill Creek, for a description of these deposits.



Excerpt from Rich, 1935



Excerpt of 1903 USGS Topographic map MU2



Historic Stream Channel Alignments in MU2

As seen from the historical stream alignments, the channel alignment has not changed significantly over the years.

According to available NYS DEC records there has been one stream disturbance permit issued in this management unit in October 1996, in response to the major flood of January 19th of that year, to the Lexington Highway Department, to install approximately

100 ft. of rip-rap. It was not apparent from the application whether the installation was a repair or a new placement.

Stream Channel and Floodplain Current Conditions

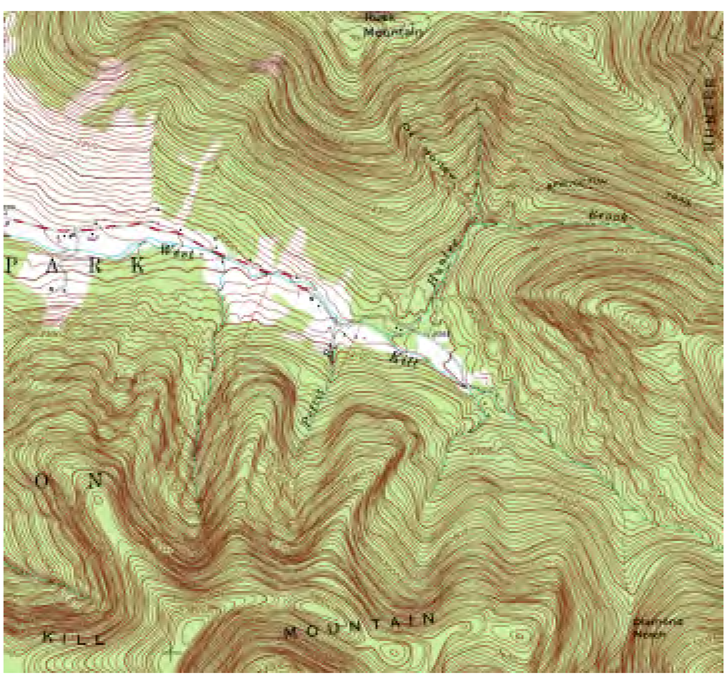
Revetment, Berms and Erosion

The 2004 stream feature inventory revealed three eroding banks. Eleven (11) percent (297 ft.) of the total channel length (2818 ft.) exhibited signs of active erosion on one or both banks (Fig. 4.2.1). Two of these areas were significant enough to warrant documentation as Bank Erosion Monitoring Sites (BEMS). There was evidence of one clay exposure in the unit. Nine percent (256 ft.) of the total channel length was revetted, and no berms were observed.

Stream Morphology

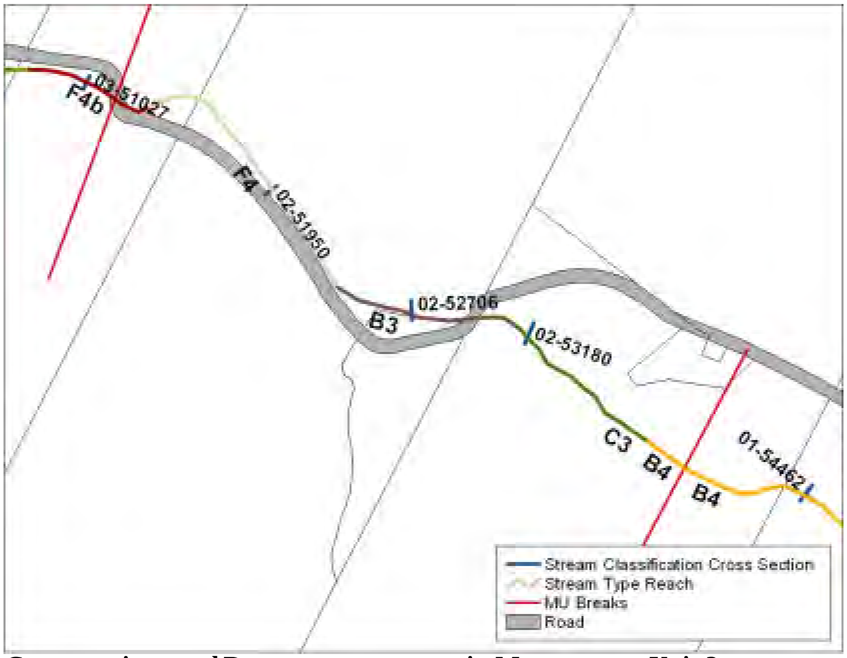
The following description of stream morphology references insets in the foldout Figure 4.2.2. "Left" and "right" references are oriented looking downstream. Italicized terms are defined in the glossary. This characterization is the result of surveys conducted in 2004 and 2005.

