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Geology, Surface Hydrology, and Fish Habitat Relationships in the
upper Shavers Fork Drainage Basin, West Virginia

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Thesis submitted to the
Eberly College of Arts and Sciences
at West Virginia University
in partial fulfillment of the requirements
for the degree of

Master of Science
In
Geology

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Shavers Fork is the mainstem stream of a unique upper elevation watershed located in the Appalachian Plateaus province of West Virginia. The continuous trellis drainage generally exhibits a C3 Rosgen-type stream classification. Surficial "facies" mapping of in-stream and floodplain-adjacent landforms helped to classify small-scale flow patterns into heterogeneous and homogeneous channel units. Channel-unit bankfull width, channel-unit length, channel-unit area, and channel-unit depth all increase in the downstream direction. Riffles constitute 32 percent of the total channel unit area, riffle-run complexes and glides make up 26 percent each, bluff-pool complexes constitute 7 percent, riffle-glide complexes 6 percent, and true pools make up only 2 percent. Upper reaches contain the most in-stream and riparian heterogeneity and the highest relative abundance of large woody debris (LWD).

In-stream heterogeneity dominates pools and channel-unit complexes, which comprise 69 percent of the total stream area. In-stream homogeneity dominates riffles and glides which constitute 31 percent of the total stream area. Homogeneous channel units below Second Fork and stream reaches that come in contact with the railroad bed are potential target areas for remediation. Restoration of a streamside canopy, particularly near the railroad bed, would mitigate large in-stream temperature fluctuations and rehabilitate the lotic system.

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Introduction

The Mountaineer Chapter of Trout Unlimited, in conjunction with the West Virginia Division of Natural Resources, the United States Forest Service, the United States Geological Survey, and West Virginia University, is developing an intensive, long-term management and remediation plan that addresses physical, chemical, and biological watershed characteristics important to the upper Shavers Fork native brook trout (*Salvelinus fontinalis*) fishery (Figure 1). The Mountaineer Chapter of Trout Unlimited adopted the 29.2 km (18.2 mi) headwater section of the Shavers Fork and its tributaries in May 1998 (Figure 2 and 3). University researchers comprise an interdisciplinary Shavers Fork cooperative unit (Table 1) that helps to understand the physical and biological, and chemical components of the trout fishery.

Cooperative Unit Member	Emphasis	Program
Patrcia Mazik	Cooperative Director	USGS
J. Todd Petty	Fisheries Biologist	West Virginia University
J. Steven Kite	Fluvial Geomorphology	West Virginia University
Robert E. Behling	Geology	West Virginia University
Ryan Gaujot	Fluvial Geomorphology	West Virginia University
Peter Lamothe	Population Dynamics	West Virginia University
Jesse Bopp	Macro Invertebrates	West Virginia University
Jeff Hansbarger	Fish Habitat Use	West Virginia University

Table 1. The members of the Shavers Fork cooperative unit, indicating research emphasis and program.

Figure 3. A DRG image of the mapped extent of Shavers Fork. This figure indicates the segment boundaries located at major tributary additions. This map was compiled by Ryan Gaujot.

Measured and interpolated data that indicate morphological and ecological connections within the watershed will help land managers and stakeholders make decisions that optimize economic and environmental benefits for the region. The overall goal is to provide an assessment for a sustainable Shavers Fork fishery that fosters recreational opportunities and encourages an understanding of the environmental and economic values of healthy watersheds.

Shavers Fork is a major tributary to the larger Cheat Watershed and is unique in its history, function, and form (Figure 2). The Shavers Fork landscape is dynamic, and its biological community is largely controlled by the quality and quantity of in-stream and riparian features. Research on the stream's fluvial and ecological development and historic and present-day land-use can help to describe the current state of the Shavers Fork fishery, identify what it may need to more fully reach its potential, and provide the basis for future remediation designs. The roles of this report were threefold: map and describe the physical landforms and flow types that are likely to influence fish population and community structure, indicate channel and floodplain morphologic disequilibria, and make remediation suggestions for the upper Shavers Fork watershed. The study was primarily focused on morphologic and hydraulic components of the channel. The study area was hierarchically organized into units of heterogeneous and homogeneous morphologic and hydrologic properties. The results and discussion from this research are intended to support future restoration efforts that will involve passive remediation that works with the

stream to reestablish in-stream and riparian habitat heterogeneity and the quality habitat essential for a sustainable brook-trout fishery.

Previous Work

Hack's (1960, 1965, and 1975) dynamic equilibrium concept, developed in the central Appalachians, supplies a foundation for modern fluvial geomorphology research. Hack focused principally on the role of bedrock structure and lithology in determining landform morphology and relief. According to Hack's concept, fluvial landscapes develop by maintaining a steady-state equilibrium between driving and resisting forces (flowing water, mass wasting, and weathering) and resisting forces (strength of the bedrock and regolith). Bedrock and regolith resistance controls the position of landforms that offer suitable fish habitat, thus linking Hack's work to the research topic.

Wolman and Miller (1960) discussed the magnitude and frequency of geomorphic processes by analyzing the threshold stresses required to move available material with variations in discharge. Major flooding has occurred in areas below Cheat Bridge (Figure 2) in 1963, 1967, 1985, and 1996 (Wiley and others, 2000.) The effectiveness of processes that control landforms depends upon their frequency as well as their magnitude (Wolman and Miller, 1960). Floods of moderate magnitude that recur frequently are geomorphically more effective than rare events of unusual magnitude. Therefore, morphologic development of the floodplain and the river channel is most effective at

discharges approximating bankfull stage (Rosgen, 1996). Bankfull stage commonly occurs during snowmelt and heavy, persistent rainfall in the Shavers Fork basin.

The river continuum concept (RCC) proposed by Vannote and others (1980) further justifies geomorphic research on the Shavers Fork fishery. The concept asserts that the biological community in a stream is largely regulated by geomorphologic factors. RCC portrays the entire fluvial system as a continuously integrating series of physical gradients and associated biological adjustments. RCC explains how species abundance and distribution, nutrient and energy sources, and functional groups of organisms are closely tied to specific zones of a drainage system and continuously change in response to variations in underlying geology and valley form. The concept has been widely criticized with reference to the initial testing on natural, undisturbed stream systems. Cushing (1994) states, "It should be remembered that the river continuum concept was initially proposed as an idea to test, not a definitive list of predictions to which all streams would conform." Minshall (1996) later expanded the concept to include aspects of climate, geology, tributary influences, local lithology, geomorphology, and long-term human impacts. Tributary additions also have a significant effect on modifying the continuum pattern, through changes in water quality and inputs of coarse organic material or sediment (Minshall, 1996).

Several studies have focused on channel classification and the importance of fluvial hydraulics to ecological units (Keller and Melhorn, 1978; MacDonald,

1991; Rabini and Jacobson, 1993; Montgomery and Buffington, 1993; Maxwell and others, 1995; Schlosser, 1995; Hayes and others, 1996). Rosgen (1994) developed a classification system for natural rivers that is widely used as an initial assessment for stream remediation efforts. Gradient, entrenchment ratio, width-depth ratio, sinuosity, channel materials, slope, and adjacent floodplain characteristics determine the general stream type in Rosgen's scheme. Most importantly, accurate bankfull discharge estimates and thalweg characteristics are crucial for obtaining the correct Rosgen-type classification and enhancing the outcome of the future remediation design. A Rosgen classification indicates morphological development characteristics that can ultimately yield a more 'natural' channel design and facilitate fish habitat remediation.

Purpose and Objectives

The purpose of this thesis is to assess the quality of brook trout habitat by mapping and classifying landscape features and flow characteristics that influence the upper Shavers Fork fishery and its remediation potential. This goal requires a contiguous fluvial geomorphological assessment of channel and floodplain components along a 24.6 km section of Shavers Fork, from Spruce to Lambert Run (Figure 3).

The objectives were as follows:

1. Develop a GIS-based cartographic framework for cooperative research efforts in Shavers Fork.

2. Describe the general geology of the field area.
3. Develop a general stream-flow classification for small-scale channel units.
4. Classify stream-morphology components with reference to a four-fold surficial geology mapping method developed by Kite (1996).
5. Identify areas of morphologic disequilibria in the watershed.
 - a) Characterize in-stream and riparian habitat relations to channel-unit characteristics.
 - b) Identify and map habitat features that influence channel unit homogeneity and heterogeneity.
 - c) Identify and map the location of large woody debris (LWD) and assess to the total volume and influence on channel-unit heterogeneity and bank stability.
6. Suggest remediation measures for the channel, lotic system, and watershed.

Methods

To accomplish the objectives set forth in the previous section, extensive field and remotely sensed data were collected on from December 1999 to June 2001 (Table 2). The nine study segments (4 through 12), bounded at major tributary confluences, contained 393 channel units from Spruce to Lambert Run (Figure 3). The following methodology allowed for the capture of high-resolution digital data that was displayed within a geographic information system.

Scale Selection

Recompilation of hard copy and digital 1:24,000 scale Cass and Snyder Knob topographic maps, digital raster graphics (DRG), and digital orthophoto quarter quadrangle (DOQQ) maps provided the initial imagery of the study area. The high resolution of the digital imagery provided an invaluable tool to the field area's geography and geology.

Selection of the appropriate field map scale was the initial mapping problem facing the research. "There is no single correct scale for the study, assessment, or management of aquatic ecosystems" (Minshall, 1996). Rather, the appropriate scale depends on the scientific question being addressed. The correct map scale for the Shavers Fork research needed to incorporate a framework that resolved geomorphologic features that influence fish. Large-scale of 1:5000 was found to be appropriate for resolving important habitat features.

Date	Mean Stage (ft) at Cheat Bridge	Field Activity
Traverse 1		
12/31/99	4.93	Reconnaissance
01/01/00	4.87	Reconnaissance
01/02/00	4.90	Reconnaissance
05/11/00	4.73	Habitat Transects
05/12/00	4.68	Habitat Transects
05/16/00	4.59	Entomology (mainstem)
05/17/00	4.55	Entomology (Second Fork)
05/22/00	5.71	Entomology (upper Second Fork)
05/23/00	5.36	Entomology (upper Second Fork)
05/24/00	5.31	Entomology (upper Second Fork)
05/30/00	5.56	Temp Loggers/Electroshock
05/31/00	5.25	Temp Loggers/Electroshock (Odey Run)
06/06/00	5.19	Electroshock (Spruce)
06/07/00	5.37	Angling for Telemetry Study
Traverse 2		
06/08/00	4.98	Channel Units (Below Rocky Run)
06/09/00	4.79	Channel Units (up to Beaver Creek)
06/10/00	4.69	Channel Units (downstream to First Fork)
06/11/00	4.61	Channel Units (from 6/8 to Spruce with Jason J.)
06/12/00	4.55	Electrofishing (Padro)
06/13/00	4.52	Channel Units (above Beaver Creek past Second Fork to finish upper section)
06/14/00	4.47	Channel Units (Field Day with Dr. Kite)
06/15/00	4.48	Channel Units (upstream past First Fork)
Traverse 3		
07/20/00	5.26	Geologic Mapping (Spruce)
07/26/00	4.71	Geologic Mapping (Spruce)
07/27/00	4.66	Geologic Mapping (Twin Tressels downstream/Ball Hooter Lift/hiked past reservoir)
08/01/00	5.29	Geologic Mapping (Lower Twin Tressels downstream)
08/02/00	5.21	Geologic Mapping (downstream from Beaver Creek)
09/01/00	4.97	Geologic Mapping (to below Beaver Creek)
09/02/00	5.26	Geologic Mapping (start above First Fork)
Traverse 4		
11/11/00	5.30	Survey
06/23/01		BVET Calibration Ratio
33 days	4.96	Average river stage of all field days

Table 2. A listing of field data collection dates, activities, and the corresponding daily stage from the USGS gauging station # 3067510: Shavers Fork at Cheat Bridge.

