UPPER KETTLE CREEK
FISH HABITAT CONSERVATION PLAN
TRIBUTARIES ADDENDUM

For: Kettle Creek Watershed Association and Trout Unlimited
March 2005

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Upper Kettle Creek Fish Habitat Conservation Plan Tributaries Addendum

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March 2005

Upper Kettle Creek Fish Habitat Conservation Plan Tributaries Addendum

For: Kettle Creek Watershed Association and Trout Unlimited

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Introduction

This report serves as an addendum to the previously completed "Upper Kettle Creek Fish Habitat Conservation Plan" completed in April 2002. Additional field assessment was completed in 2003. This second study assessed over forty miles of stream channel in major tributaries to Kettle Creek upstream of the Alvin R. Bush Dam in Clinton and Potter Counties, Pennsylvania. The additional data collection and assessment was completed to further define impacts to fish habitat and geomorphic function within the watershed. Tributaries included in this analysis are portions of Upper Kettle Creek, Little Kettle Creek, Cross Fork, Hammersley Fork, Trout Run, and Beaverdam Run. Descriptions and analysis of the assessed stream reaches are organized by sub-watershed from headwaters downstream. Stream reaches are indicated on maps included for each sub watershed. Each reach includes an overview of the current stream channel conditions, riparian canopy cover, stream dimensions, and detailed reach-by-reach information on fluvial geomorphology and habitat. Water temperatures reported were collected on a single day and represent only the water temperature at that point in time.

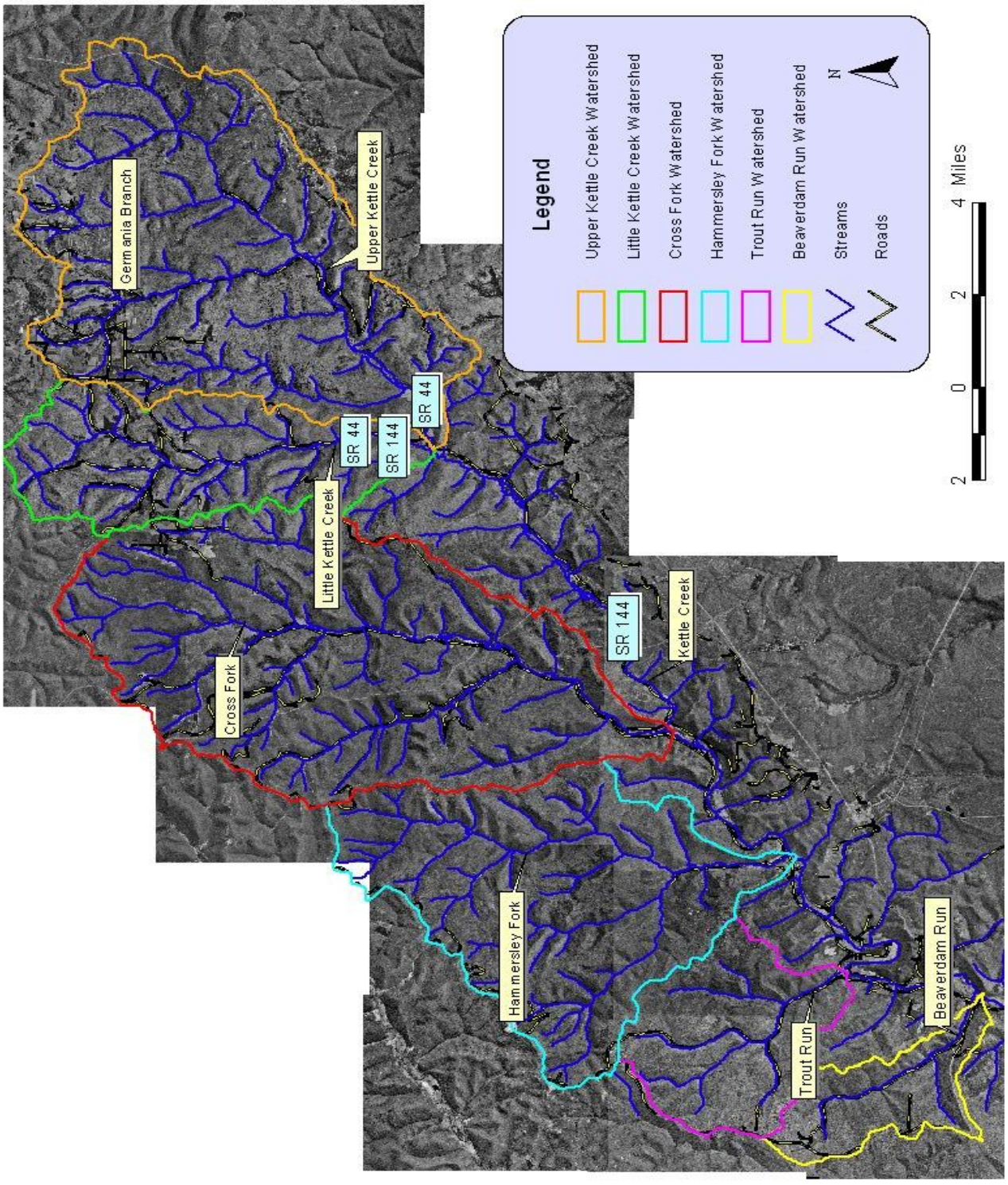


FIGURE 1. Location map of the tributaries in the Upper Kettle Creek Watershed.

STREAM CLASSIFICATION

The Rosgen Stream Classification System is widely used to represent a variety of natural states of stream channels. The classification system uses a number of physical measurements to categorize the general stream channel form of a stream reach. The physical measurements and ratios of these measurements are also used in some instances to determine whether or not the stream channel is functioning properly.

The following physical measurements are incorporated in the Rosgen Stream Classification System.

Bankfull Discharge - The discharge (or flow) that occurs, on average, every 1.2 to 2.0 years. This discharge, from relatively frequent storms, is largely responsible for the shape of the stream channel within the floodplain.

Bankfull Width - The width of the water surface at the bankfull discharge.

Bankfull Depth - The depth from the elevation of water surface at the bankfull discharge to the deepest point in the channel.

Slope - The distance that the stream channel drops divided by the distance over which that drop occurs.

Sinuosity - The ratio of the linear valley floor length to the stream length measured along the thalweg.

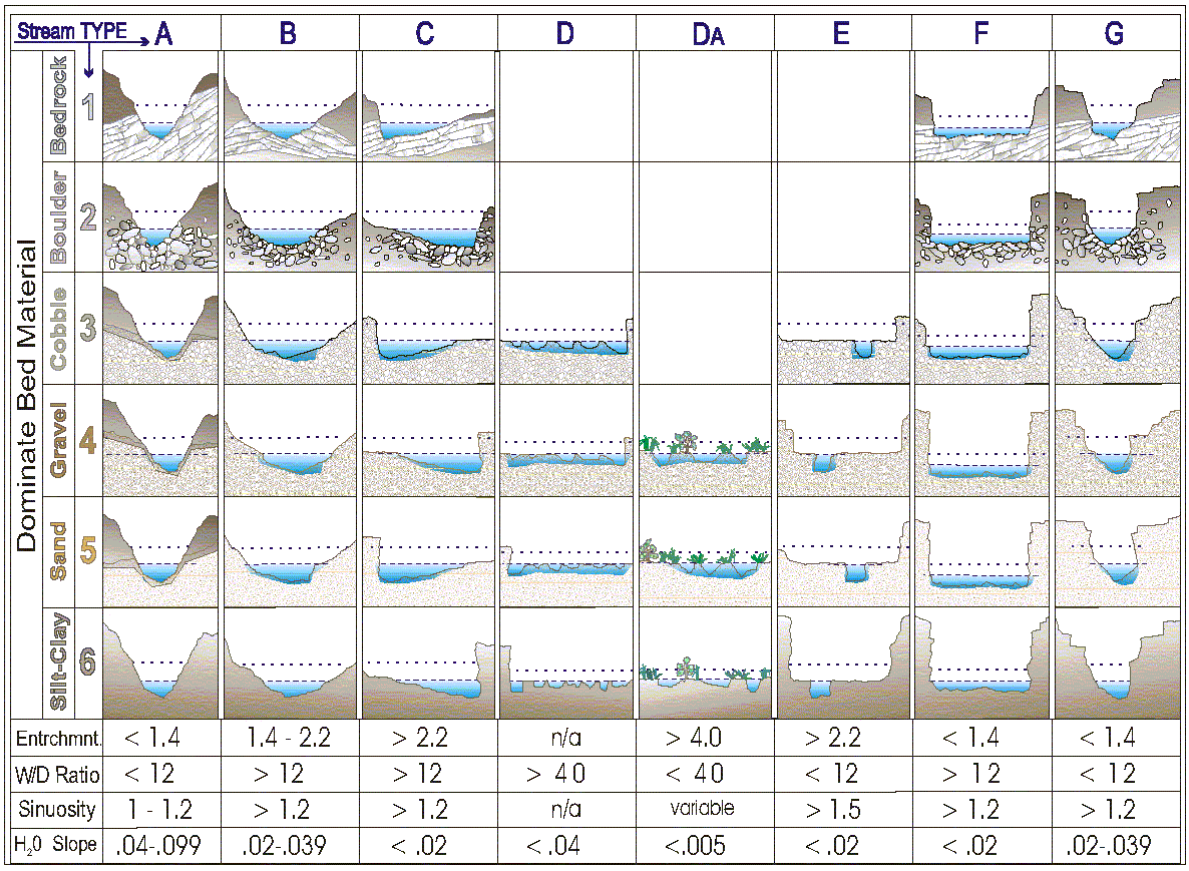
Particle Size Distribution - The statistical distribution of stream bottom material sizes measured in the stream channel below the bankfull depth.

From these measurements, the following ratios are calculated:

Entrenchment Ratio - The floodplain width at two times the bankfull depth divided by bankfull depth. A stable entrenchment ratio is 2.2.

Width/Depth Ratio -Bankfull width divided by bankfull depth.

While there are a number of stream channel classification systems, the Rosgen Classification System is the most commonly used. The table below provides a guide for references to the Rosgen Stream Type in this document.



Stream TYPE	A	B	C	D	DA	E	F	G
Entrchmnt.	< 1.4	1.4 - 2.2	> 2.2	n/a	> 4.0	> 2.2	< 1.4	< 1.4
W/D Ratio	< 12	> 12	> 12	> 40	< 40	< 12	> 12	< 12
Sinuosity	1 - 1.2	> 1.2	> 1.2	n/a	variable	> 1.5	> 1.2	> 1.2
H_20 Slope	.04-.099	.02-.039	< .02	< .04	<.005	< .02	< .02	.02-.039

FIGURE 1. Rosgen classification system for natural rivers (Rosgen, 1994).

Bed sediment size is one of the determining factors in the Rosgen Stream Classification System. Bed sediment data provides valuable information on the rock size the stream is transporting and in part helps determine if the stream bed is aggrading or degrading. Aggrading stream reaches typically have an abundance of cobble size material and often have lateral or mid-channel bars.

