CHANNEL MORPHOLOGY, SUBSTRATE VARIABILITY, AND BEDROCK INFLUENCE IN THE JAMES RIVER, SOUTHWEST MISSOURI OZARKS

A Masters Thesis

Presented to

The Graduate College of

Missouri State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science, Geospatial Sciences in Geography and Geology

By

Andrew Robert DeWitt

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CHANNEL MORPHOLOGY, SUBSTRATE VARIABILITY, AND BEDROCK INFLUENCE IN THE JAMES RIVER, SOUTHWEST MISSOURI OZARKS

Geography, Geology, and Planning

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ABSTRACT

Channel morphology equations (CMEs) quantify downstream trends in channel variables and are useful for planning stream restoration designs and comparing river geomorphology among various regions. In the Ozarks, few studies exist that quantify stream characteristics, and a watershed-scale geomorphic study of rivers in southwest Missouri is currently lacking. The purpose of this research is to use CMEs to quantify channel form, substrate variability, and valley scale characteristics in the James River basin (3,771 km^2). Specifically, the objectives are to: (1) quantify bankfull and longitudinal channel characteristics using channel form, substrate, and geospatial measurements coupled with USGS gage calibration; (2) develop channel morphology and stream power equations and evaluate sampling error and natural geomorphic variability; and (3) examine the influence of geologic controls on channel form and stream power. Field data were collected and analyzed from 17 sites along the main stem of the James River spanning a range of drainage areas from 6 to 2,530 km^2. Results indicate bankfull channels in the James River contain the 1.1 to 1.5 year recurrence interval flood. Channel variables are strongly related to drainage area with r^2 values >0.90 for equations describing cross-sectional area, discharge, depth, riffle spacing, and pool length. Poorly fitting equations for other variables are explained by variable influence of bedrock controls. Median sediment size slightly increases downstream due to tributary and bluff sediment inputs and non-linear downstream stream power trends. The CMEs produced by this research are useful for restoration designs and provide a base from which to further quantify channel forms and processes in the Ozarks.

KEYWORDS: Ozarks river, channel morphology, bankfull, restoration, bedrock control

This abstract is approved as to form and content

Robert T. Pavlowsky
Chairperson, Advisory Committee
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CHAPTER 1

INTRODUCTION

Research in the field of fluvial geomorphology explains stream channel forms and processes as they relate to and vary with geology, climate, and human activities (Montgomery, 1997, 1998; Schumm, 2005). Geomorphic studies of stream channel characteristics provide information for a variety of uses including flood analysis, bank stability and sedimentation assessments, and restoration designs. In general, channel characteristics typically vary in the downstream direction in undisturbed, self-forming alluvial rivers with increasing flow volumes, associated with contributing drainage area, forming progressively larger channel dimensions (Fig. 1). Moreover, variations in discharge or hydrologic regime, slope, and sediment supply and transport are responsible for shaping a channel (Leopold and Maddock, 1953; Dunne and Leopold, 1978; Knighton, 1998). Therefore, rivers tend toward an equilibrium state based on water and sediment inputs given the climatic and geologic controls present within the drainage basin (Schumm and Lichty, 1965; Wolman and Gerson, 1978). Any changes that alter the natural processes governing sediment inputs or flow characteristics, such as changes in land-use, climate, or tectonic uplift can affect stream channel morphology (Wolman, 1967; Booth, 1990; Booth, 1991; Clark and Wilcock, 2000; Doyle et al., 2000). Longitudinal trends in channel form may also be influenced by artificial structures, bedrock beds or obstacles, or valley confinement.