Below is an inventory of the important habitat features located, identified, inventoried, and mapped on 1:5000 DRG and DOQQ base maps:

- Stream Boundary
- Floodplain Boundary
- Alluvial Deposits
- Scour
- Bedrock Outcrops
- Boulders > 1.5m
- Large Woody Debris
- Intermittent Streams
- Channel Units

The perennial portion of Shavers Fork, upstream from Cheat Bridge, initially was divided into 13 segments, providing a large-scale framework for cooperative watershed efforts. Nine of the 13 segments (segment boundaries 4-12 on Figure 3) are located within the field area between Spruce and Lambert Run. Segments not included in the study area are 1-3, upstream of the field area boundary on Snowshoe property, and 13, downstream of the field area boundary on the Cheat Mountain Club property. The studied segments are separated by major tributary confluences with the Shavers Fork mainstem. Five of these tributaries enter Shavers Fork from the west; two tributaries enter from the east (Figure 3).

Bedrock stratigraphic sequences were not meticulously correlated, although lithologic identification of bedrock outcrops and surface landform characterization were given primary attention. The plan view orientation of the

base maps revealed bedrock and surficial features otherwise difficult to detect while mapping in the field (Compton, 1985). Several landforms associated with timbering and mining, such as railroad grades, haul roads, and ponds, were also resolved at this scale.

Geographic Information System (GIS)

A geographic information system (GIS) provided a set of tools to store, retrieve, transform, manipulate, and display digital spatial data (Minshall, 1996). All data for this project were imported into Arc View 3.2, Arc Info 8.0, Land Desktop 2002, and Imagine Virtual GIS software programs for analysis. DRG and DOQQ images were downloaded from the West Virginia University GIS Technical Center website (www.geo.wvu.edu). DRG and DOQQ images portray 1990 and 1996 conditions respectively. These base maps efficiently capture information on topography, channel geometry, sinuosity, and distribution of in-stream fluvial landforms and, therefore, became the graphical foundation for the project. These maps also accurately illustrate vegetation characteristics in the riparian zone and marshlands.

Field Data Acquisition

Flow stages for Shavers Fork at Cheat Bridge were taken from 'on-line' data from the United States Geological Survey (USGS) gauge station 3067510; located in Randolph County, West Virginia ($38^{\circ}37'01''$ latitude; $79^{\circ}52'12''$

longitude). The average stage at Cheat Bridge during field data collection was 1.51 m (4.96 ft).

Three field traverses occurred between December 1999 and November 2000 and involved walking the entire 24.6 km study area (Table 2). A reconnaissance exploration of the study area occurred during traverse 1. Traverse 2 involved mapping channel-units and measuring associated morphological characteristics. Traverse 3 involved mapping geomorphologic habitat features, including the surficial and bedrock geology, large woody debris (LWD), substrate and floodplain. A fourth field traverse in summer 2001 involved a check of mapping accuracy and changes in channel characteristics and large woody debris (LWD) occurrence.

Basinwide Visual Estimation Technique

Basinwide visual estimation technique (BVET) is the data collection method of visually estimating channel dimensions and characteristics. BVET techniques effectively quantify large numbers of specific habitat types important to fish. Hankin and Reeves (1988) used BVET to quantify unit areas within reaches of a stream for fish population studies. Considering the size of the Shavers Fork field area, BVET enabled the rapid collection of channel-unit and habitat data. Visually estimating bankfull width and channel-unit length yielded channel unit dimensions for the entire 24.6 km field area. BVET data was adjusted for error using a calibration ratio derived from measured data. Dolloff

and others (1997) found that BVET techniques accurately reflect conditions specific to an individual stream and correctly identify uncommon habitat features that may be important to fish.

Global Positioning System (GPS)

A handheld Garmin 12XL 12-channel global positioning system (GPS) unit was used during each traverse to record Universal Transverse Mercator waypoint coordinates, based on North American Datum 1983 zone 17, and map each habitat feature's shape and location. The accuracy of the hand held-unit was approximately 10 m (~30 ft) under optimal conditions. All waypoint data corresponding to in-stream features, channel geometry, channel units, and waypoints, were imported into Arc View 3.2 and Land Desktop 2000 for digital display. Waypoints helped correctly position digitized habitat polygons over base-map attributes.

A Four-Fold Surficial Geology Mapping Method

A four-fold mapping method, developed by Kite (1996), transformed the mapped geomorphic units into discrete spatial information. The mapped geomorphologic features were categorized according to their age, origin, landform, and material type (Table 3). The final GIS cartography precisely depicted geomorphic relations between mapped in-stream features and channel unit characteristics.

EDM Survey

One representative 100 m reach of stream at the lower end of segment 9 (Figure 3), above Black Run, was surveyed using the Topcon TC400 electronic distance meter (EDM). Seventy-two survey points delineated the stream boundary, alluvium in the channel, and “below bankfull elevation” profiles of a riffle, a run, a pool, and a glide.

Map Unit Label	Map Unit Description	Age	Origin	Landform	Material	Four-Fold Identifier	Comments
Pb	Point Bar	Quaternary	Alluvium	Point Bar	cobbles	Q,a,pb,c	Pb's are commonly located at the inside of meander bends.
Mcb	Mid Channel Bar	Quaternary	Alluvium	Mid Channel Bar	cobbles, boulders	Q,a,mc,b,c-b	Mcb's occur downstream of large instream features or in wide sections of the stream.
Scour	Scour	Quaternary	Alluvium	Scour	silt, sand, gravel, cobbles	Q,a,s,si-s-g-c	Scours locates areas of channel-bank instability.
Fp	Floodplain	Quaternary	Alluvium	Floodplain	sandy gravel	Q,a,flp,s-g	Fp is the flood-prone area above bankfull discharge.
Tribdel	Tributary Delta	Quaternary	Alluvium	Tributary Delta	cobbles	Q,a,td,c	Tribdel's are located downstream of tributary confluences.
IFpC	Intermittent Floodplain Channel	Quaternary	Alluvium	Intermittent Floodplain Channel	cobbles, gravel	Q,a,ifc,c-g	IFpC's are usually located near the inside of meander bends/opposite of constricting railroad structures. IFpC's contained water in channel during field data collection.
Pnr	New River Formation/sandstone outcrop	Pennsylvanian	na	Bedrock Outcrop	sandstone	P,bdrk,ss	Stream-side bedrock outcrop of the New River Formation in the Pottsville Group.
Mh	Hinton Formation/sandstone and/or shale outcrop	Mississippian	na	Bedrock Outcrop	sandstone and/or red and green shale	M,bdrk,sh	Stream-side bedrock outcrop of the Hinton Formation in the Mauch Chunk Group.

Table 3. An application of the 4-fold surficial geology mapping method (Kite, 1996) categorizing the inventoried morphologic features of Shavers Fork, West Virginia.

Physiography, Climate, and Soils of Shavers Fork

The upper Shavers Fork near the lower end of the study area is a fifth-order tributary to the Cheat River (Figure 2). The field area is located in the eastern portion of the Appalachian Plateaus physiographic province (Flegel, 1992). U.S. Route 219, approximately 9.7 km north of Durbin, West Virginia, provides access to the downstream end of the Shavers Fork field area. Bedrock underlying the ridges surrounding the stream valley are slightly dipping, resulting in a north-northeast flowing, low-gradient trellis drainage pattern for the mainstem of Shavers Fork. Conversely, high-gradient tributaries exhibit a dendritic drainage pattern due to the nearly horizontal Pennsylvanian resistant cap-rock at high elevations and the easily eroded Mississippian rock situated stratigraphically lower.

Winters are cold and snowy, but intermittent thaws occur. The average winter temperature is -5.0°C (23°F), and the average summer temperature is 16.7°C (62°F) (Flegel, 1992). Total annual precipitation at Snowshoe is 132 cm (52 in) and the average snowfall is 3.96 m (156 in) (Flegel, 1992). Prevailing winds are from the northwest, and rainfall is generally heavier on west-facing slopes (Flegel, 1992).

The Delkalb-Buchanan soil association dominates mountainous uplands, foot slopes, and mainstem channel. Upland and footslope soils are sloping, well drained, acidic, and derived from the weathering of upslope colluvial material that predominantly consists of sandstone, with limited amounts of shale,

siltstone, and limestone (Flegel, 1992). Shavers Fork is bounded by a deep, poorly drained, strongly acidic, silt loam floodplain primarily derived from alluvial processes (Pyle and others, 1983).

Land Use History and Impacts to Shavers Fork

Extractive timber and coal operations were the major land uses in this area from the 1880's to the 1920's (Price and Reger, 1929; Clarkson, 1964; Deike, 2000). The timber industry preceded the coal industry (Clarkson, 1964). The watershed contained deciduous, coniferous, and mixed coniferous and deciduous forest. The area was noted for its fine stands of red spruce (*Picea rubens*). Early loggers cleared riparian vegetation and removed large in-stream boulders to facilitate floating logs to downstream mills (Clarkson, 1964; Deike, 2000). Later, railroad construction further impacted Shavers Fork by reducing the floodplain area and riparian habitat.

The upper 607 hectare (1500 acres) Mower Lumber tract was sold to Snowshoe Ski Resort in 1973 (Figure 4) and the remaining Mower Lumber Company tract was sold to the United States Forest Service in 1988. The last coal train ran in the upper Shavers Fork in 1993 (Deike, 2000). The only remaining virgin spruce untouched by timber operations within the field area is located at Gaudineer Knob.

Figure 4. A DOQQ map (1997 imagery) of Snowshoe and Silver Creek ski resorts. The upper extent of the field area is located near Spruce. The land colors are the result of digital infrared photography during 'leaf-off.' This map was compiled by Ryan Gaujot.

Considering the area's extractive land-use history, the watershed is relatively intact, although the fishery has been significantly degraded (Petty, 1999). Large temperature fluctuations and scoured fish habitat occur coupled with the loss of in-stream and riparian heterogeneity (Petty, 1999). Today, recreation is the major land use of the upper Shavers Fork, where outdoor enthusiasts enjoy skiing, fishing, hunting, boating, biking, scenic train-rides, pleasure walks, and various aesthetic details of the area.

Stratigraphy of Shavers Fork

The North Potomac syncline dominates the structural geology underlying Shavers Fork (Figure 5). Mississippian and Pennsylvanian age sedimentary strata constitute the bedrock from Snowshoe to the end of the field area at Lambert Run (Table 4).

The bedrock stratigraphy of the entire basin from the headwaters to the downstream limit of study near Lambert Run is internally similar. Within the study area, the channel of Shavers Fork is confined to the shale-rich Hinton Formation. Red, green, and medium-gray shales and sandstone comprise most of the Hinton members, with a few thin limestone beds. The up-slope sandstone units of the Kanawha and New River formations are within the Pottsville Group. Sandstones in the study area are very well indurated and resistant to erosion. The higher stratigraphic units influence stream ecology by providing boulders delivered to the stream by slope processes. The absence of

calcareous strata in the watershed renders the mainstem naturally acidic, with little or no buffering capacity (Sherlock, 1997). The small percentage of limestones and concrete found in the streambed are anthropogenically introduced.

	<u>Group</u>	<u>Formation</u>	<u>Dominant Rock Type</u>	<u>Associated Surficial Geology</u>
	Pottsville	Kanawha	Sandstone (~50%), shale, siltstone, coal	Less resistant than New River, Kanawha bedrock caps high mountains in western and northern limits of study area, coal mines
<i>Pennsylvanian</i>	Pottsville	New River	Sandstone (~70%), conglomerate, shale, siltstone, coal	Flat-topped summits bordered by steep slopes with large boulders that may be transported to channel of Shavers Fork and it's tributaries.
<i>Mississippian</i>	Mauch Chunk	Bluestone	Shale, siltstone, sandstone	Generally steep slopes, locally mantled by coarse bouldery debris from overlying Pottsville Sandstone. (Possible source of debris flows)
	Mauch Chunk	Princeton	Sandstone	Relatively thin sandstone unit, producing large boulders, and waterfalls in tributaries
	Mauch Chunk	Hinton	Shale, siltstone, sandstone	Underlies valley floor throughout mos of the study area. Shale and siltstone intervals yield cobbles and finer materials, wide floodplains. Sandstone lenses yield boulders, waterfalls, and narrow floodplains.