TABLE 1. Size distribution for the various particle size

Category	Particle Size	Millimeters	Inches
Silt / Clay	Silt / Clay	<0.062	
Sand	Very fine	0.062 - 0.125	
	Fine	0.125 - 0.25	
	Medium	0.25 - 0.5	
	Coarse	0.5 - 1.0	
	Very Coarse	1.0 - 2.0	0.04 - 0.08
Gravel	Very Fine	2 - 4	0.08 - 0.16
	Fine	4 - 5.7	0.16 - 0.22
	Fine	5.7 - 8	0.22 - 0.31
	Medium	8 - 11.3	0.31 - 0.44
	Medium	11.3 - 16	0.44 - 0.63
	Coarse	16 - 22.6	0.63 - 0.89
	Coarse	22.6 - 32	0.89 - 1.26
	Very Coarse	32 - 45	1.26 - 1.77
	Very Coarse	45 - 64	1.77 - 2.5
Cobble	Small	64 - 90	2.5 - 3.5
	Small	90 -128	3.5 - 5.0
	Large	128 - 180	5.0 - 7.1
	Large	180 - 256	7.1 - 10.1
Boulder	Small	256 - 362	10.1 - 14.3
	Small	362 - 512	14.3 - 20
	Medium	512 - 1024	20 -40
	Large - Very Large	1024 - 2048	40 -80
Bedrock			

Tributary Descriptions

UPPER KETTLE CREEK GENERAL DESCRIPTION

Upper Kettle Creek flows through a mostly forested watershed with some riparian meadow complexes and seasonal camps. The over six miles of Upper Kettle Creek evaluated showed signs of significant recovery after historic disturbance during the logging era. The stream has good access to the floodplain with entrenchment ratios greater than 2.2 prevalent along the channel. High quality fish habitat in Upper Kettle Creek is primarily associated with large woody debris. A short reach in Section UK4 was identified as a reference reach. In this reach, stream function has improved enough that a good pool-riffle sequence with well developed pools has established. This reach should be considered an excellent reference reach for any habitat improvement work in the watershed since it has formed a stabilized channel in spite of similar sediment load conditions as other streams in the Kettle Creek Watershed. The priority issue for Upper Kettle Creek should be the stabilization of a high pressure petroleum pipeline located 1-1/3 miles upstream of the Route 44 bridge. The stream bed has degraded (lowered) which caused the pipes to be exposed and they are at risk of being ruptured during a high water event. Assuming this pipeline still contains petroleum, this would have a major impact on the stream system. The highest habitat enhancement priority for Upper Kettle Creek is improving canopy cover and stabilizing two sections of streambank erosion. As a result of historic channel migration and riparian land use, there are long reaches of stream with limited canopy cover. Improving the riparian canopy cover will contribute to both bank stability and lower summer water temperatures.

INDIVIDUAL REACH DESCRIPTIONS

UK1 One mile upstream of Butternut Hollow Bridge to 0.15 miles downstream of campsite on Butternut Hollow Road.

Channel Structure and Bank Stability

FIGURE 2. High width-depth ratio channel in Upper Kettle Creek

Upper Kettle Creek flows southwest where it joins with Little Kettle Creek forming Kettle Creek. Starting upstream of the bridge on Butternut Hollow Road the channel has few pools but has a significant amount of spawning gravel throughout the channel. At this location the stream can be classified as a Rosgen B stream type. The dominant bed sediment is cobble and gravel. The banks upstream of the bridge are stable and provide good access to the floodplain except in areas where the banks have been protected with logs. These logs may have been used to stabilize the banks for road or railroad construction during the historic logging period. The road crosses the stream on a chemically treated timber bridge that was built in 2000. The chemical treatment residue has dripped from the bridge into the stream. Five meters of rip-rap is protecting the banks immediately upstream and downstream of the bridge. The stream becomes narrower, deeper, and faster below the bridge and has good willow cover. Slider's Branch enters 0.10 miles below the bridge on the right bank. The water from this tributary enters the stream at several locations due to an upstream beaver dam on Slider's Branch. The channel has better access to the floodplain downstream of the tributary and exhibits a Rosgen C stream type. Approximately 0.2 miles downstream of Slider's Branch is a man-made dam with large logs, which may be a remnant splash dam from the historic logging in the area. The dam extends approximately 20 meters across the channel and creates a deep pool above and below the structure.

Canopy Cover and Water Temperature

Below the bridge canopy coverage is sparce and the land surrounding the stream is a meadow full of willows with a beaver dam complex. Several large sections of willows have been stripped of their leaves by black and yellow beetle grubs. About 0.25 miles downstream of this area the

canopy cover improves to 30% tree coverage. About 0.5 miles downstream the tree coverage is much fuller and increases to nearly 90%. The trees found in the riparian zone are hemlock, cherry, river birch, and ironwood (Eastern Hop Hornbeam). The water temperature for this reach was 9.7^{o}C or 67.5^{o} F on June 25, 2003 (weather - sunny, 85^{o} F).

Habitat Enhancement Opportunities

Habitat in this reach is very good, with a wide variety of habitat types represented. The most common habitat features are coarse woody debris and overhanging banks. Upstream of Sliders Branch, there are several locations of spawning gravel but few high quality pools. The only potential habitat improvements would be some riparian plantings, possible sycamore, green ash, or river birch, in the meadow downstream of the bridge to help lower water temperatures and control a small section of bank erosion.

UK2 Upstream of Germania Branch

Channel Structure and Bank Stability

FIGURE 3. Typical stream form on Upper Kettle Creek Reach UK2

The upstream portion of the reach is stable with few mid-channel bars and limited bank erosion. The stream has good access to the floodplain and exhibits a Rosgen C stream type. Embeddedness values are low and the dominant bed sediment is cobble. Pools are limited in this reach. The east bank has a rock wall along part of its length and several locations with large logs at the base of the bank. There were two sections along this reach of stream with old logs buried across the channel. As was speculated upstream, these logs could have been placed during the logging era. At 0.25 miles upstream of the confluence with Germania Branch the stream has abandoned the old channel and is now flowing in a newer channel. There is a log wall at the upstream end of the old channel. In this section there are three areas of severe bank erosion. One area is 3.5 meters high and 16 meters long with bank material composed of cobble with no vegetation, the second area is 2.7 meters high and 18 meters long with bank material composed of clay and shale, and the last area of

erosion is 3.7 meters high and 7 meters long with bank material composed of sandy cobble. There are two areas of severe bank erosion in this reach, but they are not a threat to overall channel stability since they occur where the stream channel is adjacent to the valley slopes. At the end of the reach there are numerous split channels as a result of mid-channel bars with thick herbaceous vegetation.

Canopy Cover and Water Temperature

The stream is shaded with good canopy cover at the upstream extent of the reach. Upstream of Germania Branch there is a short section (0.15 miles) where the canopy is sparse and covers only 20% of the channel. Downstream of this area the tree cover is thick and covers 78% of the channel. The trees found in this section were river birch, cherry, hemlock, and ironwood (Eastern Hop Hornbeam). Water temperature in this reach was 10.5^{o}C or 69^{o}F on June 26, 2003 (weather - Sunny, 90^{o}F.

Habitat Enhancement Opportunities

Good habitat is somewhat sparse in this section, especially when compared to the upstream reach. The primary habitat is high quality pools in the lower half of the reach. The upstream portion of the reach is primarily riffle/run habitat and therefore does not contain any high quality pools. The placement of log veins could improve the pool habitat in the upstream portion. The amount of coarse woody debris throughout the reach could be increased, but habitat appears to be developing well. The channel is achieving improved natural function which will continue to create sustainable habitat. Riparian plantings would improve the canopy cover upstream of Germania Branch. Recommended tree species are sycamore, green ash, river birch, hemlock or white pine.

UK3 Downstream of Germania Branch

Channel Structure and Bank Stability

FIGURE 4. Severe bank erosion where the stream channel is along the valley slopes

This reach appears to be more active as evidenced by bank erosion and numerous mid-channel bars. Typically the stream has a high bank on one side and an old lateral bar on the other as a result of stream channel evolution. During stream channel evolution, the channel will migrate across the valley until it stabilizes. This channel migration has widened the floodplain providing good access for overbank flows. Upper Kettle Creek in this reach is a Rosgen C stream type with cobble size bed sediment. In the middle of the reach there are several large areas of bank erosion. One eroded area is located 0.3 miles downstream of the confluence with Germania Branch and is 2.5 meters high and 22 meters long in a clay bank that has thin vegetation. Another area of erosion is 50 meters further downstream on the north bank. The erosion was rated as extreme and is 9 meters high and 28 meters long occuring where the stream runs along a steep hillside in a sandy cobble substrate devoid of vegetation. In one section of this reach the bank had eroded approximately three yards and a wire fence is now within the stream channel. The road adjacent to Upper Kettle Creek upstream of the Rauch Road bridge was recently graded which allowed fresh sediment into the stream in this area. The valley is very wide and in the lower half is the first reach on this stream to show signs of recreational use. The bed sediment is also more embedded in this area than upstream.

Canopy Cover and Water Temperature

The canopy is 78% open in the upper half of the reach and willows are found on the banks. However, most of the willows are dead or dying due to the yellow and black beetle grubs feeding on them. The lower half of the reach has 55% canopy coverage, although only one bank has mature trees. The trees found near the stream in the lower half of the reach are willows and river birch. The water temperature in this reach was 10.8^{o}C or 69.5^{o}F on June 26, 2003 (weather - Sunny, 90^{o}F).

Habitat Enhancement Opportunities

Habitat features in this section are more diverse but still not as frequent as in UK1. There are more sections with coarse woody debris and some areas of overhanging banks. In the areas with limited canopy cover, riparian plantings are recommended to reduce water temperatures in the channel. Riparian buffer and canopy cover improvements should be the focus for the middle portion of this reach.

The two sections of bank erosion approximately 0.3 miles downstream of Germania Branch should be stabilized. These are large sections of erosion that contribute fine sediments to the channel thereby degrading downstream fish habitat. Other channel modifications to improve stream channel function would be of limited benefit to the overall watershed at this location.

UK4 Rauch Road Bridge to Long Run

Channel Structure and Bank Stability

FIGURE 5. Exposed pipelines on Upper Kettle.

Upper Kettle Creek has a greater density of cabins and fulltime residences in this reach. Possible nutrient inputs from the dwellings and a low percentage of canopy cover could be contributing to the filamentous algae growth found in this section. Approximately 0.75 miles downstream of the Rauch Road Bridge the channel is functioning properly with appropriate pool-riffle sequences and channel geometry. This section should be considered as a reference reach for stream channel improvement work in the watershed. Just downstream from the reference section, coarse woody debris causes the channel to be very active. However, it is functional with good habitat development. This area of the channel shows a typical Rosgen C stream type with sweeping meanders and alternating lateral bars. About 1.5 miles downstream of the Rauch Road Bridge exposed bedrock is found in the channel bottom which provides grade control for the channel. Directly downstream of the bedrock control, the channel forms a headcut with large cobble as the dominant

substrate. The headcut will continue to travel upstream until it is stabilized by the bedrock. As a result of the instability in the downstream portion of this reach, numerous mid-channel bars have deposited immediately upstream of the confluence with Long Run. Two miles downstream from the beginning of the reach a double pipeline crosses the channel. The pipeline is completely exposed in the stream and one of the pipes has shifted during a high water event. Signage on the bank indicates that the pipelines are carrying a fiber optic cable and high pressure petroleum. Assuming that this petroleum pipeline is still active, if it were to burst, it would have a devastating impact on Kettle Creek.

FIGURE 6. Upper Kettle multiple channels and mid-channel bars just upstream of Long Run.

Canopy Cover and Water Temperature

The beginning of the reach has several areas of beetle infested dead willows, but in the remainder of the reach the willows are very healthy. Canopy cover in the beginning and end of the reach is severely limited. Tree canopy covers only about 20% of the channel in these areas. The middle section of this reach has much better canopy cover, 82% of the channel is shaded by trees. Water temperatures in this reach ranged from 11.7 to 12.4^{O}C or 71.1 to 72.3^{O}F on July 2, 2003 (weather - Sunny, 82^{O}F, water levels had dropped about 8 inches since June 26th).

Habitat Enhancement Opportunities

Habitat is plentiful in this reach with a good diversity of features. The highest concentration of features occurs in the upper portion of the reach and a shorter section in the middle. There are areas of spawning gravel and high quality pools which create excellent fish habitat. Embeddedness in cobble areas appears to be higher in this reach. A recommended enhancement would be riparian plantings on the large lateral bars to provide shade for the pools and lower the water temperature in the stream. Fast growing tree species include green ash, sycamore, and white pine. The existing headcut area has produced excess sediment downstream but it is showing signs of recovery and stabilization. Further headcuts in this reach should be prevented by the bedrock outcrop.

Although not directly related to habitat, an issue that should be addressed in this reach is the two exposed pipelines. The proper reinstallation of these pipelines should be the highest priority in the watershed. They should be reburied and the banks at the crossing should be armoured to prevent erosion during high water events. If the petroleum pipeline were to burst it would have a devastating impact on not only the habitat and fishery of Upper Kettle Creek, but every stream mile downstream to the dam.

