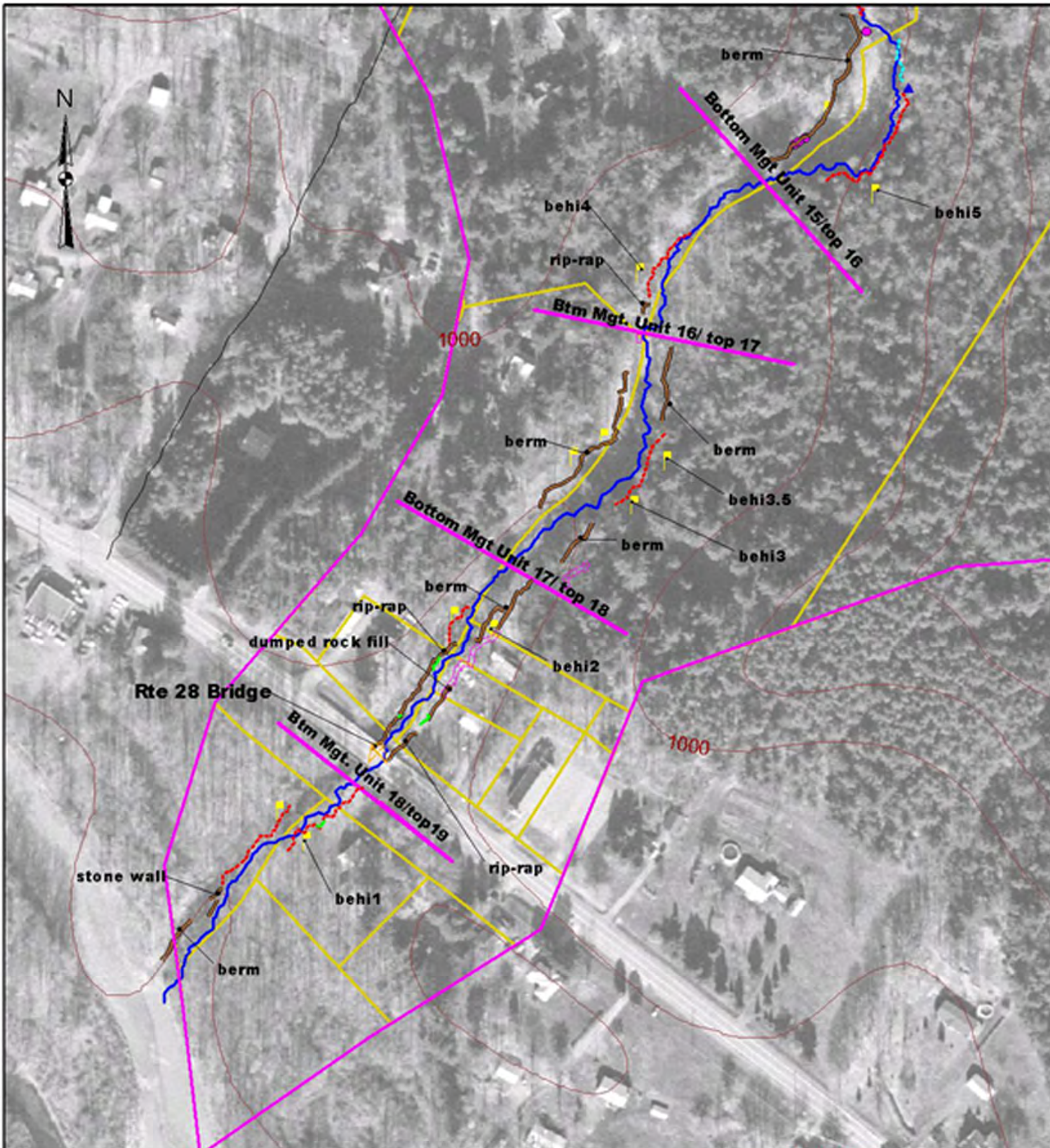

GIS Parcel, Contour and Wetland coverages are edited and provided by NYC DEP, 2000, UTM NAD 27, Zone 18 North, meters. Aerial Photography Provided by UCSWCD & NYC DEP November 2001 All other coverages were developed using GPS in the UTM, Zone 18 North projection, NADCON (Conus), datum. GPS data collected 2001, by UCSWCD & NYC DEP SMP.