Table 4. Bedrock stratigraphy of the upper Shavers Fork field area. The Mississippian section measures Approximately 250 – 400 feet.

The Shavers Fork Fishery

Modern assessments of inland aquatic ecosystems have given rise to several remediation concepts that are applicable to the upper Shavers Fork aquatic environment (Figure 6). Considering the historic extractive land uses, the upper Shavers Fork does possess *integrity*, which indicates the system is intact and restorable to its morphological and biological potential. Specific environmental stresses that determine the suitability of a particular fish are fluvial hydraulics, stream morphology, channel gradient, stream-bank characteristics, bedrock and alluvial lithology, and water temperature (Minshall, 1996).

Shavers Fork in-stream complexity is highly variable, and topography, geology, and precipitation control the basin characteristics. Fluvial processes within the basin modify bedrock surfaces and develop different habitats. Small-scale habitats are embedded within larger habitat mosaics at increasing hierarchical levels (Petty, 1999). In-stream features that constitute fish habitat are resolved at several different scales, and different levels of morphological resolution are obtained by subdividing the stream into segments, reaches, channel units, microhabitats, etc. Fish adapt to chemistry, discharges, channel morphology, and substrate composition. These varying geomorphologic components subdivide brook trout populations occupying specific habitat types. The quality of fish habitat is a direct function of the homogeneity or

heterogeneity of flow characteristics and in-stream features (Rabini, 1993).

Inferences on the biological structure and functional integrity of Shavers Fork are made by analyzing the building blocks of aquatic habitats within specific channel units.

Channel-Units

Stream water is the medium of support and movement for fish and other aquatic organisms. Bank morphology, channel gradient, channel form, stream bottom composition, and the volume of water in the channel dictate stream flow characteristics. Channel-units are subdivisions of a stream that represent flow characteristics with unique hydraulic properties. The morphology that defines channel units within a stream reach controls the biological structure of the aquatic habitat and the way it functions (Minshall, 1996). Channel-unit descriptions address local stream flow, gradient, area, depth, and channel obstructions and constrictions, including large woody debris (Hawkins and others, 1993). Petty (1999) defined channel units as discrete areas that can be classified consistently using criteria known to affect aquatic life, ultimately indicating factors that limit populations within a stream reach. Maxwell and others (1995) defined channel units as areas of consistent depth and flow bounded by sharp changes in gradient.

Channel-unit characterizations constituted the most detailed level of classification for morphological research in Shavers Fork. The channel-unit data

included contiguously mapped hydrologic boundaries that are unique in terms of homogeneity or heterogeneity (Appendix I & II). The contiguous arrangement of channel-units is a fundamental component of the quality of fish habitat in the stream. Thus, inferences on the biological structure and functional integrity of Shavers Fork can be made through delineation of the geomorphologic building blocks of the aquatic habitats.

Channel-unit classification varies with flow conditions, as does brook trout habitat variability. Channel units were determined under base-flow conditions to minimize problems with variations in discharge. Shavers Fork channel units were classified according to the 'real-time' flow characteristics within a stream reach. Channel-unit complexes were classified according to the sequence of flow characteristics in the downstream direction. Most channel units, on the map and in Appendix I & II, are labeled with abbreviations (given in italics in the following text), with the exception of *pools*. A description of geologic complexity, relative flow velocity, substrate and water surface profile, and overall quality of fish habitat was given to each unit.

Riffles

Lgr, *Igr*, *Hgr* signifies low gradient riffle, intermediate gradient riffle, and high gradient riffle, respectively. Riffles are shallow channel units with critical flow where water flows swiftly over completely or partially submerged obstructions or alluvium, producing surface agitation but no standing waves

(Maxwell and others, 1995). The longitudinal profile of the substrate is usually uniform or convex. A well-defined thalweg occurs locally and marginal slackwater occurs near the stream banks. All riffles are similar in channel form and substrate. These homogeneous channel units provide poor to good quality fish habitat and may or may not have anthropogenic influences.

Pools

Pools are deep channel units where the flow velocity is extremely low to stagnant. Most pools occur downstream from constrained regions of higher velocity and provide areas of temporary deposition at low flows. The profile of the substrate is concave. Pools are created during high flow conditions when water passes through or over obstructions and scours out a concave depression in the substrate downstream of the obstruction (Maxwell and others, 1995). Debris pools occur when a downstream debris dam causes low-velocity pooling upstream. Pools should not be confused with glides as the flow velocity and substrate profile should distinguish them. Cyclic eddy phenomena, in the form of upwellings, occur in this channel unit and provide infrequent surface-water agitation (Morisawa, 1968). Anthropogenic features, such as abandoned bridge foundations and existing tressels, influence the occurrence of many pools. The boundary between pools and the adjacent upstream channel unit is excellent congregation habitat for fish.

Glides

Gld signifies glide. Glides have low flow velocity, uniform depth, and no surface agitation. The longitudinal profile of the substrate is roughly parallel to the slope of the water surface and there is no well-defined thalweg. Glides are homogeneous channel units with poor quality fish habitat.

Riffle-Run Complexes

LgrRC_A, *IgrRC_A*, *HgrRC_A* signifies a natural low-gradient riffle-run complex (A), intermediate-gradient riffle-run complex (A), high-gradient riffle-run complex (A), respectively. Large cobbles and small boulders scattered throughout the channel provide many irregular holes that inhibit the development of a clear, defined thalweg. In-stream and riparian cover is abundant. The complex starts as flow is constrained and accelerated through habitat features such as alluvial cobbles or small boulders. Throughout the beginning of the complex, the water exhibits streaming flow (sub critical flow) under base-flow conditions, but shooting flow (critical flow) occurs with more discharge. The water's surface is aerated and roughly parallel to the overall gradient of a stream reach. As water accelerates downstream, it deflects off and around mid-channel boulders of all sizes, causing separations of flow and small mid-channel eddies. The boulders are derived from upslope colluvial processes, tributary confluences, or eroded bank-side bedrock. These three types of riffle-run complexes are heterogeneous and yield good to excellent quality fish habitat.

LgrRC_B, *IgrRC_B*, *HgrRC_B* signifies a human impacted low-gradient riffle-run complex (B), intermediate-gradient riffle-run complex (B), high-gradient riffle-run complex (B), respectively. The anthropogenic channel units have constraining features such as railroad ties or concrete blocks. These complexes have high heterogeneity and provides generally good to excellent fish habitat, although riparian cover is usually sparse.

Riffle-Glide Complexes

LgrGldC, *IgrGldC* signifies low-gradient riffle-glide complex and intermediate-gradient riffle-glide complex. These channel units typically are comprised of approximately 50 percent riffle and 50 percent glide characteristics. As water moves through the channel, it deflects around mid-channel cobbles and boulders, causing separations of flow and small mid-channel eddies. These complexes are mostly heterogeneous and provide good quality fish habitat where vegetation is well developed.

Bluff-Pool Complexes

BPC_A signifies a natural bluff-pool complex (A). Bluff-pool complexes usually have good in-stream and riparian cover, including boulders, woody debris, and root wads. The complex starts where flow is constrained and accelerated through habitat features, such as alluvial cobbles or small boulders. Here, the water exhibits streaming flow, but shooting flow can occur at higher

discharge. The water surface is aerated and roughly parallel to the overall gradient of a stream reach. As the water accelerates, it deflects off natural bedrock or boulder bluffs on the bank causing change in flow direction. Locally, these bluffs are formed by bedrock walls up to 5 m in height. The deflection of the flow direction at high flow commonly causes a scour pool just downstream from the bluff. Scattered mid-channel boulders are derived from local bluffs and cause separations of flow and small mid-channel eddies throughout the bluff-pool (A) complex. This complex has high heterogeneity and provides generally good to excellent fish habitat.

BPC_B signifies a human-impacted bluff-pool complex (B). This unit has constraining and scour pool features similar to bluff-pool complex (A), but the bluff component is railroad related, such as bankside ballast or concrete blocks. Tressel complexes also fall into the bluff-pool complex (B) category. This complex has high heterogeneity and provides generally good to excellent fish habitat although riparian cover is usually sparse.

Results

The results of this research are derived from geomorphic mapping and analysis of the field data listed in Appendix I and II. The BVET calibration ratio (Q) applied to estimated variables of bankfull width and maximum depth was calculated using the equation below:

$$Q = \Sigma m / \Sigma x$$

Where Q is an estimator of the true ratio of the area of all the units, m is the true measured unit, and x is the visual estimate (Hankin and Reeves, 1988). The calibration ratio (Q)=0.96 was generated from m and x data listed in Table 5. The calibration ratio represents an estimate of the true ratio of channel unit areas to visually estimated areas.

Location	BVET Width (x)	Actual Width (m)	Estimation Error	Actual Width squared (m ²)
1	20.0	16.2	3.8	262.4
2	21.0	18.4	2.6	338.6
3	21.0	18.9	2.1	357.2
4	18.0	19.4	1.4	376.4
5	21.0	18.2	2.8	331.2
6	16.0	14.7	1.3	216.1
7	17.0	15.8	1.2	249.6
8	15.0	15.8	0.8	249.6
9	13.0	10.2	2.8	104.0
10	8.0	8.1	0.1	65.6
11	13.0	13.3	0.3	176.9
12	14.0	15.6	1.6	243.4
13	13.0	14.5	1.5	210.3
14	14.0	14.8	0.8	219.0
15	12.0	12.1	0.1	146.4
16	13.0	12.2	0.8	148.8
17	12.0	11.6	0.4	134.6
18	11.0	10.9	0.1	118.8
19	12.0	11.8	0.2	139.2
20	11.0	11.3	0.3	127.7
Sum	295.0	283.8		4215.9
	$Q = \sum \text{Actual} / \sum \text{BVET}$			
	Q= 0.96			
	Mean Bankfull Channel Width =		11.2 m	
	Standard Deviation=		63.4 m	

Table 5. The BVET calibration ratio (Q) is determined by the sum of the measured bankfull widths (m) divided by the sum of the visually estimated bankfull widths (x) for each station. This ratio is used to correct all BVET data in Appendix I and II.

Watershed Characteristics

The basin area, encompassing the area from Thorny Flat to Cheat Bridge (Figure 3), is 155.40 km², as given for the USGS gauge station on Shavers Fork at Cheat Bridge. Figure 7 shows a longitudinal profile from Thorny Flat to Cheat Bridge. The basin length is 16.60 km straight-line measured from Thorny Flat peak to Cheat Bridge (Figure 3). The basin relief from the highest point at Bald Knob to Cheat Bridge is 384 m and was calculated using the USGS topographic quadrangles. The mapped stream length from Spruce to Lambert Run (Figure 3) is 24.6 km. Within the mapped field area, Shavers Fork drops 84.15 m from Spruce to Lambert Run as determined from USGS topographic maps.

Figure 7. A longitudinal profile of Shavers Fork from Thorny Flat to Cheat Bridge. This map was generated from data published on 1:24,000 USGS topographic quadrangles.

Channel Unit Results

The field area contained 393 channel units. Data for the 393 contiguous channel units are listed in Appendix I. Linear regressions show the downstream trends in bankfull width (Figures 8-14), channel unit length (Figures 15-21), channel unit area (Figures 22-28), and maximum depth (Figures 29-35). The mean and standard deviation for each channel-unit type's bankfull width, length, area, and maximum depth area are shown in table 6.