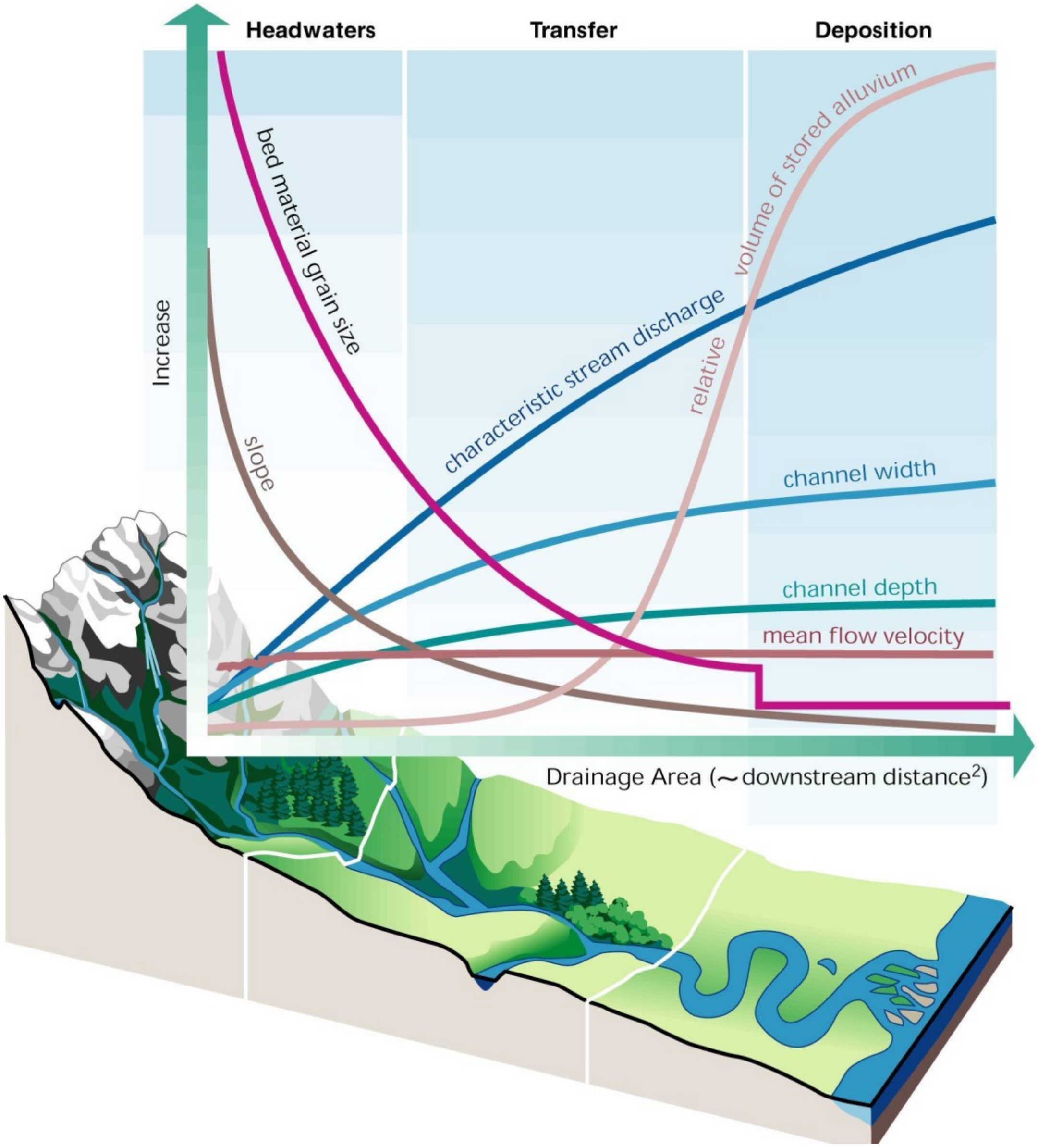


Figure 1. General trends in a fluvial system (from FISRWG, 1998).