Note: G.I.S. data are approximate according to their scale and resolution. Data may be subject to error and are not a substitute for on-site inspection or survey. Parcel coverages are based on Ulster County Real Property tax maps 2000 and may not reflect actual surveyed property boundaries.

Broadstreet Hollow Management Unit 16 -19

50 0 50 100 150 200 Feet

Scale 1:2,400

LEGEND

- 247 Street Address/911 Code
- Green Parcels
- Ulster Parcels
- Landfills
- Management Units
- Stream Center (Thalweg)
- Culvert
- Wetland
- Clay Exposure
- Revetment
- Eroding Bank
- Tributary
- Behi Pin
- Bridge
- Broadstreet Hollow Road
- Knotweed

Broadstreet Hollow Management Unit 17

General Description:

Management Unit 17 (MU17) is located in Ulster County, NY, beginning just downstream from the low pond inlet area with large boulders at the northeasterly boundary of the property. MU17 extends approximately 440 feet downstream, ending just upstream from the narrow, straight section approaching the Rte. 28 bridge (see MU18 Description)[1&2].

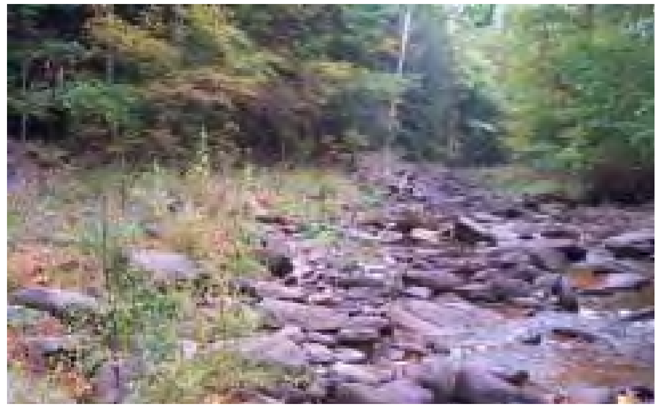

Photo 1. Looking upstream into the top of MU17.

The structural shape, or *morphology*, of the stream (i.e., slope, width and depth) is fairly uniform in this unit, comprising two sections, or *reaches*, with distinct structural character, or *stream type*[5]. Though the valley in MU17 is wider compared to other units, the stream is constricted through most of the unit by long mounds of earth pushed up along the stream bank, called *berms*, creating an *entrenched* stream shape, which in this unit represents a stream in generally poor, or *unstable*, condition.

Typically stable stream types associated with this type of valley are relatively wide, though somewhat steep, with riffles and pools, and broad, flat *floodplain* areas in addition to some stream banks formed into low benches, or *discontinuous floodplains*, that function as overflow areas during floods and provide areas for healthy streamside, or *riparian*, vegetation. Less steep valleys with more floodplain contain more space to bend, or meander, within the valley walls so streams can evolve to maintain good condition, or *stability*, and better riparian vegetation to stabilize the banks and provide other habitat benefits[5&7]. Multiple bermed banks and an entrenched stream shape limit stream meanders, and set up valley conditions in which the stream will tend to cut into its bed, or degrade, increasing stream bed and bank erosion potential.