	Mean Bankfull Width (m)	Standard Deviation of Mean Bankfull Width(m)	Mean Channel Unit Length (m)	Standard Deviation of Mean Channel Unit Length (m)	Mean Channel Unit Area (m ²)	Standard Deviation of Mean Channel Unit Area (m ²)	Mean Maximum Depth Value(m)	Standard Deviation of Mean Maximum Depth Value(m)
Riffles	162	41	455	297	7532	601.4	05	07
Pools	11.3	14.1	254	34.7	446.7	724.9	08	09
Glides	17.0	34	638	51.1	11780	1151.9	06	07
Riffle-run Complexes	150	44	727	462	11633	969.9	08	02
Riffle-glide Complexes	148	32	930	562	17853	1344.0	06	02
Bluff-pool Complexes	143	31	733	404	10980	672.8	09	02

Table 6. Channel-unit means and standard deviations for bankfull width, length, area, and maximum depth.

Bankfull Width

Channel-unit bankfull width generally increases in the downstream direction from Spruce to Lambert Run (Figure 8). The average bankfull channel-unit width is 16 m, with the most narrow mean width located in segment 7 and the widest mean width located in segment 11. Channel-unit bankfull width data for each channel unit type are illustrated on Figures 9 through 14. Riffle-glides constitute the widest channel units, with few less than 15 m, although the widest unit is a simple riffle. Pools have the most variation in width with three narrow channel units less than 7 m wide. Bluff-pools are also considerably narrower than other channel units and complexes.

Figure 8. Calibrated bankfull width for 393 channel units from Spruce to Lambert Run.

Figure 9. Calibrated bankfull width versus distance for riffles from Spruce to Lambert Run.

Figure 10. Calibrated bankfull width versus distance for pools from Spruce to Lambert Run.

Figure 13. Calibrated bankfull width versus distance for riffle-glide complexes from Spruce to Lambert Run.

Figure 14. Calibrated bankfull width versus distance for bluff-pool complexes from Spruce to Lambert Run.

Channel Unit Length

Channel-unit length averages 63 m, but generally increases in the downstream (Figure 15). Channel-unit length variability is lower closer to Spruce (Figure 15) and indicates a higher concentration of shorter channel units near the headwaters. Channel-unit length trends for each channel-unit type are illustrated in Figures 16 through 21. Glides and riffle-glides composed the longest channel units, with the exception of one riffle-run over 300 m long. There are two unusually long pools in segments 8 and 9, one long riffle-run complex in segment 12, and one long bluff-pool located near the boundary of segments 6 and 7.

Figure 18. Channel-unit length versus distance for glides from Spruce to Lambert Run.

Figure 19. Channel-unit length versus distance for riffle-run complexes from Spruce to Lambert Run.

Figure 20. Channel-unit length versus distance for riffle-glide complexes from Spruce to Lambert Run.

Figure 21. Channel-unit length versus distance for bluff-pool complexes from Spruce to Lambert Run.

Channel Unit Area

Channel-unit area (Figure 22) increases in the downstream direction. High-area channel units are predominant in segments 10, 11, and 12, although two high-area glides occur near the boundary between segments 6 and 7. Channel-unit area trends for each channel-unit type are illustrated in Figures 23 through 28. Glides, riffle-glide complexes, and riffle-run complexes constitute the largest areas within the stream with several individual units far exceeding 1500 m². Several large riffles occur in the lower segments, 11 and 12.

Figure 23. Channel unit area versus distance for riffles from Spruce to Lambert Run.

Figure 24. Channel-unit area versus distance for pools from Spruce to Lambert Run.

Figure 25. Channel-unit area versus distance for glides from Spruce to Lambert Run.

Figure 26. Channel-unit area versus distance for riffle-run complexes from Spruce to Lambert Run.

Maximum Depth

Channel-unit maximum depth (Figure 29) also increased downstream. The greatest variation from the mean maximum depth occurs in the middle segments 7, 8, 9, 10, and 11. Maximum depths less than 0.5 m are less frequent in the lower segments 11 and 12. Maximum depth information for individual channel unit types is illustrated in Figures 30 through 35. Most pools are deeper than 0.7 m. Pools, bluff-pools, and riffle-run complexes contain the deepest sections of stream with a mean maximum depth of 0.8 m. Five maximum-depth anomalies above 1.2 m, two riffle-run complexes and three bluff-pool complexes, occur near the boundary of segments 5 and 6. Riffles constitute the shallowest sections of the stream with a mean maximum depth of 0.5 m.

Figure 34. Calibrated maximum water depth versus distance for riffle-glide complexes from Spruce to Lambert Run.

Figure 35. Calibrated maximum water depth versus distance for bluff-pool complexes from Spruce to Lambert Run.

Channel Unit Proportion

The proportion of channel unit types per stream segment is illustrated in Figure 36. The proportions of pools, riffle-glide complexes, and bluff-pool complexes vary greatly from segment to segment. Significantly larger populations of riffle-glide complexes occur in segment 11. Channel units tend to have larger areas in downstream segments, so more units occur higher in the drainage and fewer occur downstream. Riffles, glides, and riffle-run complexes dominate the channel unit abundance with at least 8 per segment. Bluff pools are most abundant in the upper segments 4, 5, 6, and 8. Riffle-glide complexes uncommon or may be absent in segments 4, 5, 8, and 9.

Riffles constitute 32 percent of the total channel unit area, riffle-run complexes and glides make up 26 percent each, bluff-pool complexes constitute 7 percent, riffle-glide complexes 6 percent, and true pools make up 2 percent of the total channel unit area. True pools are very uncommon and were only observed in channel units 7, 8, and 9. Pools and complexes are good to excellent fish habitat and comprise 69 percent of the total stream area. Riffles and glides are considered fair to poor fish habitat quality and constitute 31 percent of the total stream area.

Large Woody Debris (LWD)

Large woody debris (LWD) data for each channel unit are listed in Appendix III. LWD was categorized for this study according to size classes (1-6), segregated by length and diameter. Class 1 indicates short length (<2 m) and small diameter (<3.5 cm), class 2 indicates short length and medium diameter (3.5 cm – 21.0 cm), class 3 is short length and large diameter (>21 cm), class 4 is long length (>2 m) and small diameter, class 5 is long length, medium diameter, and class 6 is long length and large diameter. A total abundance of LWD was estimated to 2926 pieces. The LWD data population decreases in the downstream direction and indicates LWD retention in the upper segments. Headwater segments 4 and 6 have the highest relative abundance of LWD. This abundance can be attributed to smaller flood flows than downstream segments and a narrower channel width where stream bank lodging of LWD can occur perpendicular to the channel. The greatest local abundance of in-stream LWD

occurs in a riffle-run complex in segment 9, channel unit#260, approximately 14,500m downstream of Spruce (measured along the sinuosity of the channel), where a downed tree confines and partially dams the channel. The debris dam and alluvial bar add morphologic and hydraulic heterogeneity to the unit and help to classify the flow complexity.

Survey Results

High-resolution survey data was acquired for a 288 m² section above Black Run with the intent of using these data for classification according to Rosgen (1994) (Figure 38). The real-time stage was 5.30 ft at Cheat Bridge during the survey. The survey data was imported into Land Desktop 2002 and yields the general stream geometry for the survey reach illustrated in Appendix IV. The survey neglected to include enough data to construct a true Rosgen stream classification. A future study may find the data included in Appendix IV useful.

Rosgen Classification

Shavers Fork was classified following the Rosgen (1994) method, but all data were compiled from remotely sensed DOQQ imagery within a GIS except for dominant substrate, which was determined in the field. The reach directly above the survey reach (Figure 38) is categorized as a C3 Rosgen-type channel based on a sinuosity of 1.38, average entrenchment ratio of 4.80, and an average gradient of 0.0037. The Shavers Fork bedload from Spruce to Cheat Bridge is predominantly cobble.

Discussion

The physical components of the Shavers Fork watershed support the fishery, and help it to maintain its current state of integrity within a larger ecological system. The overall geometry of the Shavers Fork channel may have been influenced by anthropogenic activity within the watershed, but more historical landscape and channel data must be researched. If a sustainable fishery is *(or will be?)* the goal for future remediation designs, analysis of physical disequilibria within the watershed may identify target areas and research questions that need to be addressed. A researcher must question where is the stream broken and what is the scale of the problem? Are the problems in the watershed or the channel? What does the watershed need? I hope to give insight into these questions in the following section.

Morphologic Disequilibria

Acidification of headwater streams occurs through atmospheric deposition on acidic bedrock and soils in upper headwater tributaries. Contour surface mining has occurred in the upper headwater segments of Black Run and Lambert Run. With regard to the physiography and elevational constraints of this fifth order stream, Shavers Fork is relatively wide, shallow, and low gradient. The gradient is generally consistent from Spruce to Lambert Run, averaging 0.0037. Higher gradient reaches occur below tributary confluences and in the upper-

segments at bedrock constrictions. Bedload caliber and volume reflects the local bedrock geology. The most noticeable bedload caliber disequilibria occurs above tressels, where finer grained sediment accumulates, due to aggradation above the man-made hydraulic constrictions.

Erosion and deposition are a natural phenomenon of the stream and its continuous development and balance between driving and resisting forces. Alluvial bars are abundant throughout all segments, and are expected to migrate as the stream continually develops with time. Most scour develops on the inside of alluvial point bars located on meander bends. Bank instability and scour also occurs in areas opposite of streamside railroad contact. Current sources of human-induced sedimentation in Shavers Fork include maintenance of the railroad grade, and development of buildings, ski slopes, and roads near Snowshoe and adjacent areas (Figure 3 and 4).

Today, certain anthropogenic features within the floodplain disconnect the mainstem from natural adjacent features and influence the Shavers Fork channel. The railbed laterally constrains the channel in many reaches. The bank along the railroad is generally armored with riprap that locally erodes when the stream flows at high velocity over these anthropogenic structures. With the loss of floodplain area, higher flows are constrained within the remaining floodplain, developing the channel into a straighter, shorter stream that moves faster.

Appropriate physical characteristics of a stream adequate for a fishery include dynamic, complex channels as well as sufficient vegetation to provide

shade and cover, trap sediments, and dissipate flood effects. The bank is the channelward limit of the perennial vegetation (Furtman, 1999). Adequate woody debris and other biotic materials provide shelter for fish, and the organic material serves as food for aquatic insects at the base of the food chain (Wood, 1998). Construction of the railroad has significantly affected the riparian canopy on the floodplain. The hydraulic complexity of the vegetated stream bank has been lost because of railroad construction, allowing faster flow than is natural. The lack of riparian cover has amplified the thermal temperature problem in the mainstem due to the lack of stream shading. Channel units with poor riparian cover and eastern to southeastern channel aspects are exposed to direct sunlight, and are subject to stream heating. The channel width of the Shavers Fork mainstem is wider than the height of most tree trunks along the stream banks, resulting in flushing of downed in-stream LWD during high flow events decreasing the total heterogeneity in the system. Fortunately, in-situ root masses (rootwads) are abundant and provide bank stabilization.

Channel Unit Disconformities

The abundance of specific channel-unit types within different stream segments gives insight into the total in-stream heterogeneity of Shavers Fork. Abrupt changes in the flow dynamics of Shavers Fork occur only locally. Within the field area, flow velocity is low until a significant change in gradient or in-stream and/or riparian features constrict the channel. Heterogeneous units

occur when gradient or channel characteristics change or when in-stream features inhibit streaming flow. Most heterogeneity in the upper Shavers Fork occurs in the higher elevation segments 5 and 6. Below segment boundary 6, the channel dramatically changes in geometry. The widening of the channel near Second Fork, coupled with the additional flow from this major tributary, results in the downstream transport of habitat features that produce heterogeneity in the stream. As the stream widens below Second Fork, riparian tree-fall is less likely to be 'lodged' from bank to bank and clog the channel. Among the six different channel-unit types in Table 6, riffles, pools, and glides have homogeneous flow characteristics. Channel-unit complexes (Table 6) involve several 'blended' channel units and have more heterogeneous flow characteristics. Channel unit complexes usually contain one or more mapped habitat features (alluvial deposits, scour, bedrock outcrops, boulders > 1.5m, or LWD) that control the extent of heterogeneity and the hydraulic component of flow.