UPPER KETTLE CREEK TRIBUTARIES

GB1 Germania Branch

Channel Structure and Bank Stability

FIGURE 7. Woody debris controls the stream bed elevation

Upstream of the survey reach, Germania Branch flows through the town of Germania and is heavily impacted by human activity, including roads, bridges, a horse pasture, and streambank armoring. The stream is small and meanders across the valley bottom through wetland areas with dense willow coverage. In the upper part of the reach the stream can be classified as either a Rosgen B or C stream type. There are numerous headcuts in the first 1.75 miles of the reach ranging from 0.3 meters high to 1.5 meters high. Bank erosion is found throughout the reach. The worst area of erosion is in the second half-mile of the assessment reach where the stream is entrenched. Because of the lower entrenchment ratio found in this area, more water is forced through a smaller cross-sectional area, causing increased bank erosion. The erosion in this area is 1 to 3 meters high with vegetated banks. There is also one section of extreme erosion with a 5 meter high, 20 meter long bank with a few trees present. As the stream flows downstream it widens and becomes a braided channel with numerous mid-channel bars. Meandering along the eastern hillside it encounters bedrock outcroppings, however the dominant bed sediment is gravel and small cobble.

Canopy Cover and Water Temperature

The water temperature in this reach was 10.5 to 13.5^{o}C or 68.9 to 74.3^{o}F on May 19, 2003. Canopy cover is mixed throughout the reach. There are several areas were the cover ranges from 80-100% but other areas have only 30-50% cover.

Habitat Enhancement Opportunities

Existing habitat is diverse and well distributed throughout this major tributary. There is a significant amount of large woody debris causing deep pools and good fish habitat. The large woody debris also controls the stream bed elevation protecting against upstream migration of the numerous headcuts. The woody debris should not be removed from the channel as the headcuts may then mobilize, producing excess sediment and causing further entrenchment.

The in-stream habitat in this section of Germania Branch is well established and no further enhancements are necessary. The stream could benefit from additional riparian tree plantings to improve canopy in sparce areas. Upstream of the survey reach there are some opportunities for improvements. One potential area is the horse pasture where streambank fencing and riparian plantings help the stream evolve into a more natural channel.

SB1 Sliders Branch

Channel Structure and Bank Stability

This reach begins 1.0 mile upstream of its confluence with Upper Kettle Creek. At this point, the stream is located in the middle of the valley and has good access to the floodplain. The stream has very little bank erosion and some high quality undercut banks for fish habitat. Three head cuts were located at 0.15, 0.18 and 0.55 miles upstream of the mouth. Numerous split channels and lateral bars are found throughout the reach. The dominant bed sediment is large cobble with some gravel present and the embeddedness is low. Approximately 0.4 miles upstream of the confluence with Upper Kettle Creek, at an area of a blown down trees (likely a tornado), a four-wheeler path travels off the hill and into the saturated floodplain. There are multiple four-wheeler trails throughout this section of floodplain which create large areas of exposed soil adding to sediment impacts on the stream. The channel varies between a Rosgen B and F stream type depending on width, and is sometimes a D stream type where the channel is braided. A beaver dam has flooded a forestry road crossing near the mouth. The bed sediment becomes smaller near the mouth of Sliders Branch where a large quantity of silt has accumulated behind the beaver dam complex.

Canopy Cover and Water Temperature

There is excellent canopy cover for this reach until the confluence with Upper Kettle Creek. The confluence of Sliders Branch with Upper Kettle has a large beaver dam complex with no canopy cover except for willows. Trees found in this reach were hemlock, river birch and red maple. Water temperature was 11.1^{O}C or 70^{O}F.

Habitat Enhancement Opportunities

This stream has excellent fish habitat consisting of undercut banks, high quality pools, coarse woody debris, and areas of spawning gravel. Fallen trees create many high quality pools in this reach. Canopy cover could be improved near the beaver dam through the planting of sycamore, green ash, or river birch.

While not a stream channel improvement, the floodplain would benefit by reducing the numerous four-wheeler trails into one or two main trails. The disturbed muddy areas could be reseeded so that this soil is not mobilized during a flood event. Tree plantings in this area is not needed.

LITTLE KETTLE CREEK GENERAL DESCRIPTION

As was noted in the previous assessment completed in 2002, the bed elevation of Little Kettle Creek is controlled by bedrock. The bedrock limits headcut activity and provides a stable base for the stream channel. There is diverse fish habitat in Little Kettle Creek. The concentration of habitat features is high except in the areas of longer riffle/run sequences. The stream channel conditions in Little Kettle Creek are primarily impacted by riparian zone conditions and local land use.

INDIVIDUAL REACH DESCRIPTIONS

LK1 Upstream 0.5 miles from Hungry Hollow Road

Channel Structure and Bank Stability

This reach of Little Kettle Creek is very stable and can be classified as a Rosgen B stream type. There are limited areas of erosion, typically shorter than eight meters. There are some longer sections of erosion just upstream of the Hungry Hollow Bridge. The upper end of the reach is located close to a road and there is a large overflow channel approximately 30 meters from the west bank against the hillside. The willow covered east bank has a small floodplain. Most of the willows in this reach have been eaten by beetle larva. The channel flows across the valley in some locations but tends to be along the west bank hillside for most of the length. There is a large (200 meters long) meadow, about 0.2 miles upstream of the Hungry Hollow Bridge. It is located near an old beaver dam that is no longer active. There is also evidence of past beaver activity at the upper end of the reach as well. Fine sediment is captured in the slow moving water behind the beaver dams. Roadside drainage has introduced fine sediment into the channel about 0.3 miles upstream of the bridge.

FIGURE 8. Excellent canopy cover and riparian vegetation on Little Kettle Creek

Canopy Cover and Water Temperature

Canopy coverage averaged 65% except in the upper 0.25 mile of the reach. The meadow area has the lowest percentage of canopy cover (25%) while the area just upstream of the Hungry Hollow Bridge is excellent. Tree species located in this reach are river birch, hemlock, beech, red and striped maple. There were beetle infested willows along

the streambanks. The water temperature in this reach was 11.5 to 11.8^{o}C or 70.7 to 71.2^{o}F on June 9, 2003.

Habitat Enhancement Opportunities

There is a wide diversity of habitat features evenly distributed throughout this reach. The only section that is lacking habitat is a longer riffle/run sequence in the middle of the reach. Habitat in this reach includes spawning gravel, large boulders, undercut banks, coarse woody debris, and overhanging vegetation. In the meadow, trees could be planted along the channel to provide cover for trout and reduce the water temperature. Recommended tree species are green ash, sycamore, and white pine.

Erosion below roadway culverts introduces sediment in this reach. Protection of the pipe outfalls with rock or drop pipe structures can reduce sediment inputs to the stream channel.

LK2 Hungry Hollow Road downstream 1.75 miles

Channel Structure and Bank Stability

FIGURE 9. Coarse woody debris provides high quality habitat.

Route 44 and Little Kettle Creek occupy the same narrow valley in this section. The stream abuts the road at three locations. This reach has good access to the floodplain and can be classified as a Rosgen C stream type. Undercut banks stabilized by thick vegetation are located throughout the reach. In most of the reach there is limited bank erosion, however, there are two sections of severe erosion about 0.85 miles downstream of the Hungry Hollow bridge. They both have high banks and are ten to fifteen meters in length. The reach has several large mid-channel bars which are undergoing deposition on the upstream end. The deposition will eventually cut off the channel on one side leading to an overall narrowing of the whole channel. Small cobble is the dominant bed sediment with very large rocks.

Canopy Cover and Water Temperature

FIGURE 10. Open canopy can be improved with additional riparian plantings.

Canopy cover is highly variable in the upper and lower portion of this reach ranging from less than 20% cover to over 80% cover. The middle portion of this reach has excellent canopy. Tree species in this reach are dominated by beech, river birch, hemlock, and red maple. The understory is mostly ferns and herbaceous plants with some shrubs. The water temperature in this reach averages 11.8 to 13.2^{o}C or 71.2 to 73.8^{o}F on June 9, 2003.

Habitat Enhancement Opportunities

The upper half of the reach has a higher concentration of habitat features, with frequent high quality pools associated with woody debris jams. Other habitat features include undercut banks, coarse woody debris, and numerous areas of spawning gravel. Good habitat is not as frequent in the lower half of the reach primarily due to long riffle/run sequences. Overhanging banks are the most common habitat type in this area. Habitat could be improved in the lower half of the reach with the placement of root wads, fallen trees, or large boulders.

Riparian plantings in this reach will improve canopy cover and bank stability. Recommended tree species are green ash, sycamore, and white pine.

Forest reproduction in the heavily forested buffer is a long term concern. There are few young trees and shrubs in the understory. Competition from ferns as well as browsing by deer likely contribute to this condition. As the forest matures, it will be important, particularly along the stream banks, that younger trees are established to provide bank strength and canopy cover.

CROSS FORK GENERAL DESCRIPTION

Cross Fork is a highly active system with repeating sequences of channel migration and excessive deposition. The system has started to evolve toward a more stable system. However, this evolution could take a long period of time to stabilize on its own. Most high quality habitat is associated with very active portions of the channel and therefore is not likely to persist. Good riparian conditions and excellent floodplain access make habitat enhancement activities in this portion of the watershed practical. Limited earthwork is necessary to achieve habitat and stream channel function improvement. Most work can be completed by accelerating natural processes occurring in the stream rather than reconstructing the channel.

INDIVIDUAL REACH DESCRIPTIONS

CF1 Headwaters, starting 0.15 miles upstream of Short Run Road and ending 0.25 miles downstream of Cherry Run

Channel Structure and Bank Stability

FIGURE 11. Overly wide, poor habitat reach on Cross Fork

Approximately 0.15 miles upstream of the Short Run Road bridge, the channel is over wide and braided with numerous overflow channels. There is a beaver dam 25 meters upstream of Short Run Road on the east branch of the split channel. This detains excess sediment from moving downstream. As the valley widens, the floodplain width increases and the channel is able to meander across the valley floor. The stream flows against the hillside in a number of locations. The upstream portion of the reach, to the confluence with Little Lyman Run, has an armored channel dominated by small boulders. Near the confluence with Yochum Run, the dominant bed sediment changes to large cobble. This is the most common bed sediment size that is found in the downstream reaches on both Cross Fork and Kettle Creek. Just downstream of Yochum Run, the channel is very active with multiple threads and significant channel migration. Multi-thread Rosgen D stream type channels are prevalent throughout this reach. These multi-thread channels indicate instability due to an imbalance between bed sediment load and sediment transport capacity. Bedrock outcrops emerge approximately 0.75 miles downstream of the Short Run Road Bridge which will help prevent the migration of the headcuts

located upstream of Yochum Run. This area has an abundance of large vegetated mid-channel bars.

Canopy Cover and Water Temperature

The headwaters of Cross Fork have thick hemlock cover. The beaver dam above Short Run Road bridge creates a flooded area with willows and no large trees to provide cover. Canopy cover in this area is only 25%.

Canopy cover is abundant, ranging from 85-94%, along the stream except where there are seasonal camps along the banks. The open area of camps near Yochum Run only has 48% cover. The water temperature range in this reach was between 12.1 to 15.4^{o}C or 72 to 78^{o}F on between April 28 and May 1, 2003.

Habitat Enhancement Opportunities

Pool development in this reach is generally poor with coarse woody debris providing the majority of habitat. Pools could be increased with the placement of log veins. Riparian plantings would improve the canopy cover in the beaverdam area upstream of Short Run Road and near the cabin across from Yochum Run. Recommended tree species include sycamore, green ash, river birch, hemlock, or white pine.

The lower portion of the reach from Yochum Run downstream can benefit significantly from stream channel and habitat improvement. Consolidating the multi-thread channels to single thread channels with appropriate plan form and cross-sectional geometry will improve stream channel function by increasing sediment transport. Pool habitat in the single channel could be created through the placement of rock/log structures or large woody debris and root wads. Stream flow concentrated into a single, deeper channel will generally have cooler water temperatures.

CF2 0.25 miles downstream of Cherry Run to the large meadow area with a group of camps, 0.35 miles downstream of Hungry Hollow Bridge.

Channel Structure and Bank Stability

FIGURE 12. Cross Fork reach with good stream channel geometry.