Whereas channel variables such as width, depth, cross-sectional area, and meander wavelength generally increase with increasing drainage area (downstream), channel slope decreases (Knighton, 1998). As slope decreases downstream, so does the relative ability of the channel to transport large bedload material, which often leads to a downstream fining of bed sediment. Furthermore, in meandering alluvial rivers, riffle and pool forms tend to naturally occur at a spacing of five to seven channel widths (Leopold and Wolman, 1957; Leopold et al., 1964). However, these channel features may be variable due changes in sediment supply from tributaries, or local to valley-scale influences previously discussed. Given the multiple-scale factors involved in channel form and behavior, geomorphic models are needed to understand channel variability at both the reach and watershed scale. One way to quantify general relationships and determine variability within a fluvial system is by generating channel morphology equations. Empirically-based channel morphology equations (CMEs) relate physical stream characteristics to hydrologic variables, such as discharge or drainage area and may also imply formative processes.

Channel Morphology Equations (CMEs)

Downstream hydraulic geometry relationships and regional curves are two common examples of CMEs, and these have been developed and documented by various researchers including academics and state and federal government agencies (Castro and Jackson, 2001; Doll et al., 2002; Cinotto, 2003; Lawlor, 2004; Chaplin, 2005; Mulvihill and Baldigo, 2007). Hydraulic geometry equations and regional curves typically utilize a single predictor such as drainage area or bankfull discharge as a scaling-variable to correlate with channel features. These equations are generated by evaluating geomorphic data for many streams within the same region (often physiographic) or watershed. They are typically power function (log-log) regression models, and have become increasingly important for stream restoration projects, flood predictions, and in making comparisons among watersheds in order to gain an understanding of fluvial systems and upland processes (Wharton, 1995). Where available, CMEs allow scientists, engineers, and planners to utilize stable reach morphology data as a template to restore unstable reaches as opposed to implementing practices that are known to create ecological problems such as channelization or hardening banks (Doll et al., 2002; Mulvihill and Baldigo, 2007). Using natural channel models for restoration purposes is also likely to be more cost effective and require less maintenance over time (Hey, 1997).

CMEs may also be used to compare rivers in areas with different land-use practices (urban, rural, agricultural, and forested environments) and to assess the effects of land use on channel forms and processes (Doll et al., 2002; Horton, 2003). It is important to quantify channel characteristics in physiographic region-specific localities in order to understand the response of waterways to anthropogenic factors such as urbanization or climate change. As such, CMEs must be created using channel data typical of the system under the prevailing watershed conditions. The effects of urbanization on channel features, for example, are well established in the literature (Wolman, 1967; Booth, 1990; Pizzuto et al., 2000), and in relatively large watersheds, mixing of urban and rural channel data may not yield accurate CMEs. Finally, as is the case with all regression equations, they may only be used reliably in the types of streams and watersheds that were used to create them.

Bankfull Channel Concept

Channel morphology equations commonly utilize the bankfull stage, the elevation where floodwaters fill the stream channel up to its banks while still being contained within the channel (Woodyer, 1968; Williams, 1978; Rosgen, 1996; Emmett and

Wolman, 2001; Sweet and Geratz, 2003) (Fig. 2). The discharge associated with the bankfull stage at a given cross-sectional area in a stream thus marks the discharge before overbank flooding occurs. Dunne and Leopold (1978) determined using a flood frequency analysis that the bankfull stage occurs at an interval of 1.5 years, and this is the generally accepted value for the bankfull recurrence interval. However, other studies have determined that the recurrence interval of the bankfull stage is variable and may range from 0.19 to 20 years, varying with climate, sediment characteristics, and disturbance history as well as the geomorphic assessment method used (Williams, 1978; Nash, 1994; Petit and Pauquet, 1996; Sweet and Geratz, 2003). The bankfull discharge is important because it is most responsible for shaping and maintaining the channel (Benson and Thomas, 1966; Dunne and Leopold, 1978; Williams, 1978). Although large flooding events move greater amounts of sediment in short periods of time, it is the moderate magnitude bankfull floods that mobilize the most sediment annually (Wolman and Miller, 1960). Since this discharge transports the most sediment over time, and is responsible for shaping the channel bed and banks, it is also known as the effective or dominant discharge and is therefore used for creating channel morphology equations.