This valley morphology in this management unit is characterized at the upstream end by aggradational conditions resulting from the confluence of two significant tributaries – which together double the drainage area – and a modest bridge constriction at the crossing of County Route 6. While there is significant valley broadening below the bridge, entrenchment increases as we move downstream, owing primarily to road encroachment.



Excerpt of 1980 USGS topographic map

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 for description of stream types)

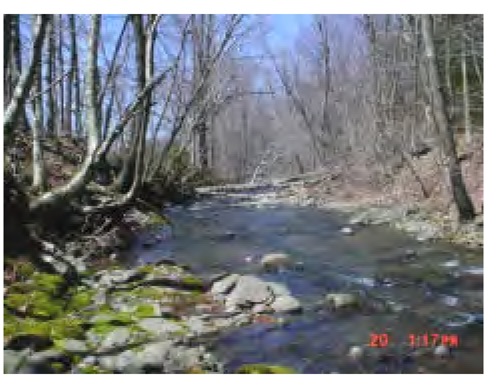


Cross-sections and Rosgen stream types in Management Unit 2

Management Unit 2 begins with a 171 ft. reach of B4 stream type, continuing from MU1 (Stations 54694, 54462). The channel is moderately *entrenched*, or somewhat confined within the stream banks during high flood events. The channel slope is 2.11 % and the bed material is dominated by gravel. There is evidence that a headcut has moved through the reach, lowering base elevation of the channel, but the reach appears to be stabilizing.

Bank Erosion, with narrow, undercut buffer

As the channel bends gently to the right, erosion is evident on the left bank, which has only a single line of trees providing buffer to the adjacent mowed pasture and unimproved road. The toe of the bank is being scoured at higher flows, and the site has been monumented as a Bank Erosion Monitoring Site (BEMS Station 02-53926) (Inset H, Fig. 4.2.2). 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.



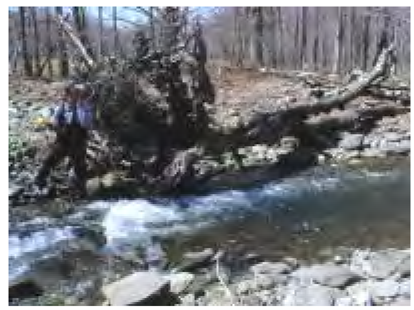
Debris Blockage

Continuing downstream, a large tree undercut by toe scour has fallen across the channel. The debris creates no obstruction at low flow, but likely more significant flow obstruction at higher flows.

Aggradation and debris jam at stream type transition

As the channel straightens, the entrenchment decreases and the dominant bed material shifts from gravel to cobble, changing the stream type to C3, which continues for approximately 800 ft. The stream widens, and slope drops to 1.74%. Aggradation is apparent here, likely the result in changing channel form and sediment load from Hunter Brook, which enters just downstream on the right. Flood flows have ample access to the mowed field on the left, and at higher flows, to a highly disturbed, forested floodplain on the right. Historic flows have left relic channels on both left and right floodplains throughout this reach.

A tree with large root fan at channel left appears to have triggered a headcut. As the headcut migrates through the reach, it may promote development of a more defined low flow channel, allowing revegetation of the relic channels on the floodplain.