In this section of stream, the floodplain is very wide. The stream flows along the west side of the valley for the entire length of the reach. The channel form and function vary widely through this section while maintaining a Rosgen C stream type. The channel ranges from overwide and sediment laden to a narrowing channel with newly developed lateral bars, to an appropriate width and depth channel that exhibits a good sediment balance. The bed sediment moving through this reach appears to be a larger size cobble and the excess sediment is forming several mid-channel bars. This reach has several sections of bedrock outcrops with deep pools. There are no head cuts and only a few mid-channel bars in the lower section. The channel is moderately entrenched in some sections. Erosion is more frequent in the upper half of the reach. The severe bank erosion occurs more frequently along the hillsides and it is typically moderate on the outer curves of long meanders. About 1.5 miles downstream of Cherry Run there is severe bank erosion on the right with a 3 meter high, 15 meter long bank. The banks downstream of Hungry Hollow Bridge are 1 to 2 meters tall; banks upstream of this section are typically lower. There is a relatively new, well armored gas pipeline crossing 0.15 mile upstream of Hungry Hollow Bridge.

Canopy Cover and Water Temperature

Canopy cover averaged 50% in this reach. There are two large meadow areas, one in the middle half of the reach and the other near several cabins on the right bank at the bottom of the reach. The reach was forested on both banks near Hungry Hollow bridge. The water temperature in this section was 11.9^{o}C or 71.4^{o}F on June 11, 2003.

Habitat Enhancement Opportunities

The habitat in this reach is primarily generated by coarse woody debris jams and the erosional portions of the channel. Bedrock pools also provide some fish habitat. High quality pools are sparse with only eight in the over two-mile reach and due to the ongoing stream channel evolution, many of the existing pools may not be maintained.

Enhancement projects to improve stream channel geometry and habitat features should be pursued in this reach. A long section of stream can be improved using low impact methods of stream channel enhancement. These include vegetative plantings on developing lateral bars, the use of wood structures to consolidate multi-thread channels, and limited channel relocation. Excellent floodplain access with entrenchment ratios greater than 2.2 allow channel enhancement work to be completed with little impact outside the active channel margins. This reach provides an excellent opportunity to accelerate the natural channel evolution sequence.

The meadow areas could be planted with fast growing trees near the stream bank to provide cover and lower the temperature of the stream. Fast growing tree species are green ash, sycamore, and white pine.

CF3 Large meadow with numerous cabins to Camp Savage, 0.5 miles below Gravel Lick Run

Channel Structure and Bank Stability

FIGURE 13. Coarse woody debris provides the majority of habitat in reach CF3.

In this reach, the stream is located along the east side of the valley and close to the hillside. There are long, older, thickly vegetated lateral bars throughout the reach. The channel is narrower with higher velocities and numerous 0.5 meter deep runs. Several rock dams are located in the lower part of the reach. There are long pools behind the dams but habitat was limited since the channel bottom was fairly uniform with no boulders or woody debris for cover. A large pool formed on both sides of a rock dam 100 meters upstream of Camp Savage. Downstream of Camp Savage, there

are numerous split channels. Bank erosion in this reach was mild with banks averaging 1.5 meters high and 40 meters long. The banks are heavily vegetated and have a loam substrate. The dominant bed sediment in the channel bottom of this reach was large cobble.

Canopy Cover and Water Temperature

This reach has adequate tree cover over the channel. Canopy cover in this section of stream averaged 65% tree coverage. The temperature in this reach ranged from 11.6 to 12.4^{o}C or 70.9 to 72.3^{o}F on June 12, 2003.

Habitat Enhancement Opportunities

The upstream portion of this reach has very sparse habitat to the confluence with Windfall Run. Downstream from Windfall Run the habitat improves significantly. Most of the high quality habitat pools are associated with coarse woody debris, the confluence of split channels, or around bedrock channel bottoms. Additional high quality habitat is composed of spawning gravel, course woody debris, and undercut banks.

While habitat enhancement in this reach can improve the existing conditions, the limitations posed by the high number of camps in the riparian area downstream from Windfall Run would make work difficult. Constructed woody debris jams in key locations can be used for moderate habitat improvement.

CROSS FORK TRIBUTARIES

LLR1 Little Lyman Run

Channel Structure and Bank Stability

FIGURE 14. Split channel on Little Lyman Run

Little Lyman Run is located in the northern part of the watershed and drains into Cross Fork from the west. The valley bottom is narrow and the stream meanders across the valley. The channel is a Rosgen D stream type in most areas and has smaller split channels than upper Cross Fork. The dominant bed sediment found in this reach is small cobble and the rocks appear to be more rounded than on other streams. There

is more human activity on this stream than other tributaries in the watershed.

Canopy Cover and Water Temperature

Most of the reach has adequate canopy cover. The lower section near the road is slightly more open with canopy coverage of 75%. Willows are growing in the open areas. The water temperature in this section of stream was 11.7^{o}C or 71^{o}F on May 27, 2003.

Habitat Enhancement Opportunities

The surveyed reach does not contain many large pools. Habitat is created by over hanging banks and small pools formed around course woody debris. Habitat can be enhanced by properly locating and constructing limited woody debris jams or log habitat structures. Due to the small stream size and excellent riparian buffer, no extensive channel modifications are recommended in this tributary. This stream should be permitted to evolve naturally with only limited intervention to improve habitat.

YR1 Yochum Run 1.5 miles upstream of the mouth to the confluence with Cross Fork

Channel Structure and Bank Stability

FIGURE 15. Split channel on Yochum Run

Yochum Run drains into Cross Fork Creek from the east and is south of the Little Lyman Run drainage. This tributary has a wide (80-100 meters) floodplain throughout the reach. It is a Rosgen C stream type with cobble as the dominant bed sediment. The upper end of the reach is in an open meadow area for approximately 250 meters. As the stream flows down the valley there are numerous split channels and dry, high water channels in the valley bottom. At the top of the reach, about 3/4 mile upstream from the mouth, there are two large wetland complexes. There are at least seven ephemeral drainages on the right bank hillside. Some of these drainages also conveyed spring water. Most of these

have scoured a gully as they flow down the hill. There were large alluvial fan deposits where these drainages enter the stream. Along the left bank an old logging road is located one-third of the way up the hillside, approximately 35 meters from the channel. It was covered in vegetation and stable except in the areas of the gullies. Most of the larger mid-channel bars that were identified are better described as split channels. They consist of old deposits that support established, mature trees. Yochum Run in this reach has low banks with good access to the floodplain, no head cuts, and bank erosion was minimal. There are two larger sections of erosion that contribute fine sediment to the system. They are located approximately 0.7 miles upstream of the mouth. The banks range from 2.5 to 6 meters high and 18 to 20 meters long. Access to these areas may be difficult.

Canopy Cover and Water Temperature

Canopy cover at the upstream extent of the reach is very open with only 12% coverage for the channel. This area is an open meadow, wetland complex. Further downstream tree coverage over the channel increases to about 88%. Water temperatures in this section of stream are 10.2 to 12.8^{O}C or 68.4 to 73^{O}F on June 10, 2003.

Habitat Enhancement Opportunities

The channel consisted of good to excellent habitat in the form of undercut banks, large woody debris, and pools on the outside curves of meanders. To increase canopy cover and lower water temperatures, trees could be planted along the stream banks in the meadow areas. Recommended tree species are green ash, sycamore, river birch, hemlock, and white pine.

While multi-thread channels are prevalent on this tributary they are stabilizing under the current conditions. Floodplain access is excellent and the riparian area is well vegetated at most locations. The stream channel is functioning properly and there are no improvements recommended in this tributary.

WR1 Windfall Run, Big Spring Road culvert to confluence with Cross Fork Creek.

Channel Structure and Bank Stability

FIGURE 16. Typical channel form on Windfall Run.

The Windfall Run drainage flows from the east and enters Cross Fork Creek south of Hungry Hollow Road. It is a Rosgen C stream type for most of its length except closer to the mouth where it is classified as a Rosgen B-C stream type. There are a few areas of split channels. The valley is narrow at the upstream end and widens as the stream flows down the valley. It is located along a steep hillside to the northeast. There are bedrock outcrops throughout the stream that help stabilize the stream bed. The stream appears to be over wide in the forested areas, although there are good entrenchment ratios in most of the channel. Bank erosion is common in the channel, with most areas rated mild or moderate erosion. There are several areas of severe erosion sites located near the top of the reach. These erosion areas have sandy substrate and all but one are greater than 19m in length. All of the erosion areas have cumulative inputs to the fine sediments in the system. Rocks on the channel bottom are flat and vary from small to large cobble. There are no willows in the open areas and little human impact in the upper mile of this reach. The channel straightens downstream of the Windfall Run Road Bridge. The bridge is skewed and a bar is forming under the bridge. Upstream of the bridge, the far right bank near the road has been rip-rapped to minimize bank erosion and protect the elevated road. Between the Windfall Run Road bridge and the Cross Fork Road bridge, the stream meanders and has two 180 degree turns with large pools. Sediment enters the channel below Windfall Run Road Bridge and appears to be coming from the road. The channel is a Rosgen G stream type by the Cross Fork Road Bridge. The downstream portion of this reach is an area of numerous headcuts, log jams, and deposition.

Canopy Cover and Water Temperature

The temperature in this reach ranges from 9.2 to 12.1^{O}C or 66.6 to 71.8^{O}F on May 28, 2003. The beginning of the reach has 40% canopy

cover. The middle of the reach has approximately 73% canopy cover and the lower section of the reach has only 22% canopy cover. The lower section of the reach has cabins with mowed lawns. Trees found in this reach are hawthorn, hemlock, beech, willows (lower), white pine, and red maple.

Habitat Enhancement Opportunities

The upper reach has excellent habitat with many high quality pools and over hanging banks. The lower reach has similar features and a significant number of areas with woody debris. There are no in-stream habitat improvements required in this reach. In the areas of low canopy coverage riparian trees could be planted. Recommended tree species include green ash, sycamore, river birch, hemlock, and white pine.

The numerous areas of bank erosion should be addressed due to the cumulative inputs of fine sediments in the system. It may be possible to stabilize the mild to moderate erosion areas by regrading the banks, installing geotextiles, and vegetative plantings. The severe areas of erosion near the top of the reach may require a more structural design.

HAMMERSLEY FORK GENERAL DESCRIPTION

Hammersley Fork flows through a designated wild area, the Forrest H. Duttlinger Natural Area, for most of its length. The upper watershed has several dirt and gravel roads near the watershed boundary, but the only access to the majority of the upper watershed is by foot. Historic logging activities were intense in this watershed, but since that time the watershed has been essentially undisturbed. The stream channel is highly variable throughout the watershed with numerous sequences of channel migration followed by deposition of midchannel bars and further instability. With limited access and a healthy riparian corridor, most enhancement work on Hammersley Fork should be limited to canopy cover improvements and habitat improvement on downstream, more populated reaches. Hammersely Fork affords an excellent opportunity to observe the natural stabilization process in a watershed with limited human activity over the last 100 years. This opportunity can be used to accurately gage the time required for a stream system to heal itself after widespread land use change and subsequent reforestation. Water quality measurements in this watershed may also be used as a benchmark for water quality in the Kettle Creek Watershed as a whole.

INDIVIDUAL REACH DESCRIPTIONS

HF1 Mainstem of Hammersley Fork from Bunnell Run to Dry Hollow

Channel Structure and Bank Stability

Hammersley Fork is in a designated wild area and there are no active roads along most of the stream. Field data collection began at Bunnell Run where there is a meadow with open canopy on the right bank. There are numerous bedrock outcrops in the upstream half of the reach which help provide vertical stability to the channel. The other major bed sediment in the stream is large cobble. The channel in this reach tends to be overwide with high banks.

FIGURE 17. Lateral bar on Hammersley Fork

The upper half of this reach is a Rosgen F stream type and the lower half is a Rosgen C stream type. The small sections of erosion were rated as mild and only three mid-channel bars are located in this reach. These mid-channel bars are aggrading on one side and trending toward a stable, single thread channel. There are some bars that are still bare or only sparsely vegetated. Excellent floodplain access allows overbank flow to be conveyed efficiently. Bank erosion and channel stability are not concerns in this reach as it appears to be well on its way to recovery.