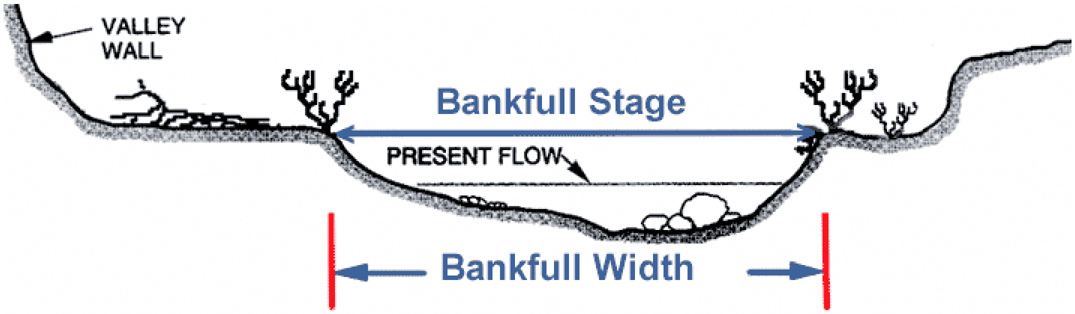


Figure 2. Schematic of the bankfull channel (from Newbury and Gaboury, 1993).

Stream Power

Although channel size and planform variables tend to increase with drainage area and bankfull discharge, stream power, the power available to mobilize sediment and do geomorphic work, can vary downstream (Bagnold, 1966; Bull, 1979; Rhoads, 1987). There are two different types of stream power, cross-sectional and mean stream power, calculated using the following equations:

Cross-sectional stream power = y Q S (power per unit length in W/m)
Mean stream power = y R S V (power per unit wetted area of the bed in W/m^2)

Where y is the specific weight of the fluid (9,810 N/m^3 for sediment-free water), Q is discharge (m^3/s), S is channel slope (m/m), R is the hydraulic radius (m), and V is mean velocity (m/s; calculated using Manning's equation). Cross-sectional stream power, commonly referred to as total stream power, reflects the transport capacity or how much sediment a stream can potentially move. This value represents the amount of fine-grained sediment a stream can transport. Mean stream power is the intensity of power and reflects the transport competence or the largest diameter that can be moved by a stream. Thus, downstream changes in stream power can directly influence sedimentation and sediment size characteristics in streams (Bagnold, 1966; Graf, 1983; Rhoads, 1987). Low stream power may imply deposition or sediment storage, whereas high stream power may mean that the stream is capable of transporting more and larger-sized sediment.

In a classic study in the Henry Mountains in Utah, Graf (1983) determined that total stream power may vary spatially and temporally within the same fluvial system. Using historical records and field data, Graf (1983) indicates variations in stream power in the downstream direction due to changes in channel dimensions and slope prior to and after an exceedingly erosive flood event. This work suggests that (in semi-arid streams) channel form is controlled by channel processes during extreme flooding events, whereas otherwise forms control processes. Furthermore, in a study on the Blue River in the Driftless Area of Wisconsin, Leece (1997a,b) determined that both cross-sectional and mean stream power values exhibited non-linearity in the downstream direction. Mid-basin locations displayed greatest stream power values where the valley was confined and channel gradients were the greatest due to changes in lithologic properties. Leece (1997a,b) linked these greater stream power values to decreased sediment storage in comparison to upper and lower reaches with comparatively lower stream power values. Results presented in these and numerous other studies suggest the importance of understanding downstream changes in stream power when analyzing trends in channel form and substrate characteristics in association with geologic and other valley-scale controls.

Geologic Controls on Channel Morphology

The majority of research in fluvial geomorphology prior to twenty years ago focused on alluvial rivers (Ashley et al., 1988; Wohl and Merritt, 2001). More recently, however, much attention has been given to bedrock/mountain river channel morphology and making comparisons between alluvial and bedrock systems. This work has involved, in part, determining whether bedrock/ mountain rivers behave as alluvial rivers in terms of developing meander geometry or downstream hydraulic geometry relationships previously only documented in self-forming, lowland alluvial rivers (Ashley et al., 1988; Montgomery and Gran, 2001; Wohl and Merritt, 2001; Wohl, 2004; Wohl et al., 2004;

Wohl and Wilcox, 2005; Turowsky et al., 2008). Results of this collective work indicate that bedrock channels generally do show developed downstream hydraulic geometry relationships where a balance between driving and resisting forces is exhibited. The definition of what constitutes a bedrock channel has also been debated, but generally bedrock channels cannot change or shift their beds without eroding bedrock (Turowsky et al., 2008).