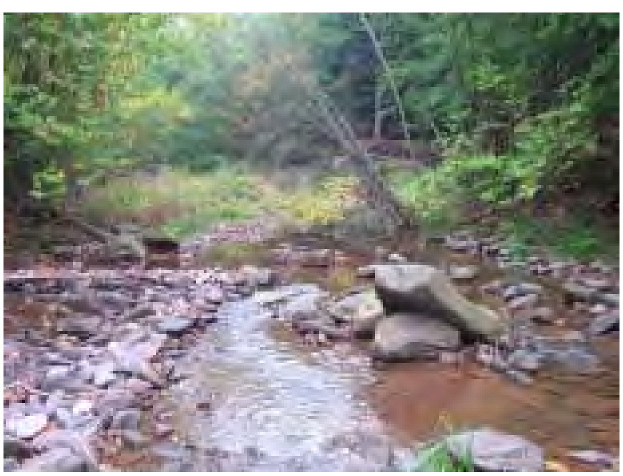

Photo 2. Looking upstream into the middle of MU17, with high eroding valley wall hillside to the right. This reach was chosen to represent an unstable "control" reach, to be monitored as part of the stream stability restoration demonstration project in MU3.

Part of the stream restoration demonstration project implemented in 2000 (see MU3) included detailed assessment and monitoring of a stable "*reference*" reach in a similar setting to use for design (see MU1) and a similarly unstable reach, or a "*control*" reach (Photo 2), in a similar setting to compare with the project and reference reaches over time[8]. Due to the unstable condition of the downstream portion of MU17, and the similarity of the stream and valley configuration, stream bed and banks, a sub-reach of MU17 has been established as a "control" reach[1].

I. Flooding and Erosion Threats

A. Infrastructure and Private Property

As in MU16, the stream course forms the boundary between two properties (land parcels) for the length of MU17 [1]. The western property has experienced repeated historic flooding, especially through a constructed pond area. The pond and inlet area (see MU16) are lower in elevation than the natural floodplain. Once floodwaters overtop the banks, water preferentially flows into the pond inlet, through the pond and reenters the stream through the pond outlet.

The centerline of Broadstreet Hollow Road ranges from approximately 525 and 610 feet from the deepest part of the stream, or stream *thalweg*. There are no bridges in this unit, and no culverts draining roadside ditches directly to the stream.

B. History of Stream Work

Approximately 470 feet, or 53%, of the stream bank in MU17 has been bermed, in three sections[3]. The largest section is 275 feet long, on the right bank (looking downstream) along the pond area, roughly from the pond inlet to the outlet (Photos 3 and 4). This berm appears to have been constructed to protect the property and pond from flood inundation and damage, and consists primarily of large cobble and earth material, with some trees and other vegetation.

Photo 3. Cobble and earth berm, on right bank in the pond area. The main stream is behind the viewer, flow is from right to left.

Photo 4. Berm on right bank, set back from the stream, allowing some wooded floodplain access. The main stream is behind the viewer, flow is from right to left.

Bermed stream banks can cause stream entrenchment and actually increase flood level, or *stage*, by preventing floodwaters from flowing over the floodplain, cutting off an important function of these flat areas. During low flow and some low magnitude floods, some berms are probably effective, keeping water from flowing over the floodplain surface, if this was the purpose of berm construction. The berm doesn't hug the stream bank for its entire length, so allows some floodplain area to be available to the stream during high flows (see Photo 4)

Unfortunately, during higher floods berms will inevitably overtop. Flood waters cascading down the other side of the berm will be falling from a much greater height than they would have done without the berm present, and will therefore have much greater erosive power. Additionally, once flood waters breach a berm, either by overtopping or by getting behind them on either end, this water is trapped on the floodplain area. The water cannot return to the stream until it reaches another break in the berm, at which point the concentrated flow will again carry more erosive energy than flat floodwaters spread evenly over a well-vegetated floodplain[5&7]. However, because this particular berm is not continuous along the entire right bank of the main stream, the stream may enter the floodplain area around the ends of the berm, especially at the pond inlet and outlet areas. These concentrated points of entry, in contrast to a more gently sloped floodplain offering continuous access by flood waters to the floodplain, create focused flow that increases the erosive power of flood waters.