Debris Jam - along head cut, low flow clear, left point bar obstruction

Hunter Brook confluence

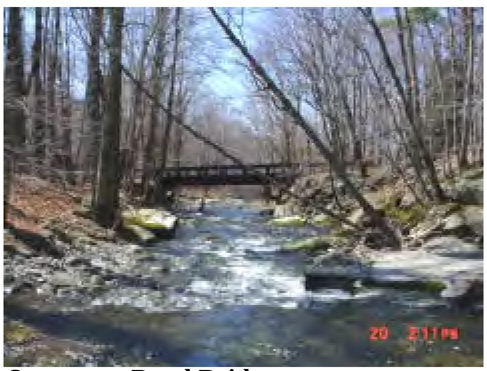
As the channel crosses over to the right, Hunter Brook enters from right bank. The tributary is well-connected, with a healthy junction pool. Aggradation is evident down stream of the confluence (Inset D, Fig. 4.2.2), suggesting excess sediment loading from the tributary. Additional investigation of sediment sources in the Hunter Brook catchment is recommended. Throughout this reach, abundant woody debris on the channel margins and floodplain is evident, but does not impede low flows.

Aggraded reach near confluence

Debris Jam

A monumented cross-section has been established at this aggradational setting (Station 53180), adjacent to an unbuffered horse pasture. The floodplain is excessively connected on both right and left, as what was a higher terrace upstream has become the bankfull floodplain. Planting trees and shrubs along the pasture is recommended to help stabilize the bank, and buffer the stream from the horse pasture.

Aggradation



Spruceton Road Bridge

As the channel bends to the left on approach to the Spruceton Road bridge (Inset C, Fig. 4.2.2) and USGS gaging station (Gage #01349711), slope increases to 2.2%, and the channel recovers its capacity to transport its sediment load. Dominant bed material remains cobble. A monumented cross-section below the bridge documents a stream type change to B3 (Station 52706).

The mortared stone bridge abutments, with a poured scour wall and a short wing wall upstream on the right, measure approximately 25 ft. from footer to footer. Bankfull channel width at the monumented cross-sections up- and downstream ranges from 36 to 40 ft. The channel constriction at the bridge may be responsible for the aggradational conditions documented upstream. Road ditch drainage enters downstream of the bridge, on the right.

USGS Gage Station

Tributary

Downstream of the monumented cross-section, a small, well-connected unnamed tributary drains the pastured field, left. There was evidence of nutrient enrichment (algal growth) at the confluence.


Pettit Brook Confluence


Pettit Brook culvert under Spruceton Rd.

Just downstream, Pettit Brook also confluences from the left, through a well-connected floodplain, after passing through a 60" culvert under Spruceton Road (Inset G, Fig. 4.2.2).


Revetment

Continuing downstream the channel bends slightly to the right, and as entrenchment and width-to-depth ratio increase, stream type changes to an F4, for 1100 ft, as documented by a monumented cross-section (Station 51950). Gravel dominates the bed material, and the channel becomes *entrenched*, or confined within the stream banks during high flood events. On the left, a 158 ft length of dumped rip rap (1-2') has been installed to stabilize Spruceton Road, which runs immediately adjacent to the stream (Inset F, Fig. 4.2.2). A single line of trees buffers a mowed field on the right. There is some evidence of channelization, widening and aggradation through the straight reach downstream.

At the downstream end of the aggradational setting, the channel bends to the left, and is divided by a well-vegetated center bar. A small, unnamed tributary enters from the right near the head of this island. This tributary is perched, with a small delta formation at the confluence. Lake clay underlies the bed of the tributary.


Unnamed tributary confluence, right

Lake clay also underlies the bed of the mainstem along the right bank, and grasses are growing in the channel bottom (Inset A, Fig. 4.2.2). Some groundwater piping through a clay-rich till exposure in a high bank is evident on the right bank of the right channel thread.