Remediation Suggestions

The upper Shavers Fork is a reference headwater stream in the Appalachian Highlands. It's morphologic and channel-unit attributes provide a blend of flow complexities and habitat characteristics that enhance the stream's authenticity of a high elevation West Virginia stream.

If research goals are to rehabilitate and sustain a trout fishery, researchers must first understand Shavers Fork's history then assess the present condition of watershed and its influence on the Shavers Fork channel. Before researchers implement a remediation design they must be clear on the expected outcomes of the project, and assess whether the problems are in the watershed or the stream channel. A hierarchical organization of the landscape at different scales can help to identify specific areas that need attention on Shavers Fork, then remediation recommendations and designs can address the actual components in the stream that are broken. Some channel components need to be considered to enhance future rehabilitation designs: high elevation, low gradient, naturally homogenous, natural lateral channel migration within the floodplain, lateral constriction of the floodplain by the railroad, and present and future headwater drainage development.

Stream reaches of low complexity below Second Fork may contain target sites for in-stream rehabilitation projects on the mainstem, in particular, reaches in contact with the railroad grade that have developed intermittent channels on the inside of meander bends. Remediation should address components of the watershed that facilitate or inhibit erosion and deposition rates. LWD and rootwads placed in heavily scoured reaches could provide bank stability and provide in-stream habitat cover for fish. Natural recovery of the upper Shavers Fork fishery may also be accomplished if measures are taken to promote riparian canopy growth without disrupting rare plant species that exist in natural open

floodplain areas. Riparian restoration along the railroad grade would also facilitate fishery rehabilitation and recovery of the lotic system. Remediation designs could be enhanced through research on tributary and mainstem interactions, and linkages between healthy components of the watershed and low quality habitat.

Land-use activities can influence the spatial heterogeneity and connectivity of physical habitats and ultimately affect functional interactions among terrestrial and aquatic elements. In light of these relationships, scientists need to focus on ways to model environmental heterogeneity and critical biological processes that will lead to insights into fishery sustainability and effective rehabilitation measures.

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Appendix I

Channel Unit #	Channel Unit	Distance Downstream	Stream Segment	Calibrated Measured		Calibrated Maximum	
		From Spruce (m)		Channel Width (m)	Length (m)	Area (m ²)	Water Depth (m)
1	Gld	0	4	11.5	55	635	0.53
2	IgrRCa	55	4	8.7	69	597	0.59
3	Debris	124	4	9.6	81	779	0.59
4	Igr	205	4	8.7	63	545	0.29
5	Gld	268	4	11.5	22	254	0.38
6	IgrRCa	290	4	9.6	21	202	0.44
7	BPCb	311	4	11.5	34	393	0.88
8	IgrRCa	345	4	9.6	40	385	0.59
9	Gld	385	4	11.5	74	854	0.47
10	IHgr	459	4	6.7	27	182	0.29
11	IgrRCa	486	4	5.8	27	156	0.59
12	IHgr	513	5	9.6	25	241	0.50
13	BPCa	538	5	11.5	71	820	0.59
14	Igr	609	5	8.7	29	251	0.29
15	Gld	638	5	10.6	23	243	0.38
16	IgrRCa	661	5	7.7	11	85	0.67
17	Gld	672	5	9.6	22	212	0.29
18	IgrRCa	694	5	9.6	63	606	0.73
19	BPCa	757	5	11.5	57	658	0.73
20	IgrRCa	814	5	11.5	65	750	0.70
21	Gld	879	5	13.5	46	620	0.67
22	IgrRCa	925	5	11.5	26	300	0.59
23	Igr	951	5	12.5	17	213	0.53
24	IgrRCa	968	5	9.6	10	96	0.73
25	Gld	978	5	12.5	20	250	0.44
26	Lgr	998	5	11.5	12	139	0.29
27	Gld	1010	5	12.5	25	313	0.44
28	IgrRCa	1035	5	10.6	17	180	0.65
29	Gld	1052	5	15.4	45	693	0.35
30	Lgr	1097	5	12.5	27	338	0.47
31	Gld	1124	5	15.4	49	754	0.38
32	IgrRCa	1173	5	14.4	25	361	0.59
33	Gld	1198	5	15.4	25	385	0.29
34	Igr	1223	5	12.5	52	650	0.35
35	Gld	1275	5	15.4	75	1154	0.53
36	IgrRCa	1350	5	13.5	66	889	0.59
37	Igr	1416	5	9.6	12	115	0.47
38	IgrRCa	1428	5	11.5	51	589	0.59
39	BPCa	1479	5	9.6	112	1077	0.44
40	IgrRCa	1591	5	16.4	76	1243	0.70
41	Igr	1667	5	20.2	30	606	0.38
42	IgrRCa	1697	5	15.4	93	1432	0.65
43	Lgr	1790	5	17.3	39	675	0.41
44	IHgr	1829	5	14.4	77	1111	0.59

45	IgrRCa	1906	5	13.5	107	1441	0.82
46	Igr	2013	5	15.4	52	800	0.29
47	IgrRCa	2065	5	14.4	146	2107	0.59
48	Gld	2211	5	24.1	117	2814	0.29
49	Igr	2328	5	25.0	25	625	0.29
50	IgrRCa	2353	5	15.4	41	631	0.53
51	Igr	2394	5	12.5	35	438	0.53
52	IgrRCa	2429	5	16.4	84	1374	0.59
53	Igr	2513	5	15.4	44	677	0.44
54	Gld	2557	5	14.4	19	274	0.44
55	Lgr	2576	5	14.4	8	115	0.29
56	Gld	2584	5	13.5	10	135	0.53
57	Igr	2594	5	15.4	69	1062	0.59
58	IgrRCa	2663	5	13.5	32	431	0.82
59	Gld	2695	5	19.2	59	1135	0.44
60	Igr	2754	5	21.2	49	1037	0.53
61	IgrRCa	2803	5	13.5	71	956	0.76
62	Hgr	2874	5	14.4	32	462	0.59
63	BPCa	2906	5	14.4	51	736	1.17
64	IgrRCa	2957	5	16.4	196	3205	0.67
65	Igr	3153	5	17.3	55	952	0.59
66	HLgr	3208	5	15.4	54	831	0.44
67	BPCa	3262	5	13.5	45	606	1.32
68	Gld	3307	5	14.4	26	375	0.82
69	IgrRCa	3333	5	16.4	135	2208	0.79
70	Igr	3468	5	17.3	33	571	0.50
71	GLd	3501	5	17.3	48	831	0.59
72	Igr	3549	5	18.3	93	1700	0.50
73	IgrRCa	3642	5	16.4	95	1554	0.79
74	Igr	3737	5	17.3	73	1264	0.59
75	BPCa	3810	5	15.4	36	554	0.88
76	Gld	3846	5	22.1	68	1505	0.29
77	ILgr	3914	5	15.4	62	954	0.67
78	IgrRCb	3976	5	13.5	110	1482	0.79
79	IgrRCa	4086	6	16.4	154	2519	1.32
80	IgrRCa	4240	6	25.0	55	1376	0.79
81	ILgr	4295	6	22.1	15	332	0.59
82	IgrRCa	4310	6	16.4	24	393	0.88
83	Igr	4334	6	21.2	26	550	0.62
84	IgrRCa	4360	6	15.4	46	708	1.00
85	Igr	4406	6	21.2	99	2095	0.51
86	Gld	4505	6	22.1	110	2434	0.59
87	Igr	4615	6	21.2	23	487	0.51
88	IgrRCa	4638	6	19.2	87	1674	0.59
89	Lgr	4725	6	22.1	35	774	0.44
90	IgrRCa	4760	6	17.3	41	710	0.73
91	Igr	4801	6	20.2	38	768	0.44
92	IgrRCa	4839	6	14.4	44	635	0.97
93	Igr	4883	6	17.3	10	173	0.47
94	Hgr	4893	6	14.4	27	390	0.73

95	BPCa	4920	6	18.3	107	1956	0.67
96	Gld	5027	6	22.1	29	642	0.50
97	Lgr	5056	6	24.1	64	1539	0.29
98	Igr	5120	6	19.2	20	385	0.29
99	BPCa	5140	6	21.2	82	1736	0.67
100	Lgr	5222	6	26.0	79	2052	0.29
101	Igr	5301	6	24.1	15	361	0.29
102	IgrRCa	5316	6	22.1	19	420	0.66
103	Igr	5335	6	18.3	13	238	0.29
104	Igr	5348	6	13.5	8	108	0.73
105	BPCa	5356	6	12.5	75	938	1.03
106	Hgr	5431	6	12.5	10	125	0.59
107	BPCa	5441	6	14.4	27	390	0.88
108	LgrGldCa	5468	6	14.4	38	548	0.73
109	IgrRCa	5506	6	13.5	135	1818	0.67
110	LgrGldCa	5641	6	12.5	44	550	0.67
111	Igr	5685	6	11.5	44	508	0.73
112	Gld	5729	6	14.4	68	981	0.82
113	BPCb	5797	6	11.5	25	289	0.88
114	Gld	5822	6	14.4	29	418	0.67
115	Igr	5851	6	16.4	46	752	0.29
116	IgrRCa	5897	6	12.5	48	600	0.59
117	Gld	5945	6	9.6	35	337	0.50
118	BPCa	5980	6	11.5	76	877	0.82
119	LgrGldCa	6056	6	15.4	66	1016	0.67
120	Igr	6122	6	9.6	54	519	0.73
121	Gld	6176	6	13.5	46	620	0.38
122	IgrRCa	6222	6	11.5	74	854	0.82
123	Gld	6296	6	12.5	28	350	0.82
124	IgrRCa	6324	6	9.6	74	712	0.67
125	Gld	6398	6	15.4	40	616	0.73
126	Lgr	6438	6	12.5	44	550	0.50
127	LgrGldCa	6482	6	13.5	30	404	0.53
128	BPCa	6512	6	9.6	110	1058	0.82
129	LgrRCa	6622	6	15.4	38	585	0.67
130	LgrRCa	6660	6	17.3	101	1749	0.53
131	Igr	6761	6	16.4	37	605	0.44
132	LgrRCa	6798	6	14.4	68	981	0.82
133	BPCa	6866	6	12.5	34	425	0.88
134	Gld	6900	6	15.4	17	262	0.73
135	LgrGldCa	6917	6	16.4	45	736	0.44
136	Igr	6962	6	14.4	50	722	0.56
137	LgrRCa	7012	6	15.4	62	954	0.59
138	Igr	7074	6	13.5	71	956	0.29
139	Gld	7145	6	15.4	52	800	0.35
140	LgrRCa	7197	6	11.5	46	531	0.73
141	Gld	7243	6	13.5	84	1131	0.53
142	IgrRCa	7327	6	26.9	58	1562	0.73
143	Lgr	7385	6	14.4	51	736	0.35
144	Gld	7436	6	13.5	71	956	0.47