Photo 5. Pushed up cobble berm on the left bank, near the top of MU17 opposite the pond inlet area. Stream flow is from left to right.

The other two berms, both on the left bank, appear to be material pushed up onto the banks in response to 1996 flood damages, and may have been the site of such practice in earlier floods (Photos 5 and 6). One berm is at the top of MU17, across from the right bank berm, and the other is near the bottom of the unit. This practice of "cleaning" the gravel out of a stream in this way is sometimes thought to increase flood capacity by creating a larger stream channel. Unfortunately, berms such as these generally do not offer much if any protection from flooding (inundation), especially if the berm is uneven or ends abruptly. The channel is typically made too wide, and not deep enough, for the stream to transport its sediment, causing additional deposits (gravel bars) and an ongoing flooding and/or maintenance problem.

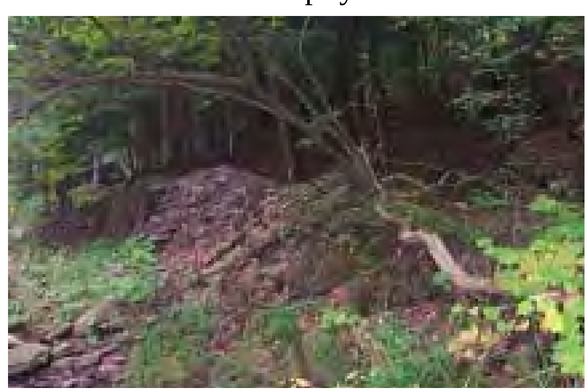

Photo 6. Pushed up cobble berm on the left bank, near the bottom of MU17 across from the pond outlet area. The main stream is behind the viewer, flow is from left to right.

Floodplains function to reduce flood velocity, increase absorption of floodwaters, encourage deposition of silt and fine sediments (keeping them from being washed further downstream) and decrease flood stage, or height, in downstream areas[5]. The majority of

Broadstreet Hollow stream floodplains consist of small, low, discontinuous floodplain benches that perform the important floodplain functions in small mountain streams. MU17 is in a section of the Broadstreet Hollow Valley that would allow the stream to maintain broader areas of floodplain, however, bermed areas limit this feature, potentially increasing the risk of flood inundation. Removal or restructuring of all of these bermed areas should be considered to add floodplain function to this area[3]. Particularly, the berm on the right bank could be restructured and set back from the stream. Alternatively, inlet and outlet areas could be reconfigured to allow flood waters to pass over and through the pond without damage or excessive sediment deposits from concentrated flows. The other bermed areas could safely be removed entirely, as there are no structures or other development in the floodplains behind them.

C. Exposed Banks

Stream assessment in 2001 showed 135 feet, or 15%, of the stream bank in MU17 is actively eroding. This erosion occurs in one continuous piece along the valley wall hillslope on the left bank, in the middle of the unit opposite the long right bank berm. The erosion occurs where the stream runs against the valley wall, with no floodplain area. Though the eroding bank is continuous, it has two distinct sections with different characteristics. Therefore, two representative locations were chosen and permanently marked, or *monumented*, for future monitoring (designated as "monitoring cross-sections 3 and 3.5") to determine erosion rates and priority for potential restoration[3]. This site has been assessed and ranked based on calculation of a *Bank Erodibility Hazard Index* (BEHI) using data collected at the time of the stream assessment survey in 2001[4].

The eroding left bank hillslope at monitoring cross-section 3 has a significant exposure of highly erodible *glacial lake clay* (Photo 7). Mature trees sliding down the hillslope and failure scarps (large cracks in the hillside, parallel to the stream, created as blocks of land slide downhill) show multiple *rotational failures* and bank *slumping*. This failure mechanism is fueled by stream erosion at the bottom, or *toe*, of the slope, continually delivering soil, rocks and vegetation into the stream and preventing an adjustment of the stream channel to a stable shape[4].