Erosion of the right bank, adjacent to the center bar, has been monumented as a Bank Erosion Monitoring Site (BEMS Station 02-51510) (Inset B, Fig. 4.2.2). In a prioritization of twenty-one BEMS sites throughout the West Kill watershed (see Section 3.3, Watershed Inventory and Assessment), this site ranked Medium Priority. 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 *exposed ice contact deposits* and *lacustrine* soils 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.

Bank Erosion, with clay exposure, right bank

Large woody debris blockage

At the downstream end of the eroding bank, large woody debris has collected along the right bank, creating some low-flow obstruction. This debris jam is likely to exacerbate the upstream erosion problem.

There is also minor bank erosion on the left bank of the left channel thread, adjacent to the downstream end of the central bar. This bank is buffered from Spruceton Road by a narrow line of trees along a low terrace. This erosion was not monumented. Erosion at the left and right of the center bar, however, as well as the mature vegetation on the island, suggests that the aggradational condition is unlikely to recover without intervention.

Bank Erosion, left bank

Recommendations for this site would be for Assisted Self-Recovery, including promotion of a single thread channel by closing the right channel thread with large rock or woody debris, to direct flows away from the terrace wall. This would likely involve establishment of a well-vegetated bench on the right with rock vanes to direct stream flows away from the right bank, and revegetation of the bank face. In-depth survey and design would be required to plan a stream restoration project at this site.

Rip-rap revetment on approach to bridge, left bank

Spruceton Road Bridge, #3201250. Note loss of floodplain connectivity due to entrenchment at bridge

The channel bends as it converges with Spruceton Road just upstream of the Bridge #3201250. The stream type changes again as the slope increases upstream of the bridge constriction, to enter a 147 ft. reach of F4b as slope increases to 2.33%. The left bank on the bridge approach has been revetted with stacked rock, portions of which have been undermined (Inset E, Fig. 4.2.2). F4 stream types exhibit extreme sensitivity to disturbance, poor recovery potential, very high streambank erosion potential and typically produce a very high sediment supply.

The poured concrete bridge abutments measure approximately 35 ft. from footer to footer. Bankfull channel width at the monumented cross-sections both up- and downstream is approximately 34 ft. While bankfull flows would appear to pass without constriction at the bridge, backwatering of higher flows due to the disconnection of the floodplain may be contributing to the aggradational conditions documented upstream. The abutments and deck of this bridge have severely deteriorated. When bridge replacement is scheduled, consideration should be given to installing a geomorphically appropriate bridge span to improve sediment transport continuity. Additional *floodplain drainage*, using culverts set at the floodplain elevation under the south bridge approach, may also help mitigate this problem.

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).

Entrenched conditions in the upstream reaches of this management unit have resulted in channel incision as the channel bed –both the bedload pavement and the clay sub-pavement-- is scoured deeper than it is refilled during high flows. Without intervention, channel widening and associated stream bank erosion is likely in these reaches, until entrenchment is reduced.

In the reaches just upstream of the USGS gage and first crossing of Spruceton Road, conditions are generally aggradational. This is likely the result of excess sediment supply and large woody debris inputs from incising upstream reaches and Hunter Brook, as well as backwatering of high flows at the bridge crossing.

In the straight reach that runs adjacent to Spruceton Road, there is evidence of channelization which may have contributed to the existing aggradational conditions.

At the downstream end of MU2, active erosion on both channel threads around a well-vegetated center bar indicates that historic aggradational conditions persist in this reach. Installation of flood plain drainage and lengthening the span would help reduce the backwater conditions and improve sediment transport continuity through the bridge.