Canopy Cover and Water Temperature

The canopy cover in the upper section is 62% tree coverage. The lower section in this reach has more tree coverage with an average of 86%. The majority of trees found in this reach are maple and beech. The water temperature in this reach ranges from 10.0 to 12.3^{o}C or 68 to 72^{o}F on July 29, 2003.

Habitat Enhancement Opportunities

The pools created in the bedrock channel bottom are very deep and provide good fish habitat. Mid-channels bars usually have good habitat in the form of log jams, deep pools on meander bends, or pools at the convergence of the split channels. There are also numerous overhanging

banks, locations containing spawning gravel and some coarse woody debris. No habitat enhancement work is recommended in this reach.

HF2 Dry Hollow downstream to the confluence with Nelson Branch

Channel Structure and Bank Stability

FIGURE 18. Typical channel form on Hammersley Fork.

Dry Hollow joins Hammersley Fork from the west. Beginning 150 meters downstream of Dry Hollow, bedrock is the dominate bed sediment for the next mile. In areas where there is no bedrock exposed, the bed sediment is primarily large cobble. Numerous deep bedrock pools were found in this mile section of stream. A large bedrock pool has formed 175 meters downstream of Dry Hollow. Near this pool, there are several well established campsites on the left bank. Cow Run is one of the major tributaries in this reach. It drains the western portion of the watershed and joins the mainstem approximately 1.8 miles downstream of Dry Hollow. There are two sections of severe bank erosion on the right bank approximately 0.5 miles downstream of Cow Run. There is very little erosion in the section that is all bedrock. About 0.5 miles upstream of Cow Run, a 250 meter section of the stream is split into numerous channels. There are many long channel splits and overflow channels in this reach that only convey water during bankfull events. This reach is a Rosgen C stream type in the upper third, B in the middle third, and an F to D in the lower third.

Canopy Cover and Water Temperature

The upper third of the reach has 93% tree coverage, the middle third of the reach has 58% coverage, and the bottom third of the reach has 89% tree coverage. The water temperature in the reach ranges from 11.1 to 12.8^{o}C or 70 to 73^{o}F on July 30, 2003.

Habitat Enhancement Opportunities

There are numerous areas of coarse woody debris, high quality pools, and over hanging banks. Spawning gravel and undercut banks are lim-

ited in this reach. The downstream third of this reach is active, but moving towards stability. Split channels are moving toward single thread channels and lush riparian vegetation provides bank stability even in active portions of the reach. No habitat enhancement work is recommended in this reach.

HF3 Confluence of Hammersley Fork and Nelson Branch to ford crossing approximately two miles downstream

Channel Structure and Bank Stability

FIGURE 19. Headcut on Hammersley Fork.

The stream flows in the middle of the valley for most of the reach except at the downstream end where it flows along the eastern hillside. The upper section of this reach has frequent erosion areas that often alternate banks depending on the location of the thalweg in the channel. The upper reach consists of eroded banks, sparsely vegetated lateral bars, numerous overflow or split channels, and large mid-channel log jams. This section of Hammersley Fork has more human activity than upstream. There are cabins starting at the lower end of the reach and continuing to the mouth. There are several campsites in the area near Nelson Branch. A dirt road in the valley bottom crosses the creek at the downstream end of the reach. The road is in poor condition, with long, deep, muddy puddles. About 1 mile downstream of the confluence an old CCC camp is located on the east bank. The stream channel behind the CCC camp is very wide, with active erosion and a large log jam in the middle of the channel. Downstream of the CCC camp, a split channel has eroded the bank and now flows over the road surface for a distance. Upstream of the CCC camp, streambank stabilization has been implemented in the form of a stone wall, netting, and plantings. This reach is a Rosgen C stream type in the first 0.5 miles; the rest of the stream is a Rosgen F stream type. There are a few bedrock outcrops in the lower section of the reach, but the dominant bed sediment is large cobble. Due to the large amount of sediment being transported, this section is one of the most unstable reaches in the entire tributary assessment project.

Canopy Cover and Water Temperature

The water temperature in this reach ranges from 17.1 to 21.3^{o}C or 81 to 88^{o}F on July 16, 2003. Canopy cover at the confluence of Hammersley Fork and Nelson Branch is 70% tree coverage. The rest of the reach has an average canopy cover of 40%. Tree species observed in this reach are red maple, river birch, sycamore, hemlock, and willows. Canopy cover could be improved by planting additional trees in the riparian zone.

Habitat Enhancement Opportunities

The confluence of Hammersley Fork and the Nelson Branch creates a deep pool. Habitat features found in this reach are: coarse woody debris, thick root mats, some spawning gravel, and a few large boulders. In the areas of low canopy coverage fast growing trees could be planted. Fast growing tree species are green ash, sycamore, and white pine. The primary habitat enhancement opportunity in this reach is riparian zone revegetation. This will improve canopy cover and strengthen the banks. Additionally, just downstream from the former CCC camp, it is recommended that the channel be directed into a single thread channel and planted with woody vegetation on the banks to ensure that the dirt road does not continue to erode and become a new stream channel.

HAMMERSLEY FORK TRIBUTARIES

BB1 Bell Branch to the confluence with Nelson Branch

Channel Structure and Bank Stability

FIGURE 20. Step-pool formation on Bell Branch.

The beginning of this reach is approximately 0.75 miles upstream from the confluence with Nelson Branch. The stream is relatively steep and flows on the left side of the valley. The upper section has bedrock substrate and a few deep bedrock pools. The overall dominant bed sediment size is large cobble. Although not directly impacting the stream, a large pile of coal ash in the area indicates historic human activity in this reach. This reach is a Rosgen B stream type with little bank erosion and few mid-channel bars.

Canopy Cover and Water Temperature

Canopy cover is excellent throughout the reach with 85% canopy coverage. Canopy cover is enhanced by the steep hillslope to the south of this reach. Water temperature in this reach was 12.7^{O}C or 73^{O}F on July 31, 2003.

Habitat Enhancement Opportunities

Good stream channel function coupled with excellent riparian conditions support high quality habitat in this reach. Habitat features found in this reach are high quality pools, under cut banks, and coarse woody debris. No habitat enhancement work is recommended in this reach.

BB2 Bell Branch downstream of Nelson Branch confluence

Channel Structure and Bank Stability

FIGURE 21. End of meadow area on Bell Branch.

Nelson Branch flows into Bell Branch 0.5 miles above the confluence with Hammersley Fork. The left bank of Bell Branch is a meadow with several overflow channels and historic beaver activity. The banks in this area are typically verticle with little woody vegetation. Approximately 0.35 miles upstream of the confluence with Hammersley Fork, the right bank has a section of severe erosion that is 18 meters long by 8 meters high. The lower half of the reach has numerous split channels with good habitat. The stream is a Rosgen D stream type in this area. The dominant bed sediment is small cobble. Approximately 300 meters above the confluence with Hammersley Fork, there is a split channel that flows along the western hillside. This channel enters Hammersley Fork at a different location approximately 350 meters downstream of the main confluence. The stream channel function on this reach of Bell Branch is consistent with that of a steep mountain stream entering a wide floodplain complicated by the area of the old beaver dam. Continued channel evolution in this reach will likely produce additional off channel wetlands as the channel trends toward a single channel.

Canopy Cover and Water Temperature

The canopy is very open at the upper end of the reach with a value of only 11% cover. The channel continues to have limited canopy cover until approximately 200 meters upstream of the confluence with Hammersley Fork where the canopy is dense and there is 99% cover. The water temperature in this reach was 15.9^{o}C or 78.6^{o}F on July 31, 2003.

Habitat Enhancement Opportunities

Habitat in this reach is diverse and evenly distributed. The major fish habitat is high quality pools and coarse woody debris. There are also a few areas of spawning gravel and under cut banks. The predominant opportunity for habitat enhancement in this reach is establishment of additional woody riparian vegetation in the meadow area in the upstream portion. Improved canopy cover will help to reduce water temperatures and additional root mass will strengthen the banks.

NB1 Nelson Branch starting approximately 1 mile upstream of the mouth

Channel Structure and Bank Stability

The valley of this tributary is narrow and steep. Toward the mouth of Nelson Branch the stream becomes narrow, entrenched with high banks, and has very limited access to the floodplain. The dominant bed sediment consists of both large and small cobble. This reach is predominantly a Rosgen F stream type with short reaches of Rosgen C stream type channel distributed throughout the reach. Bank erosion is mild or moderate in most areas with a few areas of severe bank erosion. The severe erosion is in areas where the channel is against the valley side causing small landslides on the valley walls. Most of the mid-channel bars that are located in the lower half of the reach are heavily vegetated. The mid-channel bars located in the upper half of the reach are bare.

Canopy Cover and Water Temperature

Water temperature in this reach was 14.4^{o}C or 75.9^{o}F on July 28, 2003. There is thick canopy along most of the reach with little direct sunlight able to penetrate the tree cover. Canopy cover in the upper three quarters of a mile has approximately 82% tree coverage. The lower 0.25 miles of stream is more open and has 48% tree coverage. Trees found in this reach were red maples, river birch, beech, and several old apple trees.

Habitat Enhancement Opportunities

The highest concentration of habitat in Nelson Branch corresponds to areas of bank erosion and channel instability. Habitat is primarily in the form of high quality pools, with some overhanging banks and areas of spawning gravel. Since the stream channel is entrenched with poor floodplain access, active erosion, and active mid-channel bar migration, this reach would be a good candidate for stream channel stabilization. However, due to limited access and the impacts associated with creating access, it is recommended that this reach be allowed to stabilize through the natural channel evolution process.

TROUT RUN GENERAL DESCRIPTION

The upper portions of the Trout Run watershed consist of smaller, high gradient tributaries. These major tributaries include Calhoun Branch, Greene Branch, and Wykoff Branch. These channels are typically stable, step pool sequences with a small boulder substrate. Trout Run is also a relatively stable stream channel with little channel migration and good entrenchment ratios. While there is some mid-channel bar formation, excess sediment does not appear to be a problem in this watershed.

INDIVIDUAL REACH DESCRIPTIONS

TR1 Confluence of Green Branch and Calhoun Branch to Route 144 Bridge

Channel Structure and Bank Stability

Trout Run is created from the confluence of Greene Branch and Calhoun Branch approximately 0.4 miles upstream of the Trout Run Road bridge. Wykoff Branch joins the mainstem at this bridge. It is a Rosgen C stream type for most of its length with short sections of a B stream type. The dominant substrate is cobble although there is a bedrock outcrop in the area of the bridge. The stream meanders across the valley floor. In one of the hemlock stands, the stream flows through a recently formed split channel. This newer channel has some erosion areas and excellent fish habitat. Trout Run Road parallels the stream and travels along the western hillside. At one point the road is close to the stream and a concrete support structure was constructed to stabilize the bank under the road. There is a second area that has not been stabilized where the stream is eroding the bank under the road. This area is located approximately 0.85 miles downstream of the bridge and is about 5 meters high and 28 meters long. There are numerous pipeline crossings, some of which are very old, below the Trout Run Road Bridge. Several of the pipes are exposed. At 1.0 mile downstream of Trout Run Road Bridge, the John Summerson Branch enters the channel on the east bank. The valley widens as it approaches Kettle Creek.

Canopy Cover and Water Temperature

The canopy covers 75% of the channel in this reach of stream. Tree species in this section of stream include hemlock, white pine, sycamore,

and beech. Water temperature ranges in this section of channel from 9.1 to 11.7^{o}C or 66.4 to 71.1^{o}F on May 22, 2003. The water temperature entering from John Summerson Branch was 8.4^{o}C or 65.4^{o}F on May 22, 2003.

Habitat Enhancement Opportunities

Habitat in this reach is abundant and varied. The dominant habitat features are numerous high quality pools and coarse woody debris, with scattered areas of undercut banks, overhanging vegetation, and spawning gravel. Due to the frequent bedrock and boulders in the channel bed, channel stability, and excellent riparian conditions, no habitat enhancement is recommended. Protection of the riparian zone to preserve water temperature should be a priority in this reach. The eight gas pipeline crossings in this reach, some of which are above the streambed elevation, cause channel widening in the immediate area. An inventory of the active pipelines should be undertaken and all active pipeline crossings should be stabilized. The eroding streambank threatening the Trout Run Road, 0.85 miles downstream of the bridge, should be further examined and a stabilization plan developed. This may require structural techniques such as a retaining wall.