145	IgrRCa	7507	6	11.5	65	750	0.73
146	LgrGldCa	7572	6	14.4	95	1371	0.29
147	Igr	7667	6	9.6	30	289	0.29
148	LgrGldCa	7697	6	24.1	31	746	0.29
149	BPCb	7728	6	15.4	38	585	1.17
150	IgrRCa	7766	6	13.5	66	889	0.82
151	Gld	7832	6	13.5	46	620	0.82
152	LgrRCa	7878	6	15.4	87	1339	0.59
153	IgrRCa	7965	6	13.5	71	956	0.82
154	Gld	8036	6	19.2	62	1193	0.47
155	LgrRCa	8098	6	15.4	42	646	0.73
156	Gld	8140	6	24.1	246	5917	0.29
157	Lgr	8386	7	9.6	44	423	0.67
158	Gld	8430	7	16.4	80	1308	0.44
159	Igr	8510	7	15.4	42	646	0.38
160	Gld	8552	7	16.4	61	998	1.03
161	LgrGldCa	8613	7	17.3	102	1766	0.59
162	IgrRCa	8715	7	9.6	136	1308	0.82
163	LgrGldCa	8851	7	16.4	79	1292	0.44
164	Igr	8930	7	13.5	33	444	0.38
165	Gld	8963	7	16.4	57	932	0.59
166	Lgr	9020	7	15.4	34	523	0.59
167	Gld	9054	7	18.3	69	1261	0.73
168	Igr	9123	7	17.3	34	589	0.38
169	LgrGldCa	9157	7	16.4	29	474	0.35
170	Igr	9186	7	16.4	33	540	0.44
171	BPCa	9219	7	14.4	117	1688	0.82
172	Gld	9336	7	25.0	230	5753	0.82
173	Igr	9566	7	11.5	86	993	0.35
174	LgrGldCa	9652	7	16.4	83	1357	0.44
175	BPCa	9735	7	14.4	110	1587	0.59
176	IgrRCa	9845	7	15.4	80	1231	0.79
177	LgrRCa	9925	7	14.4	38	548	0.73
178	IgrRCa	9963	7	15.4	123	1893	0.88
179	HgrRCa	10086	7	14.4	45	649	1.17
180	LgrRCa	10131	7	14.4	14	202	0.73
181	Igr	10145	7	16.4	123	2012	0.53
182	Gld	10268	7	21.2	53	1122	0.88
183	BPCa	10321	7	9.6	44	423	0.88
184	Gld	10365	7	15.4	31	477	0.73
185	Igr	10396	7	21.2	59	1249	0.35
186	Gld	10455	7	19.2	58	1116	0.53
187	IgrRCa	10513	7	7.7	94	723	0.73
188	Gld	10607	7	17.3	137	2372	0.38
189	Igr	10744	7	19.2	38	731	0.47
190	IgrRCa	10782	7	17.3	67	1160	0.73
191	Gld	10849	7	18.3	148	2705	0.79
192	LgrGldCa	10997	7	19.2	38	731	0.44
193	IgrRCa	11035	7	15.4	75	1154	0.73
194	Gld	11110	7	16.4	22	360	0.44

195	IgrRCa	11132	7	15.4	123	1893	0.59
196	Igr	11255	7	15.4	21	323	0.53
197	Gld	11276	7	17.3	46	797	0.47
198	Igr	11322	7	16.4	56	916	0.50
199	Gld	11378	7	16.4	49	801	0.29
200	IgrRCa	11427	7	16.4	101	1652	0.73
201	Gld	11528	7	17.3	21	364	0.41
202	Igr	11549	7	15.4	20	308	0.35
203	Gld	11569	7	16.4	20	327	0.29
204	LgrGldC	11589	7	17.3	64	1108	0.29
205	IHgr	11653	7	15.4	51	785	0.29
206	Pool	11704	7	2.8	14	40	0.73
207	Gld	11718	7	15.4	66	1016	0.44
208	IgrRCa	11784	7	14.4	28	404	0.73
209	Gld	11812	7	14.4	23	332	0.67
210	Hgr	11835	7	17.3	35	606	0.29
211	Gld	11870	7	15.4	49	754	0.44
212	Lgr	11919	7	13.5	37	498	0.38
213	Gld	11956	7	18.3	59	1078	0.44
214	Lgr	12015	7	13.5	16	215	0.44
215	Gld	12031	7	14.4	48	693	0.59
216	Igr	12079	7	14.4	24	346	0.47
217	Gld	12103	7	16.4	23	376	0.53
218	Lgr	12126	7	15.4	39	600	0.41
219	Gld	12165	7	16.4	40	654	0.53
220	Igr	12205	8	15.4	47	723	0.67
221	Gld	12252	8	16.4	45	736	0.53
222	IgrRCa	12297	8	17.3	50	866	0.88
223	Gld	12347	8	15.4	41	631	0.67
224	Ihgr	12388	8	17.3	61	1056	0.38
225	Pool	12449	8	13.5	23	310	1.03
226	Gld	12472	8	17.3	33	571	0.44
227	IHgr	12505	8	11.5	33	381	0.53
228	IgrRCa	12538	8	15.4	86	1324	0.73
229	Gld	12624	8	17.3	146	2528	0.44
230	IgrRCa	12770	8	17.3	16	277	0.44
231	Gld	12786	8	17.3	39	675	0.41
232	IgrRCa	12825	8	14.4	85	1227	0.59
233	Pool/backwater/lagoon	12910	8	6.7	13	88	0.38
234	BPCa	12923	8	15.4	200	3079	0.73
235	Gld	13123	8	22.1	19	420	0.38
236	Hgr	13142	8	12.5	29	363	0.59
237	IgrRCb	13171	8	16.4	48	785	0.73
238	BPCa	13219	8	17.3	79	1368	0.65
239	Gld	13298	8	21.2	22	466	0.50
240	BPCa	13320	8	15.4	150	2309	0.88
241	IgrRCa	13470	8	16.4	50	818	0.73
242	Igr	13520	8	16.4	30	491	0.44
243	IgrRCb	13550	8	16.4	107	1750	0.82
244	Pool	13657	8	19.2	49	943	1.17

245	BPCa	13706	8	15.4	90	1385	0.82
246	LgrRCa	13796	8	26.0	120	3117	0.35
247	Gld	13916	8	17.3	40	693	0.44
248	lhgr	13956	8	18.3	39	713	0.29
249	BPCa	13995	8	18.3	51	932	0.79
250	Igr	14046	8	14.4	24	346	0.59
251	Gld	14070	8	17.3	77	1333	0.59
252	BPCa	14147	9	14.4	52	750	0.88
253	Gld	14199	9	18.3	64	1170	0.65
254	Igr	14263	9	17.3	73	1264	0.59
255	Pool	14336	9	21.2	74	1566	0.94
256	Gld	14410	9	19.2	18	346	0.82
257	Igr	14428	9	18.3	23	420	0.35
258	Gld	14451	9	19.2	35	673	0.50
259	Lgr	14486	9	17.3	37	641	0.29
260	IgrRCb	14523	9	13.5	123	1657	1.03
261	Hgr	14646	9	16.4	62	1014	0.38
262	IgrRCa	14708	9	16.4	75	1227	0.59
263	Gld	14783	9	19.2	25	481	0.35
264	Igr	14808	9	18.3	31	567	0.29
265	IgrRCa	14839	9	15.4	38	585	1.03
266	Igr	14877	9	17.3	30	519	0.44
267	IgrRCa	14907	9	28.9	42	1212	0.67
268	Igr	14949	9	17.3	17	294	0.44
269	IgrRCa	14966	9	15.4	34	523	0.67
270	Gld	15000	9	18.3	34	621	0.44
271	Igr	15034	9	17.3	34	589	0.41
272	IgrRCa	15068	9	15.4	46	708	0.70
273	Igr	15114	9	17.3	62	1074	0.38
274	IgrRCa	15176	9	17.3	58	1004	0.73
275	Pool	15234	9	22.1	20	443	1.03
276	Gld	15254	9	20.2	30	606	0.59
277	Igr	15284	9	18.3	26	475	0.29
278	Gld	15310	9	18.3	12	219	0.44
279	Igr	15322	9	17.3	22	381	0.38
280	Gld	15344	9	17.3	17	294	0.44
281	Igr	15361	9	17.3	16	277	0.38
282	IgrRCa	15377	9	14.4	67	967	0.88
283	Gld	15444	9	18.3	40	731	0.47
284	IHgr	15484	9	16.4	20	327	0.44
285	IgrRCa	15504	9	15.4	91	1401	0.82
286	Gld/Pool	15595	9	20.2	206	4162	0.59
287	IgrRCb	15801	9	33.7	47	1583	0.59
288	Pool	15848	9	4.8	10.1	49	0.88
289	Igr	15858	9	13.5	92	1239	0.44
290	IgrRCa	15950	9	12.5	43	538	0.59
291	Igr	15993	9	13.5	21	283	0.44
292	Gld	16014	9	15.4	38	585	0.38
293	Lgr	16052	9	14.4	24	346	0.47
294	Gld	16076	9	18.3	22	402	0.59

295	LgrRCa	16098	9	15.4	30	462	0.59
296	Gld	16128	9	16.4	36	589	0.56
297	LgrRCa	16164	9	15.4	16	246	0.59
298	Igr	16180	9	17.3	73	1264	0.44
299	HgrRa	16253	9	12.5	33	413	0.73
300	Igr	16286	10	9.6	56	539	0.29
301	BPCa	16342	10	14.4	55	794	0.88
302	Gld (mostly)	16397	10	14.4	23	332	0.88
303	ILgrRCa	16420	10	15.4	163	2509	0.67
304	HgrRCa	16583	10	9.6	63	606	1.11
305	Gld	16646	10	17.3	51	883	0.59
306	Igr	16697	10	25.0	69	1726	0.53
307	IgrRCa	16766	10	14.4	21	303	0.82
308	Lgr	16787	10	14.4	30	433	0.50
309	Gld	16817	10	16.4	28	458	0.59
310	IHgr	16845	10	15.4	24	369	0.29
311	Gld	16869	10	13.5	64	862	0.53
312	Igr	16933	10	15.4	68	1047	0.59
313	Gld	17001	10	19.2	237	4560	0.44
314	IgrRCa	17238	10	28.9	137	3954	0.53
315	Lgr	17375	10	14.4	102	1472	0.59
316	IgrRCa	17477	10	13.5	36	485	0.82
317	Gld	17513	10	15.4	59	908	0.53
318	Igr	17572	10	11.5	18	208	0.29
319	Gld	17590	10	17.3	59	1022	0.44
320	Igr	17649	10	14.4	22	317	0.29
321	Gld	17671	10	17.3	198	3429	0.38
322	IgrRCa	17869	10	9.6	56	539	0.73
323	Gld	17925	10	17.3	29	502	0.73
324	IgrRCa	17954	10	13.5	59	795	0.73
325	Igr	18013	10	17.3	61	1056	0.53
326	LgrGldCa	18074	10	15.4	188	2894	0.73
327	Gld	18262	10	18.3	117	2139	0.47
328	Igr	18379	10	14.4	36	519	0.35
329	Gld	18415	10	16.4	115	1881	0.53
330	HgrRCa	18530	10	11.5	133	1535	0.73
331	Gld	18663	10	16.4	77	1259	0.53
332	IHgr	18740	10	13.5	18	242	0.29
333	Gld	18758	10	19.2	118	2270	0.59
334	IgrRCb	18876	10	14.4	133	1919	0.70
335	Gld	19009	10	16.4	135	2208	0.59
336	ILgr	19144	10	16.4	152	2486	0.59
337	Gld	19296	10	20.2	100	2020	0.67
338	Igr	19396	11	16.4	58	949	0.59
339	Gld	19454	11	28.9	129	3723	0.73
340	Igr	19583	11	16.4	33	540	0.59
341	BPCb	19616	11	22.1	50	1106	1.03
342	IgrRCa	19666	11	15.4	144	2217	0.82
343	LgrGldCa	19810	11	25.0	157	3927	0.59
344	Igr	19967	11	38.5	87	3348	0.59