The effects of bedrock on present-day channel morphology are fairly intuitive. Where channels lack resistant (bedrock) bed and bank materials less time and energy is required for the channel to change its shape or planform. In contrast, bedrock channels possess higher thresholds for geomorphic change under the same driving hydraulic forces and channel deepening, widening, or lateral migration may be hindered in these areas at timescales associated with human activities (years to decades). At the reach-scale, bedrock also plays an important role in longitudinal bedform patterns and variability as a forcing factor influencing pool depth, riffle spacing, and local slope (Montgomery and Buffington, 1998). Other geologic and valley scale controls may also influence channel morphology, response, and stability at various scales (Montgomery and Buffington, 1998; Montgomery and MacDonald, 2002). Where channels meet bedrock bluffs, secondary (helical) flow circulations promote scouring and deepen the channel into large, stable 'bluff' pools that generally contain large (cobble to boulder size) bed material (Lisle, 1986; Rabeni and Jacobson, 1993). Also, wide valleys generally allow for higher volumes of overbank sediment deposition whereas narrow valleys promote erosion and sediment transport (Magilligan, 1985). Finally, valley width may influence bed elevation (Jacobson and Gran, 1999) and riffle substrate size, location, persistence, and spacing

(McKenny, 1997 in White et al., 2010; Coulombe-Pontbrianb and Lapointe, 2004; White et al., 2010).

Purpose and Objectives

Rivers in the Ozark Highlands physiographic region (Ozarks) are influenced by bedrock, both in the channel bed and valley/bank walls, and an abundance of chert gravel. The Ozarks drain the Springfield and Salem Plateaus and the Boston and St. Francois Mountain sub-regions (Fig. 3). Although streams in this region possess varying degrees of bedrock control, channels generally posses lower gradients than the typical, well published bedrock systems found in mountainous regions further west. Due to bedrock presence, ample chert gravel supply, and relatively confined valleys, Ozarks rivers offer unique fluvial environments to study to gain a better understanding of these influences on channel morphology and process. However, Ozarks stream research is currently underrepresented in the literature compared to other regions (Pacific Northwest and northeast United States, for example). A watershed-scale geomorphic study that quantifies downstream trends, reach scale variability, and valley scale controls on channel morphology and substrate characteristics is presently lacking in the Ozarks.

The purpose of this study is to use channel morphology equations (CMEs) to quantify channel form, substrate variability, and valley scale characteristics in the James River Basin of southwest Missouri. Specifically, the objectives of this study are to: (1) quantify bankfull and longitudinal channel characteristics using channel form and sediment measurements coupled with USGS gage calibration; (2) develop CMEs and evaluate sampling error and natural channel variability on equation precision; and (3) describe the influence of geologic controls on channel form and stream power where evident.