TROUT RUN TRIBUTARIES

WB1 Wykoff Branch

Channel Structure and Bank Stability

This is a smaller mountain stream that flows in a narrow valley bottom. Wykoff Branch is a Rosgen B stream type with a continuous sequence of step pools. The bed sediment consists primarily of large boulders with some gravel and small cobble. There is limited floodplain area and little evidence of bank erosion. A road parallels the stream but is located on the hillside away from the channel. A gas pipeline crosses the channel 0.15 miles upstream of the Trout Run Road Bridge.

FIGURE 22. Step pool channel on Wykoff Branch.

Canopy Cover and Water Temperature

Canopy cover is excellent with nearly 100% coverage for the entire reach. The temperature in this reach ranged from 9.0 to 9.5^{O}C or 66.2 to 67.1^{O}F on May 21, 2003.

Habitat Enhancement Opportunities

The amount of high quality habitat is limited in this stream, primarily due to the steep gradient. The dominant fish habitat found in this reach is smaller step pools and a few undercut banks. There is a lack of coarse woody debris compared to Greene and Calhoun Branches in the upper watershed. With a dense riparian zone, good stream channel function, and limited opportunities due to the size and steepness of the channel, no habitat enhancement activities are recommended in this reach.

GB1 Greene Branch

Channel Structure and Bank Stability

The stream is a Rosgen B stream type with a wide valley floor and it is not as steep as Wykoff and Calhoun Branches. Meandering across the valley, the stream has several step pool sequences. An old dam might have been located at the downstream end of the tributary where the stream splits. Erosion was observed only where the stream flows against the hillsides and cobble was the dominant substrate in the channel.

Canopy Cover and Water Temperature

Greene Branch tributary has excellent canopy cover (96%) throughout the reach. The water temperature for this reach was 11.5^{O}C or 70.7^{O}F on May 20, 2003.

Habitat Enhancement Opportunities

This stream has good habitat features throughout the surveyed reach. Habitat was primarily in the form of overhanging vegetation, high quality pools, and coarse woody debris. The stream channel is stable in this reach and no habitat enhancement is needed.

CB1 Calhoun Branch

Channel Structure and Bank Stability

This tributary has similar characteristics as Wykoff Branch. It is relatively steep with a narrow valley bottom, classified as a Rosgen B stream type with a high entrenchment ratio. The stream does not meander within the valley and is in a step pool sequence for most of its length. Much of the bed sediment in this section of stream is large and small boulder with gravel and cobble filling in the spaces. Bedrock is located in 10% of this reach. This section of watershed had little human impact except for a forestry gravel road located on the hillside away from the stream. The road does not appear to have any major impacts on the stream.

Canopy Cover and Water Temperature

Canopy cover for this reach is excellent at 99% coverage. The water temperatures found in this section of stream are 9.7 to 11.1^{O}C or 67.5 to 70^{O}F on May 20, 2003.

Habitat Enhancement Opportunities

Calhoun Branch is a narrow, high-gradient system with a series of deep step pools. Other habitat features include undercut banks and coarse

woody debris. Habitat enhancement is limited due to the size and steepness of the channel, therefore no improvements are recommended in this reach.

BEAVERDAM RUN GENERAL DESCRIPTION

Beaverdam Run flows through a forested valley and flows along a hillside in most areas. It is a relatively stable system with limited channel migration and sediment transport. The stream meanders very little, has few mid-channel bars, and scattered bank erosion. The stream has very different characteristics near the mouth, where it flows through a meadow area, is more entrenched, and has a smaller average size bed sediment than the forested section upstream.

INDIVIDUAL REACH DESCRIPTION

BR1 1¾ miles upstream of confluence with Kettle Creek.

Channel Structure and Bank Stability

FIGURE 23. Beaverdam Run near the confluence with Kettle Creek.

This tributary flows into Kettle Creek at the northern end of Kettle Creek State Park. This is a small stream (<8 meters wetted width) flowing through hemlock forest. There is a state park road in poor condition on the west bank hillside, that may introduce fine sediment to the stream during high runoff events. The channel is entrenched in most areas with 1.5 meter high banks. However, the entrenchment ratio improves downstream as the floodplain widens. There are several pipeline crossings and well heads throughout the reach. The channel ranges between Rosgen F and B stream types. There are relatively few areas of bank erosion and mid-channel bars. There is one area of severe erosion located 0.65 miles upstream of the bridge on Kettle Creek Road/Route 144. This site is 7 meters high and 20 meters long with no vegetative cover. There are two headcuts and two bedrock outcrops in this reach which affect the grade of the channel. Bed sediment is primarily large cobble or gravel. Near the picnic area the valley bottom widens. The channel downstream of the bridge flows through a meadow area with willows and multiflora rose next to the stream. The stream is much narrower with several long pool sections.

Canopy Cover and Water Temperature

Water temperatures found in this reach ranged from 13 to 13.6^{o}C or 73.4 to 74.5^{o}F on June 18, 2003 (weather - overcast, 70^{o}F). The first half mile in the reach has excellent canopy cover (98%) with hemlocks and beech trees. The lower mile has approximately 45% canopy cover with more open canopy near the Route 144 bridge. The lower portion of the reach is very different than upstream. It flows through a meadow with shrubs along the streambanks and no mature tree canopy. Several invasive species including Japanese knotweed, Japanese barberry, and multiflora rose are located 0.25 miles upstream of the bridge on Route 144 and continue to the mouth.

Habitat Enhancement Opportunities

The stream flows through a heavily forested valley bottom, except at the lower end of the stream. There are diverse habitat features with large numbers of high quality pools, woody debris, and some undercut banks. There is good habitat for trout especially around fallen trees and there are numerous areas of spawning gravel deposits. Habitat is lacking in the middle portion of the reach and can be improved by adding some large woody debris or root wads. The downstream portion of the reach is very different than upstream with a more defined riffle/pool sequence. The primary habitat is in the form of pools. The bed sediment is more silty with less areas of cobble and gravel. The reach that flows through the meadow should be planted with trees to provide canopy cover and lower the water temperature. Recommended tree species include sycamore, red maple, white oak, and white pine. If possible, efforts should be made to eliminate the invasive species in the meadow area. To eliminate a potential source of fine sediments, the park road should have additional drainage features constructed and the road bed covered with gravel.

Recommendations

GENERAL RECOMMENDATIONS

Protection and enhancement of the existing riparian corridors should be the highest priority throughout the portions of the watershed addressed in this addendum. The existing forested corridors create shade on the water surface, root mass for bank stability, provide unimpeded floodplain access, and allow for the deposition of suspended sediments during high water events.

Streambank erosion contributes large quantities of fine sediment to the stream systems and alters the riparian corridors by relocating the stream channel and felling trees. Stabilizing these areas should be a priority since fine sediments impact spawning areas for the native trout population. Stabilizing the banks would also reduce the number of mature trees falling into the stream, thereby protecting the riparian area. The most severe areas of bank erosion on each tributary have been identified in the below sections.

There are numerous pipeline stream crossings within the Upper Kettle Creek Watershed. Some of the pipes are buried and the stream is stable, while there are many other areas where the pipes are exposed. The companies operating these pipelines should be contacted to determine which pipelines are still active. All exposed, active pipeline crossings should be buried and stabilized.

Dirt and gravel roads contribute sediment to the stream system throughout the tributary watersheds. Erosion at the outfall of culverts is especially a problem. Improvements to these roads and drainage systems should be a priority to reduce fine sediment inputs to the stream channels.

Additionally, future development in the watershed, including roadway improvements should comply with stormwater management regulations and dirt and gravel road maintenence specifications to ensure that stormwater discharges and associated pollutants do not adversly impact the stream system.

WATERSHED SPECIFIC RECOMMENDATIONS

Upper Kettle Creek

Assuming that it is still active, the exposed petroleum pipeline is a serious threat to the health of the stream system. If this pipeline were to burst during a high water event it would affect not only Upper Kettle Creek but the mainstem as well. It would immediately affect the fishery and other aquatic life in the streams, as well as having a prolonged effect on the water quality and habitat. The pipeline should be reburied and the streambank armored at that location.

Most of the stream channel evaluated in Upper Kettle Creek is recovering well without intervention. The primary focus of any stream work on Upper Kettle Creek should be the two areas of severe erosion located 0.30 miles downstream of Germania Branch. The first is rated as severe; it is a 2.5 meters high and 22 meters long section of nearly vertical clay bank (Figure 24 on page 42). The second erosion site is rated as extreme; it is a 9 meters high and 28 meters long section of sandy cobble (Figure 4 on page 11). This area is private land ownership.

FIGURE 24. Severe erosion on Upper Kettle Creek downstream of Germania Branch

This erosional area has very little canopy cover, with coverage at only 25%. This section of stream would benefit from riparian plantings, which would help stabilize the banks and reduce lower water temperatures.

There are several areas of severe erosion on Germania Branch approximately 2.15 miles upstream of the confluence with Upper Kettle Creek. At least five separate areas of erosion combine to a total of one quarter mile in length. The banks range in height from 1-5 meters and some sections are up to 70 meters long. These areas should be stabilized by regrading the banks and planting woody vegetation.

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FIGURE 25. Severe erosion on Germania Branch

Little Kettle Creek

Little Kettle Creek is a very stable stream channel. This is largely due to the bedrock control of bed elevation and the excellent riparian vegetation in the stream corridor. Some sections of poor canopy cover can be improved with riparian plantings.

There are two areas of severe bank erosion located 0.85 miles downstream of the Hungry Hollow Bridge that should be stabilized. These areas may require structural as well as vegetative techniques for stabilization. The banks range from 4-5 meters high and 10-15 meters long. Both areas have thin vegetative cover.

FIGURE 26. Severe erosion on Little Kettle

Cross Fork

There are opportunities on Cross Fork to improve stream channel function and habitat. A 3.5 mile reach of Cross Fork from Yochum Run to Windfall Run has been identified as a priority for stream channel enhancement. Work in this reach using natural channel restoration techniques in concert with naturally occurring channel evolution can provide significant habitat and stream channel function improvements. This work will be beneficial to the native trout population in Cross Fork. Improved habitat and stream channel function will allow habitat to develop and persist through time while stabilizing this active system. Habitat enhancement in Cross Fork, including improved canopy cover, has the potential to benefit not only the immediate enhancement reach, but downstream reaches as well.

Pre-construction data collection and ongoing monitoring of the post-construction stream channel and habitat conditions should be conducted to provide a benchmark for other, similar habitat enhancement work. This monitoring should include both macroinvertebrate and fish population sampling and analysis.

One priority area for streambank stabilization is located approximately 0.75 miles downstream of Yochum Run, near a cabin. Due the the curvature of the stream and the location of an older recreational rock dam, the stream has eroded both banks at this location. This area would also benefit from riparian plantings as there is only 28% canopy cover at this location. This area would have relatively easy equipment access.

FIGURE 27. Cross Fork erosion downstream of Yochum Run.

Stabilization should be considered for two areas of bank erosion on Windfall Run 1.15 and 1.65 miles upstream of bridge on Township Road 416. The severe erosion is 1.5 meters high, 19 meters long with sandy substrate and thin woody vegetation. The area of extreme erosion is 5.5 meters high, 24 meters long with cobble substrate and thin woody vegetation.

FIGURE 28. Bank erosion on Windfall Run

Yochum Run also has two bank erosion sites located 0.7 miles upstream of confluence with Cross Fork that should be stabilized. The severe erosion site is 2.5 meters high, 18 meters long with loam soil and with thick woody vegetation. The extreme erosion area is 6 meters high, 20 meters long in sandy gravel with thin herbaceous vegetation.

FIGURE 29. Bank erosion on Yochum Run.