345	LgrGldCa	20054	11	18.3	174	3180	0.70
346	Igr	20228	11	16.4	40	654	0.59
347	Gld	20268	11	17.3	105	1818	0.70
348	Igr	20373	11	16.4	75	1227	0.59
349	Gld	20448	11	17.3	108	1870	0.70
350	Igr	20556	11	16.4	130	2126	0.59
351	Gld	20686	11	18.3	31	567	0.67
352	LgrGldCa	20717	11	16.4	84	1374	0.53
353	Igr	20801	11	14.4	156	2251	0.59
354	LgrGldCa	20957	11	18.3	68	1243	0.73
355	Gld	21025	11	19.2	227	4368	0.82
356	Igr	21252	11	15.4	22	339	0.59
357	Gld	21274	11	18.3	20	366	0.76
358	LgrRCa	21294	11	15.4	71	1093	0.73
359	Igr	21365	11	15.4	42	646	0.67
360	LgrGldCa	21407	11	16.4	121	1979	0.88
361	LgrRCa	21528	11	17.3	154	2667	0.88
362	LgrGldCa	21682	11	19.2	107	2059	0.67
363	Igr	21789	11	19.2	23	443	0.53
364	LgrGldCa	21812	11	20.2	92	1859	0.82
365	LgrRCa	21904	11	16.4	62	1014	0.73
366	LgrGldCa	21966	11	17.3	74	1281	0.59
367	Igr	22040	12	15.4	88	1355	0.67
368	IgrRCb	22128	12	14.4	103	1486	0.97
369	LgrRCa	22231	12	16.4	42	687	0.88
370	IgrRCa	22273	12	24.1	302	7263	0.73
371	Igr	22575	12	21.2	116	2455	0.59
372	Gld	22691	12	19.2	144	2771	0.82
373	IgrRCa	22835	12	17.3	24	416	0.88
374	Igr	22859	12	24.1	138	3319	0.59
375	LgrGld Ca	22997	12	25.0	239	5978	0.82
376	Igr	23236	12	17.3	62	1074	0.59
377	Gld	23298	12	21.2	52	1101	0.73
378	LgrGldCa	23350	12	18.3	183	3345	0.88
379	Igr	23533	12	19.2	23	443	0.82
380	Gld	23556	12	24.1	139	3343	0.88
381	IgrRCa	23695	12	12.5	113	1413	0.88
382	Gld	23808	12	21.2	47	995	0.82
383	Igr	23855	12	16.4	18	294	0.73
384	Gld	23873	12	17.3	72	1247	0.73
385	Lgr	23945	12	16.4	22	360	0.82
386	Gld	23967	12	18.3	44	804	0.73
387	IgrRCa	24011	12	16.4	38	621	0.94
388	Igr	24049	12	23.1	35	808	0.82
389	Gld	24084	12	25.0	121	3027	0.88
390	IgrRCa	24205	12	9.6	80	770	0.73
391	Igr	24285	12	11.5	64	739	0.59
392	Gld	24349	12	26.0	163	4234	0.88
393	LgrRCa	24512	12	9.6	147	1414	0.88
				16	63	1054	0.61

Appendix II

Large Woody Debris (LWD) Data

Channel Unit #	Channel Unit	Distance Downstream From Spruce (m)	Stream Segment	LWD short/skinny	LWD short/medium	LWD short/fat	LWD long/skinny	LWD long/medium	LWD long/fat	Relative Volume of LWD	Rootwads and other LWD
1	Gld	0	4	1						1	exposed
2	IgrRCa	55	4	1		5				6	exposed
3	Debris	124	4	1			2	4	6	13	
4	Igr	205	4	1				8	12	21	*(8/3/2)
5	Gld	268	4	1				8	12	21	
6	IgrRCa	290	4	1			2			3	*rr-debris
7	BPRCb	311	4	1	3	5				9	*rr-debris
8	IgrRCa	345	4	1				4	6	11	*rr-debris
9	Gld	385	4	2						2	
10	IHgr	459	4			5				5	
11	IgrRCa	486	4					8	12	20	*(3/2/3)
12	IHgr	513	5	1						1	
13	BPRCa	538	5					8	12	20	*(1/1/1)
14	Igr	609	5	1						1	*(sml)
15	Gld	638	5	1						1	
16	IgrRCa	661	5		3					3	
17	Gld	672	5	1						1	
18	IgrRCa	694	5	1						1	*(8/5/5)
19	BPRCa	757	5		6					6	
20	IgrRCa	814	5	1						1	
21	Gld	879	5			5				5	
22	IgrRCa	925	5	1		5				6	
23	Igr	951	5				2	8		10	
24	IgrRCa	968	5		3					3	
25	Gld	978	5	1						1	
26	Lgr	998	5							0	*(sml)
27	Gld	1010	5	1						1	
28	IgrRCa	1035	5					4	6	10	*(2/2/4)
29	Gld	1052	5	1						1	
30	Lgr	1097	5	1	3		2			6	
31	Gld	1124	5		6					6	
32	IgrRCa	1173	5	1		10	4			15	
33	Gld	1198	5	1						1	
34	Igr	1223	5	1	3		2			6	*(sml)
35	Gld	1275	5		3					3	
36	IgrRCa	1350	5		3					3	
37	Igr	1416	5			5	2			7	
38	IgrRCa	1428	5	1			2			3	
39	BPRCa	1479	5	1	3		2	4		10	
40	IgrRCa	1591	5					4		4	*(2/1/1)
41	Igr	1667	5				4	4		8	*(6/3/2)
42	IgrRCa	1697	5					4		4	
43	Lgr	1790	5		6					6	
44	IHgr	1829	5		3		2			5	
45	IgrRCa	1906	5				4			4	
46	Igr	2013	5		3				12	15	
47	IgrRCa	2065	5	1			4	4	18	27	*(1/1/1)

48	Gld	2211	5				4			4	
49	Igr	2328	5			3				3	
50	IgrRCa	2353	5			3				3	*
51	Igr	2394	5				5		12	17	
52	IgrRCa	2429	5					4	6	10	
53	Igr	2513	5	1				2		3	
54	Gld	2557	5	1						1	
55	Lgr	2576	5	1	3					4	
56	Gld	2584	5		3					3	
57	Igr	2594	5	1				2		3	
58	IgrRCa	2663	5	1	6				18	25	
59	Gld	2695	5	1	3	5	2		18	29	*(3/3/5)
60	Igr	2754	5						4	6	10
61	IgrRCa	2803	5		3		2			18	23
62	Hgr	2874	5							6	6
63	BPRCa	2906	5	1							1
64	IgrRCa	2957	5		6	5	2	4	12	29	**(2/1/1)
65	Igr	3153	5	1					6		7
66	HIgr	3208	5	1							1
67	BPRCa	3262	5	1							1
68	Gld	3307	5	1	3				6		10
69	IgrRCa	3333	5	1					6		7
70	Igr	3468	5	1	6						7
71	GLd	3501	5	1							1
72	Igr	3549	5				2				2
73	IgrRCa	3642	5					8	6		14
74	Igr	3737	5		3				6		9
75	BPRCa	3810	5			5		4			9
76	Gld	3846	5	1	3			4	6		14
77	ILgr	3914	5	1					12		13
78	IgrRCb	3976	5	2		5			12		19
79	IgrRCa	4086	6	2							2
80	IgrRCa	4240	6	3		5					8
81	ILgr	4295	6						6		6
82	IgrRCa	4310	6	1	6	5			6		18
83	Igr	4334	6	1				4	6		11
84	IgrRCa	4360	6	1		5					6
85	Igr	4406	6	1							1
86	Gld	4505	6					4	6		10
87	Igr	4615	6	1	3						4
88	IgrRCa	4638	6	1			2				3
89	Lgr	4725	6				2				2
90	IgrRCa	4760	6	1	6						7
91	Igr	4801	6		3						3
92	IgrRCa	4839	6				2	4	6		12
93	Igr	4883	6				4				4
94	Hgr	4893	6	1							1
95	BPRCa	4920	6				2				2
96	Gld	5027	6								0
97	Lgr	5056	6								0
98	Igr	5120	6				4				4
99	BPRCa	5140	6								0
100	Lgr	5222	6								0
101	Igr	5301	6	2			2				4
102	IgrRCa	5316	6	1							1

103	Igr	5335	6							0	
104	Igr	5348	6				2		6	8	*(4/3/2)
105	BPRCa	5356	6							0	
106	Hgr	5431	6							0	
107	BPRCa	5441	6							0	
108	LgrGldCa	5468	6	1						1	
109	IgrRCa	5506	6	1	3		2	4	6	16	
110	LgrGldCa	5641	6	1						1	
111	Igr	5685	6	1	3	5	2			11	
112	Gld	5729	6							0	
113	BPRCb	5797	6			10				10	
114	Gld	5822	6		3	5	2		6	16	
115	Igr	5851	6		3		2		6	11	
116	IgrRCa	5897	6	1	3	5		4		13	
117	Gld	5945	6	1						1	
118	BPRCa	5980	6	1				4		5	
119	LgrGldCa	6056	6	1						1	
120	Igr	6122	6	1		10				11	
121	Gld	6176	6		3					3	
122	IgrRCa	6222	6	1						1	
123	Gld	6296	6	1				4		5	*(2/2/2)
124	IgrRCa	6324	6	1						1	
125	Gld	6398	6		3					3	
126	Lgr	6438	6	1		5		4		10	** (sml)
127	LgrGldCa	6482	6	1	3		2	8		14	** (3/3/5)
128	BPRCa	6512	6	1						1	
129	LgrRCa	6622	6	1	3					4	
130	LgrRCa	6660	6	1						1	
131	Igr	6761	6	1					6	7	
132	LgrRCa	6798	6	1	3	5	2			11	*(3/5/2)
133	BPRCa	6866	6	1						1	
134	Gld	6900	6	1			2			3	
135	LgrGldCa	6917	6	1						1	
136	Igr	6962	6	1	3					4	
137	LgrRCa	7012	6	1		5			6	12	*rr-tie
138	Igr	7074	6	1						1	
139	Gld	7145	6	1			2			3	
140	LgrRCa	7197	6	1					6	7	
141	Gld	7243	6	1	3	5	2	4	6	21	*2x's
142	IgrRCa	7327	6	1	3		2			6	
143	Lgr	7385	6	1	3	5	2	4	6	21	*3/5/8
144	Gld	7436	6	1	3					4	
145	IgrRCa	7507	6							0	
146	LgrGldCa	7572	6					4	6	10	
147	Igr	7667	6	1						1	
148	LgrGldCa	7697	6		3	5			6	14	
149	BPRCb	7728	6	1	3	5				9	
150	IgrRCa	7766	6			5				5	
151	Gld	7832	6	1	3	5	2			11	
152	LgrRCa	7878	6	1		5	2			8	*15/8/3
153	IgrRCa	7965	6	1	3	5	2	4	6	21	
154	Gld	8036	6						6	6	
155	LgrRCa	8098	6	1		5				6	
156	Gld	8140	6	1	3	5	4	4	6	23	*in-stream debris