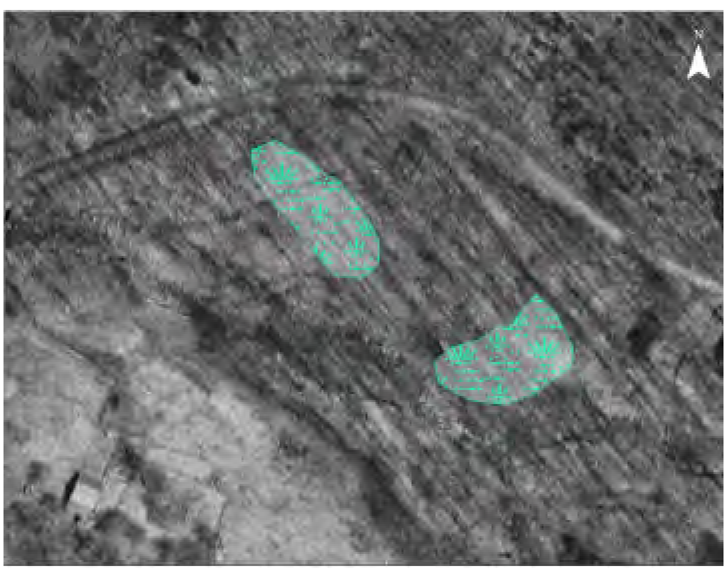
<u>Riparian Vegetation</u>

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 2001 and field inventories (Fig. 4.2.3). 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 (56%) followed by Herbaceous (29 %). *Impervious* area (3 %) 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 MU2

There are two wetlands within this management unit (Fig. 4.2.1) 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). Both are 0.3 acres in size, and are classified as *palustrine forested, broad-leaf deciduous, and seasonally flooded/saturated* (PFO1E).

Areas of herbaceous (non-woody) cover may 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, potential riparian improvement planting sites were identified through a watershed-wide remote evaluation of current riparian vegetation conditions. These are sites where plantings of trees and shrubs on and near stream banks would likely reduce the threat of serious bank erosion, and can improve aquatic habitat as well. In some cases, these sites 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.

In many cases, these sites can not be effectively treated with riparian enhancement alone, and full restoration efforts would include bank and/or channel restoration components in addition to vegetative buffer plantings. The risk associated with the decision whether or not to invest in streamside vegetation improvements will depend partly on the current channel conditions, and local channel surveys are recommended at each site.

Seventeen potential planting sites were identified within this management unit (Fig. 4.2.4).

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. There are currently no FIRMs for this management unit. 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.

The current NFIP maps are available for review at the Greene County Soil & Water Conservation District office.

Bank Erosion

Most of the stream banks within the management unit are considered stable. However, 11% (297 ft.) of the stream length is experiencing major erosion, and 9% has been stabilized, indicating historic instability.

There are two Bank Erosion Monitoring sites in MU2, and one (BEMS#2) 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 can create debris jams at bridges or mid-channel bars and may shift the flow pattern of the stream, threatening roads and residential properties. BEMS#2 ranked as a Medium Priority.

Infrastructure

Rip-rap has been installed along 256ft. of the 2818ft of the stream bank to protect Spruceton Road and the upstream approach of the downstream bridge (Insets E and F).

Nine 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 in this management unit, significant portions of the stream channel in this unit run adjacent to Spruceton Road, and some of these required stabilization by the Town of Lexington highway department following the 1996 floods.

The continued failure of the rip rap on the left stream bank on the upstream approach to Spruceton Road Bridge #3201250 poses a threat to the crossing. Modifications to this revetment should include stabilization of the toe of the bank, to a depth greater than anticipated stream bed scour depths. Vegetative applications on the face of the revetment and upper bank would increase the strength and longevity of these measures while enhancing the habitat function and aesthetic value of the treatment.

Aquatic Habitat

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

Habitat was fairly good throughout this management unit, with abundant woody debris, no apparent physical or temperature barriers. However several reaches appear somewhat impaired, with inadequate canopy cover, low diversity of bedform and introduction of fine sediment at one eroding bank.

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 is one significant clay exposure in this management unit (Station 51500), which should be addressed through Assisted Self-Recovery.

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 are three stormwater culverts in this management unit, but less than 5% 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 five 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.

There was evidence of nutrient enrichment at the confluence of one small tributary, which drains a horse pasture, which should be investigated further.

Hunter Brook appears to be contributing a disproportionately large sediment load. Possible causes should also be investigated further.