Photo 7. Eroding clay valley wall hillside, left bank, showing trees sliding downslope into the stream. The white tape across the stream shows the location of monitoring cross-section 3. Stream flow is from left to right.

This clay comprises the entire hillside, similar to the eroding banks at the bottom of MU8 and MU15, and the middle of MU5, over which the riparian forest is sliding and slumping into the stream in large sections, despite the presence of large healthy trees (see Photo 7).

Photo 8. Eroding left bank at wooded terrace bank, just upstream of eroding clay valley wall hillside. White tape across the stream shows the location of monitoring cross-section 3.5. Stream flow is from left to right.

In contrast, the upstream section at monitoring cross-section 3.5 does not contain visible clay, and the valley wall is not as steep (Photo 8). There is one failure surface, on top of which is a fairly stable riparian forest, though the roots of the trees are not deep enough to hold this high bank in place.

This bank received a "high" bank erodibility hazard index (BEHI) ranking at both monitoring cross-sections[3&4]. The stream bank is high (approximately 10 to 13 feet), the angle of the bank is steep, the material is poorly consolidated (especially with clay materials), and there is little stable vegetation with enough root strength or depth to hold bank materials in place. The stream is entrenched in this area, partially due to the presence of the low flood-control berm on the opposite bank (see photos 3 and 4). Additionally, the berm may be increasing flood risk by raising flood stage and increasing stream velocity and erosion at the toe of the opposite bank. This situation could also increase erosion downstream as flood waters are concentrated and accelerated through this reach by the other berms just upstream and downstream from the eroding bank.

The eroding bank represented by monitoring cross-sections 3 and 3.5 would benefit from a full-scale stream stability restoration project (one that uses natural stability restoration principles and design) to prevent further erosion of unstable bank materials, and reduce the potential hazard from increased velocity and excessive amounts of *large organic debris* (i.e., tree trunks and branches). Restoration of this bank should include removal or reconfiguration of the berm on the opposite bank, to return the stream to a more stable and sustainable stream shape, reducing entrenchment in this section and reducing flood pressure on the opposite bank. Structural re-vegetation, or *bioengineering*, should be considered in conjunction with a full-scale restoration of the stream channel morphology in this reach. Additionally, the hillslope failure should be assessed to determine the extent of *geotechnical* failure mechanisms, as well as to advise the appropriate solution for this continued problem[7&8].

II. Water Quality

A. Sediment

At least two thirds of the eroding bank at monitoring cross-section 3 and 3.5 contains significant areas of exposed clay in the bank and bed, and the entire bank contains exposed fine sediments (*silt* and *clay*) in the banks and bed that may cause increased *turbidity*, especially during high flow[4].

Due to the inherent instability of the valley wall hillslope, the extent of the clay exposure and the generally poor quality of streamside, or riparian, vegetation due to the thin soils[10], the potential for large inputs of silts and clays into the stream during floods will continue to be a problem unless the reach is restored.

B. Landfills/Dumping Sites

In addition to the small area on the border between MU16 and MU17, the stream assessment survey conducted in 2001 documented one large dumping site, on the hillside on the left bank, behind the downstream-most berm, where the valley broadens and the stream moves away from the valley wall [1] (Photo 9). This area is extensive, composed primarily of glass and metal. This site is about 70 feet in length, and approximately 70 feet from the thalweg. Planning efforts to organize cleanup of sites like this were initiated in 2002, and should continue, as labor and funding are available, though any risk from this site to water quality is probably minor, though no specific analysis of materials was conducted.