157	Lgr	8386	7	1						1	*1/3/2
158	Gld	8430	7	1	3		2	8		14	
159	Igr	8510	7			5	2	4		11	
160	Gld	8552	7	1		5	2			8	
161	LgrGldCa	8613	7	1	3					4	
162	IgrRCa	8715	7	1	3		2			6	
163	LgrGldCa	8851	7	1	3		2	8		14	*2x's at lft.
164	Igr	8930	7				2			2	
165	Gld	8963	7	1			2			3	
166	Lgr	9020	7	1						1	
167	Gld	9054	7	1						1	
168	Igr	9123	7	1		5		4		10	*(1/3/2)
169	LgrGldCa	9157	7	1	3	10			12	26	*rw
170	Igr	9186	7	1			2			3	
171	BPRCa	9219	7	1			2			3	
172	Gld	9336	7	1	3	5		4	6	19	
173	Igr	9566	7	1					6	7	*(sml)
174	LgrGldCa	9652	7	1	3	5	2	4	12	27	*rw
175	BPRCa	9735	7	1	3					4	
176	IgrRCa	9845	7	1	3	5	2	4	12	27	*(25/5/5)
177	LgrRCa	9925	7	1		5			6	12	
178	IgrRCa	9963	7		6		2			8	
179	HgrRCa	10086	7	1	3	5	4	4	6	23	*(vry lrg)
180	LgrRCa	10131	7				2		6	8	*(25/5/3)
181	Igr	10145	7			5	2	4	12	23	*(25/5/3)
182	Gld	10268	7						6	6	
183	BPRCa	10321	7	1	3	5				9	
184	Gld	10365	7	1						1	
185	Igr	10396	7				2		6	8	
186	Gld	10455	7	1			2			3	
187	IgrRCa	10513	7	1	3		2	4		10	
188	Gld	10607	7	1						1	*(sml)
189	Igr	10744	7	1	3		4			8	
190	IgrRCa	10782	7						12	12	
191	Gld	10849	7	1	3		2		6	12	*(1/2/3)
192	LgrGldCa	10997	7	1		5				6	
193	IgrRCa	11035	7	1	3	5	2	4	6	21	** (4/4/15)
194	Gld	11110	7							0	
195	IgrRCa	11132	7					4		4	
196	Igr	11255	7	1			2			3	
197	Gld	11276	7	1	3	5	2	4	6	21	*rw at rt.
198	Igr	11322	7		3					3	
199	Gld	11378	7	1						1	
200	IgrRCa	11427	7	1			2			3	
201	Gld	11528	7	1						1	
202	Igr	11549	7	1						1	
203	Gld	11569	7				2			2	
204	LgrGldC	11589	7	1			2			3	
205	IHgr	11653	7	1	3					4	
206	Pool	11704	7	2	6					8	
207	Gld	11718	7							0	
208	IgrRCa	11784	7	1						1	
209	Gld	11812	7	1						1	
210	Hgr	11835	7	1						1	
211	Gld	11870	7							0	

212	Lgr	11919	7	1	3	5	2	4	6	21	*(vry lrg) at rt.
213	Gld	11956	7	1						1	
214	Lgr	12015	7	1						1	
215	Gld	12031	7	1	3	5	2	4	6	21	*
216	Igr	12079	7	1	3					4	
217	Gld	12103	7		3		2	8	12	25	*(3/2/5)
218	Lgr	12126	7				4			4	
219	Gld	12165	7	1	3					4	
220	Igr	12205	8				2			2	
221	Gld	12252	8							0	
222	IgrRCa	12297	8	1	3	5	2	4	12	27	
223	Gld	12347	8		3					3	*rw
224	Ihgr	12388	8	1	3					4	
225	Pool	12449	8	1	3	5	2		6	17	
226	Gld	12472	8		3					3	
227	IHgr	12505	8							0	** (5/3/2)
228	IgrRCa	12538	8							0	*(lrg)
229	Gld	12624	8	1	3					4	
230	IgrRCa	12770	8	1	3	5				9	
231	Gld	12786	8		3					3	*(1/2/2)
232	IgrRCa	12825	8	1	3	5	2	4	18	33	
Pool/backwater/lago											
233	on	12910	8	1	6					7	*rw(very large)
234	BPRCa	12923	8	1			2			3	
235	Gld	13123	8	1			2			3	*(4/2/3)
236	Hgr	13142	8	1			2			3	
237	IgrRCb	13171	8		3					3	
238	BPRCa	13219	8	1					6	7	
239	Gld	13298	8	1						1	
240	BPRCa	13320	8			5	2	4		11	
241	IgrRCa	13470	8	1			2			3	
242	Igr	13520	8	1	3					4	*(2/2/3)
243	IgrRCb	13550	8	1		5			6	12	*rw(sml)
244	Pool	13657	8		3		2		12	17	
245	BPRCa	13706	8		3	5	2		12	22	*(1/1/2)
246	LgrRCa	13796	8		3			4		7	*good-fair habitat
247	Gld	13916	8		3					3	*
248	Ihgr	13956	8	2				4		6	
249	BPRCa	13995	8		3				6	9	
250	Igr	14046	8	1	6	5	4	4		20	
251	Gld	14070	8	1		5	2			8	
252	BPRCa	14147	9	2			2			4	
253	Gld	14199	9				4			4	
254	Igr	14263	9				2		6	8	
255	Pool	14336	9	2					12	14	*(2/3/1)
256	Gld	14410	9			10			6	16	*(5/5/2)
257	Igr	14428	9				2	4		6	
258	Gld	14451	9							0	*sml rw
259	Lgr	14486	9	1	6					7	*
260	IgrRCb	14523	9	2	6	10	4	8	18	48	** (20/5)
261	Hgr	14646	9							0	
262	IgrRCa	14708	9	1						1	

263	Gld	14783	9	1				4	5		
264	Igr	14808	9	1			2		12	15	
265	IgrRCa	14839	9	1	3			8		12	
266	Igr	14877	9	1					6	7	
267	IgrRCa	14907	9						12	12	
268	Igr	14949	9		3					3	
269	IgrRCa	14966	9			5			6	11	
270	Gld	15000	9	1						1	
271	Igr	15034	9	1			2		6	9	
272	IgrRCa	15068	9				4		6	10	
273	Igr	15114	9	1						1	
274	IgrRCa	15176	9			5		4	12	21	
275	Pool	15234	9	1	3					4	
276	Gld	15254	9	1	3		2			6	*rr tie
277	Igr	15284	9	1						1	
278	Gld	15310	9	1			2	4	6	13	
279	Igr	15322	9		3					3	
280	Gld	15344	9						6	6	*rw sml
281	Igr	15361	9		3					3	
282	IgrRCa	15377	9	1	3				6	10	*(8/3/2)
283	Gld	15444	9	1	3		2			6	
284	IHgr	15484	9	1		5				6	
285	IgrRCa	15504	9	1	3					4	
286	Gld/Pool	15595	9	1	3	5	2	4	6	21	*stick and leaf patch
287	IgrRCb	15801	9	1	3	5	2	4	6	21	*rr tie and rw
288	Pool	15848	9	1	3	5	2	4	6	21	*multiple rw(8/6/2)
289	Igr	15858	9					8	12	20	
290	IgrRCa	15950	9				2			2	
291	Igr	15993	9	1		5		4	6	16	*(3/8/5)
292	Gld	16014	9		3		2			5	
293	Lgr	16052	9		3		2		18	23	*(4/6/4)
294	Gld	16076	9	1	3					4	
295	LgrRCa	16098	9				2			2	
296	Gld	16128	9	1						1	
297	LgrRCa	16164	9	1	3		2		6	12	cool scour at lft.
298	Igr	16180	9							0	*(5/4/3)
299	HgrRa	16253	9	1		5				6	
300	Igr	16286	10			5				5	**(3/5/6)
301	BPRCa	16342	10			10	2	8		20	*(3/3/2)
302	Gld (mostly)	16397	10	1	3	5	2	4	18	33	*(big)
303	ILgrRCa	16420	10				4			4	*(sml)
304	HgrRCa	16583	10		3					3	
305	Gld	16646	10	1	3					4	
306	Igr	16697	10			5	6			11	
307	IgrRCa	16766	10	1		10				11	*(sml)
308	Lgr	16787	10	1						1	
309	Gld	16817	10							0	
310	IHgr	16845	10	2	3		2	4	12	23	*(15/5/8)
311	Gld	16869	10	1						1	
312	Igr	16933	10		3		2			5	
313	Gld	17001	10	1		5				6	

314	IgrRCa	17238	10			5	2		6	13	
315	Lgr	17375	10	1						1	
316	IgrRCa	17477	10							0	*(20/5/4)
317	Gld	17513	10	1	3	5			6	15	*(at top)
318	Igr	17572	10							0	
319	Gld	17590	10	1						1	*3/5/3)
320	Igr	17649	10				2			2	*(3/3/3)
321	Gld	17671	10	1	3	5	2	4	6	21	*(5/3/3) decent riparian
322	IgrRCa	17869	10							0	
323	Gld	17925	10	1	3					4	
324	IgrRCa	17954	10						6	6	
325	Igr	18013	10		3	5	4			12	
326	LgrGldCa	18074	10		3	5				8	
327	Gld	18262	10	1	3	10				14	
328	Igr	18379	10	1				4		5	
329	Gld	18415	10		3	5				8	*(sml at lft.)
330	HgrRCa	18530	10	1	3	5		4	12	25	*lots of back water debris
331	Gld	18663	10	1	3		2			6	
332	IHgr	18740	10	1	3	5	2			11	
333	Gld	18758	10	1	3	5		4	6	19	*rr-tie
334	IgRCb	18876	10	1		5			12	18	*good debris
335	Gld	19009	10	1						1	
336	ILgr	19144	10		3	10	2			15	*debris at bottom rt.
337	Gld	19296	10	1						1	
338	Igr	19396	11	1	3			4	6	14	
339	Gld	19454	11					4	6	10	*rr-tie
340	Igr	19583	11	1				4	6	11	
341	BPRCb	19616	11			5				5	*(high)rt.
342	IgrRCa	19666	11		3					3	
343	LgrGldCa	19810	11	1	3					4	*(at bottom rt.)
344	Igr	19967	11				4			4	
345	LgrGldCa	20054	11	1	3	5				9	*rr-tie
346	Igr	20228	11		3					3	
347	Gld	20268	11							0	
348	Igr	20373	11	1						1	
349	Gld	20448	11	1						1	
350	Igr	20556	11	1						1	
351	Gld	20686	11	1		5		4		10	*(12/3/2)
352	LgrGldCa	20717	11	1	3				6	10	
353	Igr	20801	11	1						1	
354	LgrGldCa	20957	11	1	3					4	*(sml)
355	Gld	21025	11	1			4			5	
356	Igr	21252	11							0	
357	Gld	21274	11	1						1	
358	LgrRCa	21294	11	1						1	
359	Igr	21365	11	1						1	
360	LgrGldCa	21407	11	1			2		6	9	
361	LgrRCa	21528	11	1	6					7	
362	LgrGldCa	21682	11						12	12	*(3/1/1)
363	Igr	21789	11				2			2	

364	LgrGldCa	21812	11	1	3		2			6	
365	LgrRCa	21904	11	1	3			4		8	
366	LgrGldCa	21966	11	1						1	
367	Igr	22040	12	1						1	
368	IgrRCb	22128	12	1	3	5				9	
369	LgrRCa	22231	12	1	3	5	2	4	6	21	*(14/5/3)
370	IgrRCa	22273	12	1	3	5				9	*rr-tie
371	Igr	22575	12	1			2			3	
372	Gld	22691	12	1	3	5	2	4	6	21	*(5/3/6)
373	IgrRCa	22835	12		3	5	2	4	12	26	
374	Igr	22859	12	1						1	
375	LgrGld Ca	22997	12				2			2	
376	Igr	23236	12					8	12	20	**(3/3/4)
377	Gld	23298	12		6			4		10	
378	LgrGldCa	23350	12	1	3		2	4		10	*(3/1/1)
379	Igr	23533	12	1						1	
380	Gld	23556	12							0	
381	IgrRCa	23695	12							0	
382	Gld	23808	12						6	6	*(3/2/2)
383	Igr	23855	12							0	
384	Gld	23873	12							0	
385	Lgr	23945	12							0	
386	Gld	23967	12							0	
387	IgrRCa	24011	12	2	3					5	
388	Igr	24049	12							0	
389	Gld	24084	12							0	
390	IgrRCa	24205	12		3					3	
391	Igr	24285	12				2	8	6	16	
392	Gld	24349	12	1	3	5	2	4	6	21	
393	LgrRCa	24512	12	1						1	*(3/3/2)
										2926	