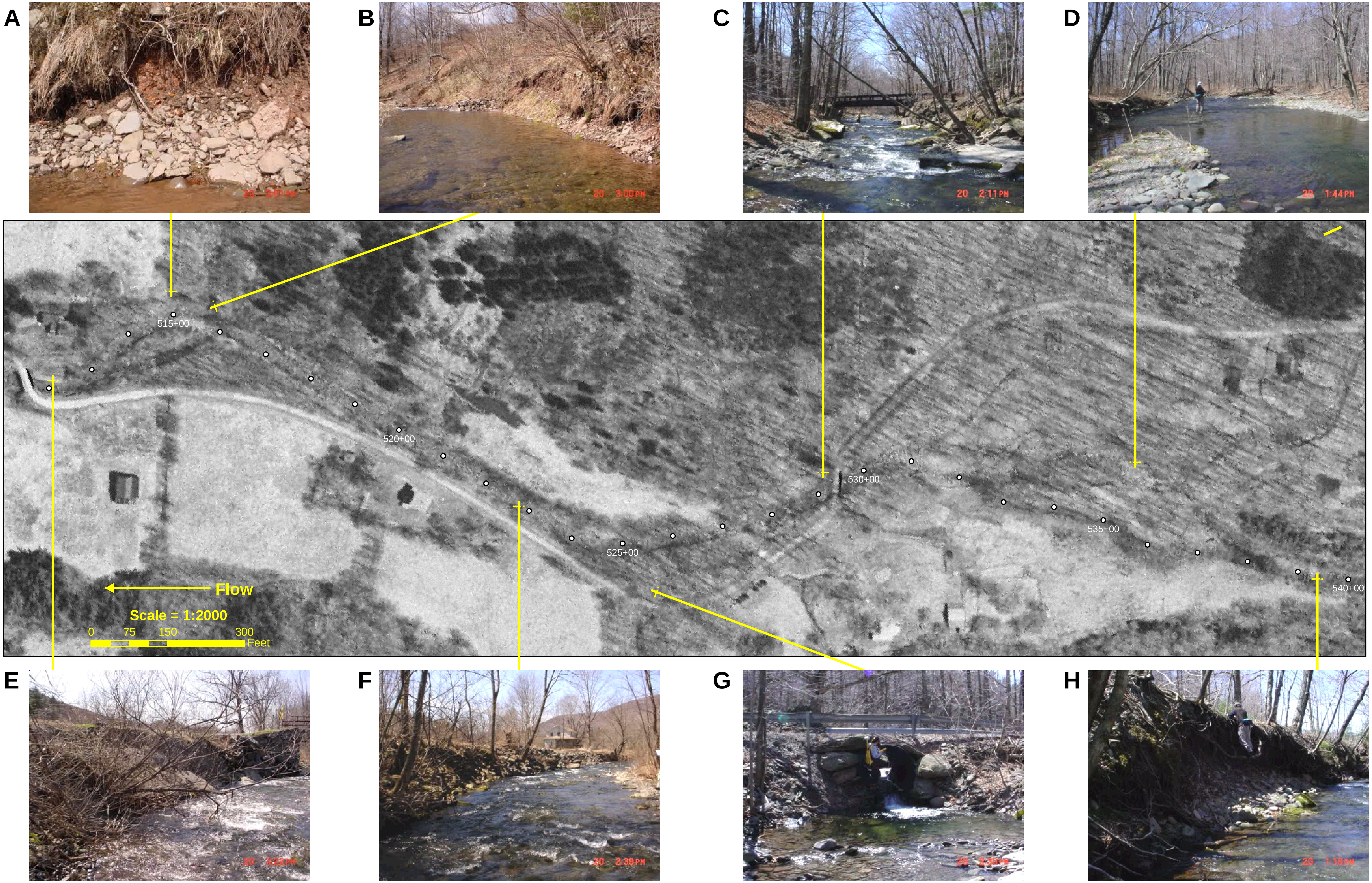


Figure 4.2.2 Management Unit 2 - 2004 aerial photography