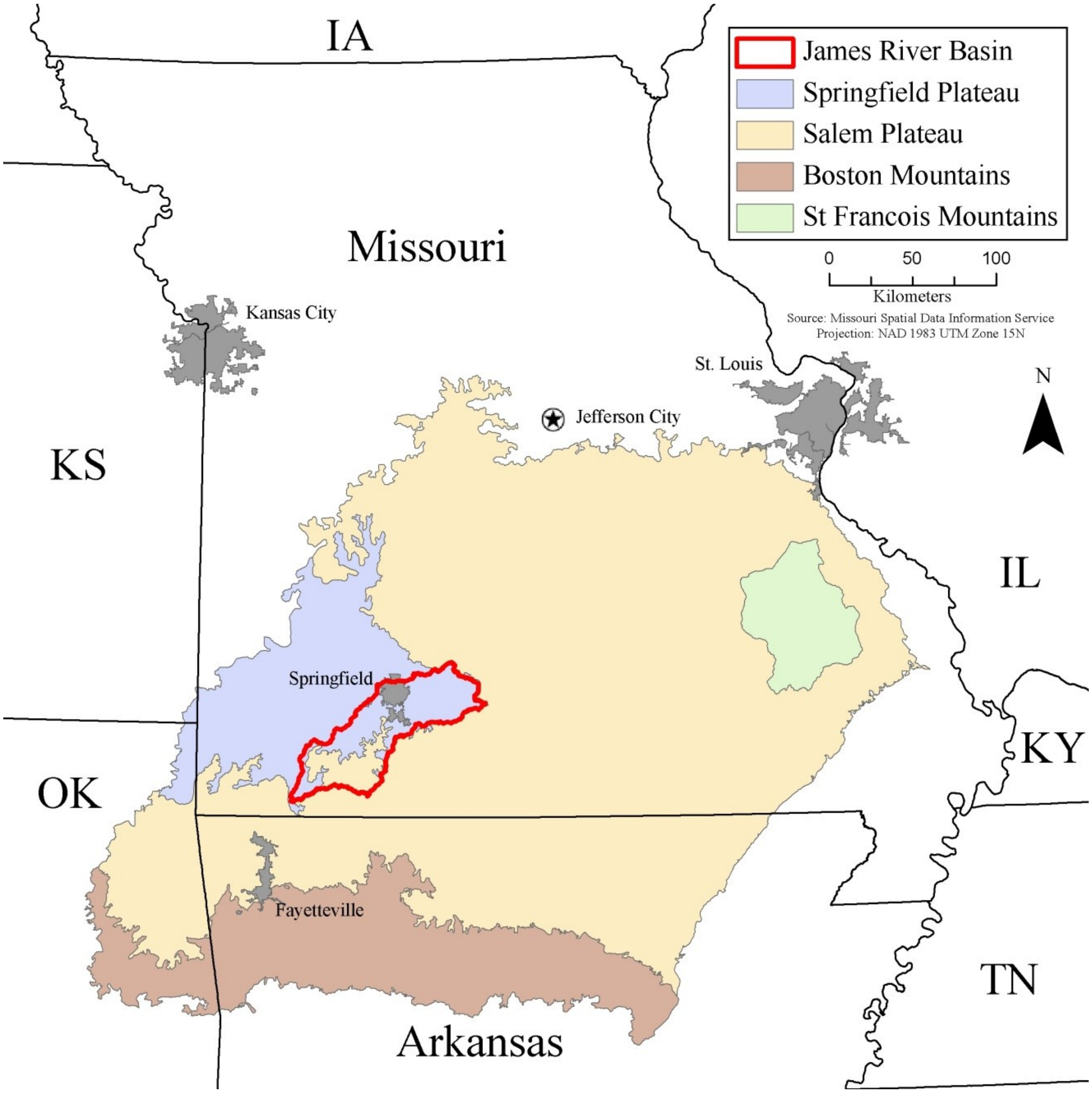


Figure 3. Ozark Highlands Physiographic region and sub-regions.

There are several benefits provided by the results of this study. First, it is the first study to examine downstream trends and variability in channel form, substrate size, and stream power in an Ozarks river influenced bedrock and ample gravel bedload. The James River watershed is unique since it drains an extensive karst limestone area of higher relief compared to the Ozarks in southern Missouri, northern Arkansas, northeast Oklahoma, and southeast Kansas (Rafferty, 2001). Second, the data base created from this work quantitatively describes the geomorphic characteristics (morphology, substrate size, geologic and valley-scale controls, etc.) of a sub-region of the Ozarks not previously studied. Third, this study fills a gap in geomorphic knowledge of rivers that will be compared and contrasted with other studies in the Ozarks and Midwest region in general to develop a better understanding of the continuum of geomorphic process and form. Finally, there are significant concerns over water quality, aquatic habitat condition, and river management since the James River drains one of the fastest growing areas in the country, including Springfield, the third largest city in Missouri, with a population of ~160,000 and area of ~212 km^2 (U.S. Census Bureau, 2012). This study provides management benefits by providing geomorphic models useful for restoration design and habitat improvements and describing channel behavior in an area where there is concern about fine and coarse sediment sources and water quality problems.