Hammersley Fork

Hammersley Fork is a very active system with channel migration and ongoing stream channel evolution. This system will likely be active within the foreseeable future. Upstream reaches in the watershed are fairly stable. Limited canopy cover can be addressed with riparian plantings of fast growing shade tree species. Significant channel improvements could benefit this watershed. However, the majority of the watershed is accessible only by foot making equipment access impractical. Planting newly established lateral bars with willow stakes and native shrubs to enhance and accelerate channel evolution is the most practical recommendation. Hand construction of small log structures to limit split channels can further improve channel evolution and enhance habitat. Due to the designation of the area as the Forrest H. Duttlinger Natural Area, any enhancement work may not be politically feasible or desirable.

Instability in Hammersley Fork Reach HF3 should be addressed to prevent further stream channel migration particularly in the vicinity of the historic CCC camp. Throughout the majority of this reach installation of small, log structures to limit channel splits and planting native shrubs on established lateral bars will enhance stability and improve habitat.

The lower one-half mile of Nelson Branch and Bell Branch Reach BB2 can also benefit from enhanced riparian vegetation including both native shrubs and shade trees.

However, if channel stability enhancements are not constructed on Hammersley Fork, then monitoring the natural evolution process over time and comparing the data with Cross Fork after habitat improvement improvements can provide information on natural evolution processes versus human enhancement efforts.

Trout Run

Trout Run is a properly functioning stream with relatively little channel migration and a balanced sediment transport system. The primary habitat and stream channel function concern in Trout Run is in the vicinity of eight gas pipeline crossings. The stability and impact of these crossings should be evaluated on an individual basis. Stabilizing the crossings should be the highest priority on Trout Run.

Preservation of the high quality riparian zone surrounding Trout Run should be a maintained as a priority.

There is one area of extreme streambank erosion that should be addressed. The stream is eroding into a shale bank underneath Trout Run Road approximately 0.85 miles below the bridge on Trout Run Road. The bank is 5 meters high, 28 meters long in loam soil with thin woody vegetation. This area should be further examined and a stabilization plan developed. This may require structural techniques such as a retaining wall.

FIGURE 30. Trout Run bank erosion near road.

Beaverdam Run

Beaverdam Run is also a properly functioning stream with relatively little channel migration and balanced sediment transport. An extreme bank erosion site is located 0.65 miles upstream of the bridge on Route 144. The site is 7 meters high, 20 meters long with loam soil and no vegetation. This area contributes a large amount of fine sediment to the system. The proper stabilization of the park road should reduce some of the fine sediments entering the system. Preservation of the large amounts of spawning gravel in the channel should be a priority by reducing the amount of fine sediments entering the system.

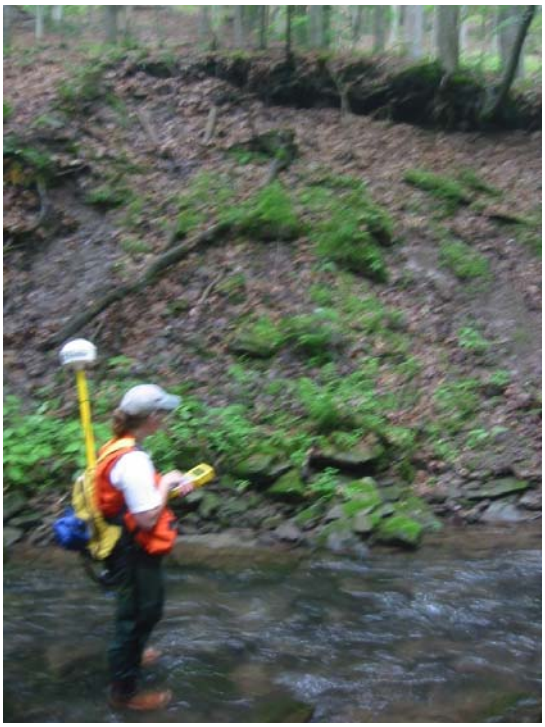

FIGURE 31. Bank erosion on Beaverdam Run.

Invasive plant species located in the lower 0.25 miles of Beaverdam Run pose a significant threat to the native riparian vegetation. Japanese Knotweed, Japanese Barberry, and Mulit-Flora Rose are fiercely competitive plant species with little riparian value for either canopy cover or bank protection. Eradication of these species and replacement with native riparian shrubs should be considered to prevent further impacts to the riparian vegetation.

Summary

The recommendations contained in this addendum should be considered with regard to the overall Upper Kettle Creek Watershed. When accounting for impacts on the mainstem of Kettle Creek, the most important recommendations from this addendum are those which will limit sediment input to Kettle Creek and protect cold water flowing from the tributaries.

Habitat and stream channel function improvements on Cross Fork address both of these important issues. By narrowing the bankfull channel, improving canopy cover, and limiting excessive bank erosion aquatic habitat in this reach will be enhanced. Additional water temperature benefits and reduced sediment loads will enhance stream function in downstream reaches.

Likewise, the small channel improvements on Bell Branch and Hammersley Fork Reach HF3 will protect habitat in the Hammersley Fork Watershed. Work in this area can likely be completed under general permits since it not a high-impact activity and it can be completed from the streambanks with primarily hand labor.

Improvements to riparian vegetation are relatively inexpensive and do not carry the financial burden and time constraints of detailed design and permitting associated with in-stream habitat improvement. Improved riparian canopy cover in sections identified as having low percent coverage and on lateral bars can help reduce water temperatures both in the tributaries and in portions of the mainstem of Kettle Creek.

The majority of the riparian zone in the Kettle Creek Watershed is not impacted by invasive species. Eradication of the invasive species on Beaverdam Run will reduce the available seed source and limit the spread of invasives in that area. Efforts should be made to educate watershed residents and users about invasive species and their impacts on the ecosystem. It is far easier to prevent the introduction of invasive plant species than to eradicate them once they are established.

In general, the riparian condition along the surveyed tributaries is excellent. Great care should be exercised to protect the riparian zones and limit future impacts to them. Care for these valuable resources will ensure improving stream channel function and improved habitat for the long term.

Updated Strategic Plan

This strategic plan for preservation and enhancement of habitat and stream stability in Upper Kettle Creek is a compilation of all the recommendations that were developed during the initial Upper Kettle Creek Watershed Assessment in the Summer of 2001 and the Tributary Addendum that was undertaken in the Summer of 2003.

HABITAT PROTECTION

High quality reaches of stream within the Kettle Creek Watershed should be protected from future impacts. Fortunately, many of the channel reaches with the highest habitat quality are located in either remote areas of the watershed or areas of the watershed that are physically difficult to reach and/or develop.

Along the mainstem of Kettle Creek, the majority of high quality habitat occurs where the channel is aligned immediately adjacent to a ridgeline. Many high quality pools in the Mainstem occur adjacent to the bedrock ridgelines. The majority of well-developed pool-riffle sequences occur in these locations. In the tributaries, most of the high quality pools occur at the location of log jams or areas of large woody debris. Any construction or change in land use on the steep ridges adjacent to one side of the channel is extremely unlikely. However, at many of these locations the opposite side of the channel lies in a broad floodplain and can be accessed and potentially developed. Any future growth in the watershed especially near the stream channel should be monitored closely to insure that cabins are not constructed too close to the streams and that the riparian areas are not cleared.

Reaches of stream channel with high quality pools, appropriate channel dimensions, good pool-riffle ratios, and moderate to good canopy cover are mapped for protection. Care should be taken to insure that the riparian area and channel are not disturbed in these areas.

Riparian zones throughout the watershed should be targeted for protection. Where good riparian buffers exist, their preservation and maintenance should be a priority. The shading from riparian zones directly impacts water temperature and stream channel stability can be significantly enhanced where dense riparian zones are present. Dense riparian forests can also help remove fine sediments from the stream during overbank flows.

Sediment inputs to the stream channel can reduce in-stream habitat and impact the geomorphology of the system. A number of sediment inputs were identified through the course of these studies. A large number of sediment inputs originate with roadways. Both roadway drainage and poorly maintained dirt roads contribute sediment to streams in the Kettle Creek Watershed. Drainage pipes which outlet on steep slopes adjacent

to roadways create large scour holes and destabilize the hillside causing further erosion. Hanging cross-pipes can be improved in a number of ways. Two popular methods are drop structures, which extend the drainage pipe to the base of the hill and outlet onto more stable material and stabilization of the outlet point using large rock or pavement. The other major source of sediment inputs is bank erosion along the channels.

Water quality should be a priority for protection throughout the middle and upper watershed. Protection of this valuable resource can be achieved by pursuing wise land use. Changes to the existing land use in the watershed can negatively impact water quality. Zoning requirements for any future development in the watershed through the local municipalities can prevent water quality degradation. The State of Pennsylvania has published an excellent guide to land use planning in their Growing Smarter Land Use Guidelines.

An often-overlooked component of water quality is precipitation. Acid precipitation, common in Pennsylvania, can severely impact water quality of streams. Acid from rainfall can reduce the acid neutralization capacity of soils over the entire watershed resulting in pulses of acid associated with rainfall or snowmelt events. Overall forest health can also suffer when vital nutrients are leached from the soil column thereby reducing the amount available for plant growth. If acid neutralizing capacity is lost from watershed soils, toxic metals can be flushed into the stream system impacting fish populations. Future water quality monitoring in the watershed should include pH and alkalinity measurements during rainfall and snowmelt high flow events.

HABITAT ENHANCEMENT

Through the planning process, four primary enhancement goals have been identified.

1. Water Temperature Reduction and Riparian Canopy Enhancement

2. Development of Natural Stream Channel Dimensions and Lowering Sediment Transport

3. Riparian Area Preservation

4. Habitat Improvement

These goals should be reached in an organized, science-based fashion. A series of projects to achieve these goals has been identified along with the associated timeline for implementation. In some cases, projects rely on the completion of other preceding projects. In other cases, the projects can be completed and will yield benefits independent of the other projects. While large-scale implementation of some aspects is

desirable, large tasks have been phased to provide a manageable solution that can be implemented over time. Projects have been identified throughout the watershed for broad reaching results and to attract a variety of participants.

LONG-TERM FRAMEWORK AND PRIORIZATION

The systematic approach to improvement in the Kettle Creek Watershed should address the four issues identified above concurrently.

Improvements to reduce sediment in the stream system should begin in the tributaries. Tributary reaches that are unnaturally wide should be a priority. These reaches of stream channel contribute sediment to downstream reaches and help to increase water temperatures far downstream. By improving conditions in the tributaries, the entire stream system downstream of the tributary benefits from the improvement. Sediment inputs are reduced downstream and the natural channel evolution of downstream reaches is accelerated. Lower water temperatures are transported downstream by improved canopy in the tributaries.

There are some indications that reaches of the mainstem of Kettle Creek, especially downstream of Cross Fork are beginning to reach Class VI of channel evolution. Gravel bars are depositing on the margins of the channel and in some reaches, a low flow channel is beginning to develop. Reduced upstream sediment inputs coupled with aggressive revegetation of young bars on the channel margins will improve the stream's ability to recover without invasive channel construction procedures in the lower reaches.

Large reaches of the tributaries should be designed, permitted, and constructed at the same time. This provides an economy of scale for both the design phase and construction phase. Long design reaches allow for a cohesive design that considers valley slope and the relationship of multiple channel sections. This will provide a much better result than numerous small projects. Within design reaches it is likely that some sections of channel can be relatively unchanged. This is especially likely for reaches of stream that parallel ridgelines or bedrock outcrops and are currently functioning effectively.

Cross Fork should be the top priority among the tributaries. The first survey focused on approximately the lower 1½ miles of the stream and determined that the channel is overwide. The second survey focused on the remainder of the watershed and found only limited overwide sections. Modifications to these sections of the channel could result in significant improvements in Cross Fork in the near future. Reduced water temperatures and sediment loads from Cross Fork will benefit the fisheries on the mainstem of Kettle Creek downstream of Cross Fork.

Revegetation of bars in the immediate future will provide vegetation that is large enough to stabilize bars and encourage meander development in the lower watershed at the same timeframe that upstream sediment supplies are reduced by projects in the tributaries.