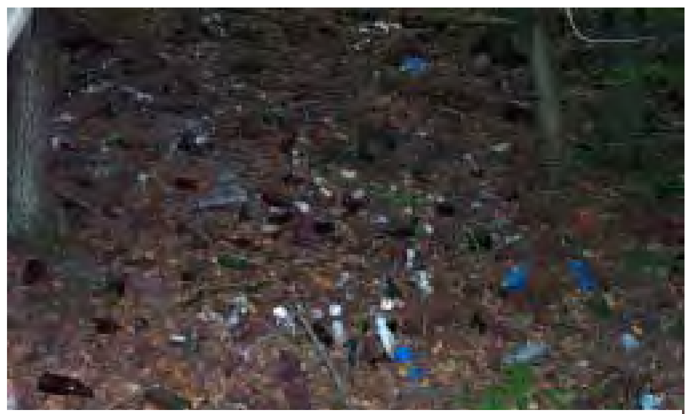

Photo 9. Dumping site with glass and metal materials, on the left bank near the bottom of MU17, behind the berm shown in Photo 6.

C. Other Water Quality Issues

Investigation of other possible sources of contamination was not part of the stream assessment conducted in 2001. However, no evidence was found for *nutrient* or *pathogen* contamination in the stream (i.e., odors or discolored water). Any runoff of water from the road and culverts that may contain salts or other pollutants was not specifically investigated. However, the long distance from the road, and the density and health of the riparian vegetation, definitely provides some protection from such runoff.

III. Stream Ecology

A. Aquatic Habitat and Populations

As part of the stream restoration demonstration project completed in MU3 in 2000, fish and aquatic insect population data have been gathered yearly since 1998 within the stable reference reach (MU1), the project site (MU3) and the control reach (here in MU17). These data show the Broadstreet Hollow self-supports, without stocking, populations of all three common trout species (rainbow, brook and brown) as well as a healthy and diverse community of aquatic insects[6&9]. See section 3.1.5, Fisheries and Wildlife.

B. Riparian Vegetation

Stream assessment conducted in 2001 did not investigate specific streamside (riparian) plant species or density condition, other than to note areas of insufficient or stressed vegetation that could affect stream stability, flooding or erosion threats, water quality or aquatic habitat for trout species. Based on these general observations, riparian vegetation throughout MU17 appears to be in fairly good condition along both banks in non-bermed or eroding sections, sufficient to provide the full benefits of a healthy, functioning riparian area[7].

However, the hillside and bank surface at monitoring cross-section 3 and 3.5 and along the berm and pond outlet areas on the opposite bank contains stressed and insufficient riparian vegetation to overcome inherent stream channel instability due to unbalanced stream morphology in this reach. While under-vegetated areas discussed above should be augmented with a mixture of native riparian species to improve shade, cover and water temperature conditions for aquatic habitat, vegetation alone will be insufficient to address stability in this reach, though augmentation may reduce or delay the need for bank or channel stabilization work[7&9].

No *Japanese Knotweed* [7], a non-native, *invasive* plant, was noted in this unit at the time of the assessment survey. Source populations of this plant have been documented upstream, increasing the potential for colonization of any disturbed or under-vegetated areas in MU17. In particular, the wide expanse of gravel bars, bare bank areas along the clay hillside and berm area may be particularly vulnerable to colonization, as open disturbed areas, with less shade, are generally preferred by Knotweed. This reach should be inspected yearly to detect new stands of Japanese Knotweed before they can become established, and further threaten stream stability or habitat quality.

[1]Broadstreet Hollow Management Unit 17 Map
[2] Volume II Appendix 3.1.5 Management Unit 17 Workbook.
[3] Volume II Section 2.2 Watershed Management Recommendations
[4] Volume II Section 2.2.1-Monitoring Cross Section and Summary Tables
[5] Volume I Sections 3.2.1&2 Stream Processes, Morphology and Classification
[6] Volume I Section 3.5 Fisheries and Wildlife
[7] Volume I Sections 3.4 & Volume II 2.2.2 Riparian Vegetation Issues and Recommendations
[8] Volume II 2.0 Stream Stability Restoration Projects, Techniques and Contact Information & Appendices
[9] Volume I Sections 3.4 & Volume II 2.2.2 Riparian Vegetation Issues and Recommendations
[10] Section 3.2.4.2 Broadstreet Hollow Geology