Ozarks River Geomorphology

Previous work in fluvial geomorphology in the Ozarks has fallen into several broad categories including (i) historical disturbances and channel response, (ii) watershed scale planform patterns, (iii) floodplain sedimentation, (iv) linking channel morphology to physical habitat, and (v) the effects of recent urbanization on small tributaries.

One effort in river studies in the Ozarks has involved taking a historical view of watershed morphology and disturbances such as channel response to settlement-driven gravel waves (Jacobson, 1995; Jacobson and Primm, 1997; Jacobson and Gran, 1999; Panfil and Jacobson, 2001; Martin, 2005). Gravel has been delivered in excessive amounts to Ozarks streams due to land use changes since European settlement (Jacobson, 1995; Jacobson and Primm, 1997). Specifically, post settlement practices of land clearing, timber cutting, seasonal burning, row cropping, and livestock grazing were responsible for increasing runoff and amplifying headward erosion of tributaries, releasing gravel from colluvial storage and transporting it downstream (Jacobson and Primm, 1997). As determined from bed elevation changes at gage stations, this gravel travels in pulses (or waves) through streams and has caused channel instability in the form of both degradation and aggradation (Jacobson and Gran, 1999; Panfil and Jacobson, 2001). Aggradation occurs where excess gravel is deposited within a reach, thus influencing slope and allowing for increased flooding and bank erosion at these localities, whereas degradation occurs where gravel deposits are being eroded and incised. Both aggradation and degradation occur in Ozarks streams in response to gravel waves. The timing and magnitude of these waves depends on watershed size. Small drainage areas (less than 1,400 km^2) have shown sediment waves moving past gages from 1920 to 1940. Mid-sized drainage basins (1,400 to 7,000 km^2) have displayed multiple waves of sediment moving through systems during the last 70 years (Jacobson, 1995).

Another effort in the Ozarks has focused on understanding channel planform adjustments over time using field reconnaissance as well as historic aerial photo analysis techniques and GIS (Jacobson, 1995; Jacobson and Gran, 1999; Martin, 2005; Martin and

Pavlowsky, 2011). Longitudinally, Ozark streams have been characterized by possessing alternating stable and active (disturbance) reaches with active reaches spaced at distances greater than typical pool/riffle sequences (Jacobson, 1995; Jacobson and Gran, 1999) (Fig. 4). While there has been no definitive link between land use history and the pattern of stable and active reach morphology, Martin and Pavlowsky (2011) provide a classification scheme for objectively identifying stable and active reaches and understanding stability trends in the Ozarks. By analyzing planform changes along 80 km of the Finley River, a tributary to the James River in southwest Missouri, their study determined that 79% of the main stem has been stable using aerial photos dating to 1955.