Riparian buffer improvement should initially focus on tributaries and reaches of the mainstem where cool waters are found. Tributary riparian buffers should be re-established from the upstream extent of poor canopy cover to the mouths as quickly as possible. Cross Fork, Hammersley Fork, Little Kettle Creek, and upper Kettle Creek are the most important tributaries for canopy cover improvement. On the mainstem, the area of Ole Bull State Park and the confluence of Little Kettle and Kettle Creeks are high priorities for canopy improvement. Cooler water entering the mainstem at Ole Bull should be protected as far downstream as possible. Below the park, canopy cover improves the delayed harvest fly-fishing area. By improving canopy cover at Ole Bull three to four miles of stream could benefit from lower water temperatures.

Once riparian buffers are re-established along the tributaries, in the vicinity of Ole Bull, and at the confluence of Little Kettle and Upper Kettle, poorly vegetated reaches of the mainstem from two miles upstream of Cross Fork to the downstream extent of the survey become a priority. Reaches from one mile downstream of Trout Run to the pool of Alvin C. Bush Dam may benefit from riparian buffer improvement as well.

If channel improvements in the headwaters reduce sediment inputs to middle Kettle Creek and the channel does not continue to recover, some minor channel adjustments may be necessary in the lower reaches.

By following this order and systematically approaching improvements in the watershed, results will be more far reaching than scattered projects throughout the watershed could produce. This system-based approach allows downstream reaches of stream to recover as a result of changes upstream. While realizing the final results of this work will take decades, immediate improvements should be noticed as each phase is completed. Water temperature and sediment will decrease and as projects are completed, each project should result in greater decreases in overall water temperature and sediment supply. The benefits of each project should grow exponentially as work progresses, riparian trees grow, and the channel recovers.

IMMEDIATE PROJECT RECOMMENDATIONS

The following projects are not listed by priority; instead project numbers are assigned for organizational purposes only.

Project 1: Stabilize Areas of Extreme and Severe Bank Erosion on the Tributaries.

Priority: High

Justification: High sediment loading from the tributaries causes excessive bed sediment in Kettle Creek. Streambank erosion is a major source of the sediment load. By stabilizing the banks in the tributaries, the amount of sediment transported downstream will be reduced and a more stabilized channel should develop. Reductions in fine sediment will also improve fish spawning habitat.

Methods: Before any stabilization methods can be considered, the types of scour must be identified. There are three types of scour: toe scour, where the bottom of a slope is being eroded by lower flows, causing the whole slope to cave; middle and top scour, where the middle of the slope is being scoured by higher flows. After the type of scour is identified, the appropriate type of bank stabilization method can be utilized to prevent further erosion in the area. Bank stabilization methods would range from grading to a flatter slope and planting vegetation, to brush layering. Access to the site will play a major role in the feasibility of a bank stabilization project location.

Phase 1: Scour type identification

Estimated Costs: $ 8,000-12,000 (2005 dollars) (includes all 16 areas identified in the watershed specific recommendations) (4 days in the field, 2 people, 2 days to write report and do calculations)

Phase 2: Design and Permitting

Estimated Costs: $ 23,000-25,000 (2005 dollars, if permitting is needed, $6600 per permit)((2000 linear feet)2000 dollars to survey, 20 hrs per area for design)

Phase 3: Construction

Estimated Costs: $ 2 - 40 per linear foot of bank being stabilized. Cost depends on method being undertaken.

Project 2: Pipeline Crossing Investigation and Stabilization

Priority: High

Justification: There are numerous pipelines within the Kettle Creek Watershed. Most of these transport natural gas although other uses include petroleum and fiber optic cables. Pipelines cross the creeks in numerous locations and some are exposed at the surface due to upstream migration of headcuts. In many locations they are acting as grade control. If the pipes were to burst, particularly the petroleum pipelines, it would have a severe effect on the ecosystem of all downstream waters.

Methods: Areas of pipeline exposure that were identified in this study should be stabilized. Also, an investigation of other pipeline crossings should be undertaken, to determine their contents and susceptibility to exposure. Once all of the exposed pipelines have been identified, measures to stabilize the crossing location should be undertaken. Methods of stabilization include installing grade control downstream of the crossing to prevent further headcuts from migrating upstream and armoring the streambanks to prevent erosion.

Phase 1: Pipeline Crossing Investigation and Recommendation Report

Estimated Costs: $ 5,000 to 7,000 (2005 dollars) based upon only 5 crossings being investigated. Cost will increase gradually if more crossings are found. (2 days in the field, 2 people, 3 days to write report and do calculations)

Phase 2: Design and Permitting

Estimated Costs: $ 4,000 - 7,000 per location (2005 dollars, if permitting is needed, $6600 per permit)

Phase 3: Construction

Estimated Costs: $ 10,000-20,000 per location. Cost depends on method being undertaken.

Funding might be provided from the companies who own/operate the pipelines.

Project 3: Riparian Buffer Enhancement and Lateral Bar Re-Vegetation

Priority: High

Justification: Numerous areas in the Kettle Creek Watershed have been identified as having thin riparian zones or poor canopy cover. All areas with less than 50% canopy cover should be enhanced. Water temperature will remain elevated without improved riparian canopy cover. Elevated water temperatures affect the health of trout and other cold water species of fish. Due to the period of time required for newly planted buffers to reach maturity, this project should be implemented as soon as possible. Strategically designed plantings on lateral bars forming on the mainstem of Kettle Creek and on the tributaries provides the opportunity to enhance channel shading while increasing roughness on the bars and encouraging the stream to deposit more material on the lateral margins of the channel. While upstream work strives to reduce the sediment inputs to the mainstem, this effort will allow downstream reaches to continue to naturally develop a narrower, more functional channel within the floodplain boundaries, which will more effectively transport the sediment load. This is a long-term solution, which works jointly with other enhancement efforts in the watershed.

Methods: Plant native vegetation such as willows, sycamore, white pine, river birch, and alder to improve the riparian canopy and root mass. Water loving shrubs like willow and alder will enhance stream function and provide some shade when planted on the margins of the active channel. Larger shade species, especially the native, fast-growing sycamore will provide a great deal of canopy cover over time. These species will also regenerate vigorously providing a self-sustaining system.

Phase 1: *Identify Reaches for Immediate Riparian Buffer Planting.*

Recommended implementation rate - 18 acres per year (approximately five miles of 30 foot wide planting)

Estimated Costs: dependant on vegetation sources and labor

Design: Minimal

Plant Materials, Tools, Supplies, etc: $11,000 (2005 dollars) with volunteer labor

Phase 2: *Plant Lateral Bars in Conjunction with Continued Riparian Buffer Enhancement from Trout Run to Cross Fork.*

Estimated Costs:

Design: $8,000 - 10,000 (2005 dollars) - includes identifying and marking bars to be planted, specifying plant materials, and designing planting scheme for bars to account for future bar development.

Plant Materials, Tools, Supplies, etc: $13,000 (2005 dollars) with volunteer labor

Project 4: Dirt and Gravel Road/ Drainage Improvement

Priority: High

Justification: Significant portions of the roads in the Kettle Creek Watershed are dirt and gravel roads. These roads and the drainage systems from all the roads in the basin contribute sediment to Kettle Creek which impairs fish habitat.

Methods: Detailed information about the location and severity of erosion associated with roadways in the watershed should be collected. This information can be leveraged to obtain funding from the state's Dirt and Gravel Roads program under which individual municipalities and agencies can make necessary improvements to reduce sediment inputs from the roadways.

Estimated Cost: Dependent on agency participation.

Project 5: Public Outreach and Education

Priority: High

Justification: Public involvement on Kettle Creek is very high. Many benefits can be realized by educating landowners and visitors about stream function and how their actions can impact the stream channel and its habitat.

Methods: Implement a public education program to enhance landowner awareness of streamside maintenance and alternative maintenance programs that can provide both good stream access and enjoyment while benefiting the stream channel. An example of good streamside stewardship is ceasing to mow the entire stream edge to provide access and mowing only a single path to the waters edge. Planting specific tree species that will establish branches high enough not to obstruct stream views from a nearby camp or residence can enhance this management plan.

Rock dams are commonplace along Kettle Creek and its tributaries. A public education program to promote construction of structures that enhance stream function while providing recreational opportunities will allow streamside landowners and visitors to continue to build the structures without potentially damaging side effects.

There are numerous cabins in the riparian zone throughout the watershed. A program should be developed to inform people about the proper disposal of gray water and the location and construction of outhouse or other septic systems.

Estimated Cost: Minimal

Project 6: Ole Bull Channel and Canopy Enhancement

Priority: High

Justification: This area of Kettle Creek provides public access to large numbers of visitors every year. The dam at Ole Bull provides local geomorphic control so improvement projects can be completed here independent of other upstream reaches of the stream. This reach of stream is relatively isolated from outside geomorphic activity in the stream channel. Kettle Creek through Ole Bull has poor canopy cover and stream form. The channel is over-wide and pool-riffle sequences are not well developed. Additionally, local groundwater inputs cool the water in this reach of stream. Protection of this cooler water should be a priority and can benefit downstream reaches including the delayed harvest fly fishing area. Fishing opportunities in the youth-only fishing area in the park and the natural beauty of the park would be enhanced by channel and riparian zone enhancements. Cooler water refuges for fish stressed by adjacent warm water would be provided in the re-established pools.

Methods: Both natural channel design and re-establishment of a functioning riparian zone in this location will benefit the stream system. Design and construction of more natural channel dimensions and pool-sequence can be completed within the park infrastructure. The reach from the dam to the downstream park limit should be treated as a whole. Some structure control may be necessary through this reach.

Phase 1: Design and Permitting

Estimated Costs: $50,000 (2005 dollars)

Phase 2: Construction and Planting

Estimated Costs: $106,000 (2005 dollars)

Project 7: Instream Habitat Structures

Priority: High

Justification: Cross Fork, Little Kettle and Little Lyman Run have a deficiency of high quality pools and/or numerous multiple thread channels. Cross Fork is especially lacking any habitat between Hungry Hollow bridge and Windfall Run. Beaverdam Run could benefit by placement of more large woody debris. By increasing the amount of pools and consolidating the multiple thread channels, the water temperature will be lowered and the amount of good quality fish habitat will increase.

Methods: Habitat can be enhanced by properly locating and constructing log habitat structures to create pools or engineering woody debris jams in locations that would consolidate a number of smaller channels into a single channel. Less intrusive construction techniques and smaller construction equipment can be used for this type of work.

Phase 1: Design and Permitting

Estimated Costs: $ 4,000 - 7,000 per location (2005 dollars, if permitting is needed, $6600 per permit. If multiple locations are pursued at the same time, cost will gradually increase.)

Phase 2: Construction

Estimated Costs: $ 1,000-6,000 per structure. Cost depends on type of structure being constructed and whether heavy machinery is needed.

Project 8: Additional Water Quality Monitoring

Priority: Moderate

Justification: Acid precipitation falls in the Kettle Creek Watershed during every storm. Understanding the impact of acid rain on the watershed and water quality is important to the future of the watershed. Indicators of problems now can be met with action before water chemistry degrades significantly, thereby affecting the aquatic life in the streams.

Methods: Implement a rain and storm flow monitoring program to measure at a minimum pH, alkalinity, and turbidity. Additional water quality parameters should be added if high flows become acidic. This monitoring program can be implemented using volunteers if available or can be completed using automated samplers to collect water at intervals through a storm event. Data should be analyzed based on pH of precipitation; stream pH and alkalinity, and volume of discharge in the stream. If low pH's are detected during storm flow events, acid-neutralizing capacity of the watershed soils should be investigated.

Estimated Cost: Dependent on methods

Project 9: Bridge Maintenance and Reconstruction

Priority: Moderate

Justification: Continual maintenance of existing bridges and replacement of existing structures can result in significant impacts to the stream channel. Existing maintenance protocols encourage widened channels and removal of riparian cover near bridges. Proper stream channel management through bridge openings can reduce maintenance costs and promote stream stability.

Methods: Establish a relationship with PENNDOT, Townships, and DCNR parties responsible for bridge maintenance, design, and construction in the watershed. Significant opportunities exist for demonstration projects to illustrate the usefulness of channel management at these structures. The Road Hollow Bridge and Cross Fork Bridge on the mainstem both represent opportunities to implement a demonstration project and further relationships to improve stream management at bridges

Estimated Cost: Dependent on agency participation.