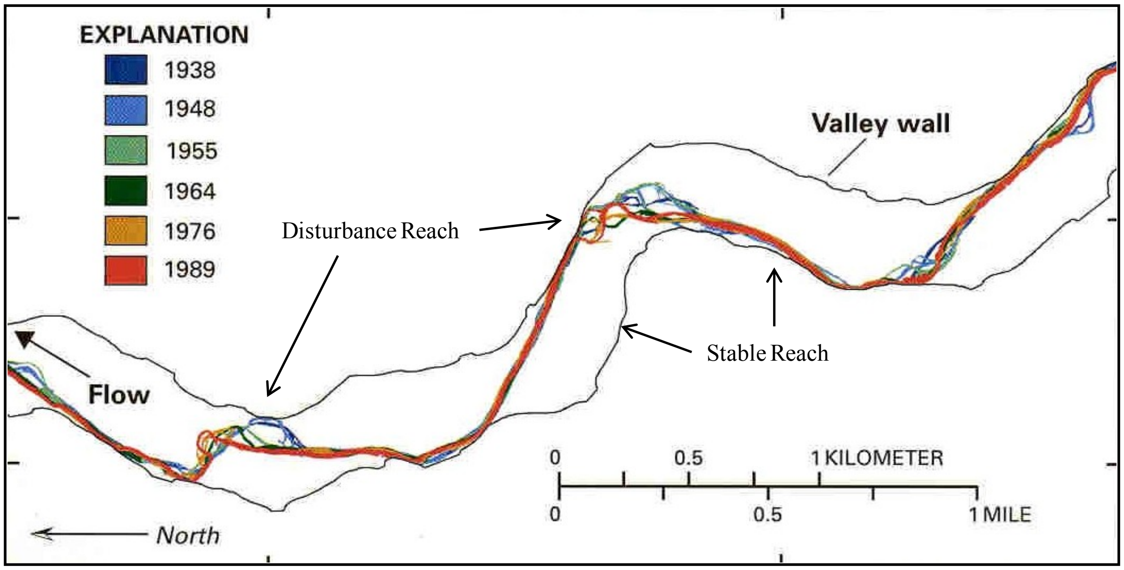


Figure 4. Stable and disturbance (active) reaches characteristic of Ozark streams (modified from Jacobson, 1995).

The third category of previous research involves linking floodplain sedimentation to land-use changes and potential remobilization of contaminated sediment. Since European settlement, fine-grained overbank deposition has been replaced in many streams by banks and floodplains with an abundance of gravel and gravel splay deposits (Jacobson and Pugh, 1992). Where this occurs locally, the ability of these surfaces to trap moisture is hindered, thus influencing riparian vegetation and its ability to stabilize banks (Jacobson and Pugh, 1992). Furthermore, Carlson (1999), Rodgers (2005) and Owen et al. (2011) used well tested floodplain sedimentation dating methods (including Cs-137, soil properties, and mining or industrial sediments) to quantify changes in floodplain stratigraphy, providing insights regarding the response of Ozarks rivers to land use changes and the potential for remobilization of contaminated sediment.

Another category of literature has provided morphological insights in understanding how watershed morphology and channel networks relate to physical stream habitat within highland and mountain ecoregions of eastern Oklahoma. Results of this work indicate that geomorphic characteristics of stream size, local channel morphology, and substrate characteristics have a greater effect on fish species composition and density than typical habitat variables such as vegetation (Dauwalter et al., 2007; Dauwalter et al., 2008). Further, by analyzing 128 randomly selected sites (not drainage-area based), Dauwalter et al. (2007) found that Ozarks channels (n = 21) were wider, deeper, possessed less bedrock, and finer sediment than Ouachita (n = 78) and Boston Mountain (n = 29) streams. Other differences in watershed (Splinter et al., 2011) and channel (Splinter et al., 2010) morphology have been quantified by ecoregion in eastern Oklahoma, and this work has stressed the applicability of using ecoregion frameworks to study channel characteristics. Specifically, Splinter et al. (2010) provides channel substrate size, bankfull channel dimensions, gradient, and sinuosity trends for randomly selected sites in the three ecoregions (n = 34 for Ozarks channel data), providing drainage area-based trends for channel variables measured in different streams. Although not differentiated, this dataset includes channel data for the Springfield Plateau within the Ozark Highlands. Collectively, this work has stressed the importance of using ecoregions to study watershed characteristics as they relate to both physical and biological variables important in watershed management.

Finally, the effects of recent urbanization on small tributaries in the Ozarks have been assessed by comparing channel features in urban and rural watersheds (Martin, 2001; Horton, 2003). Similar to results published elsewhere, urban channels in the Ozarks display larger channel dimensions than their rural counter parts with the same drainage area (Horton, 2003). Furthermore, urban development has been linked to the initiation of upland erosion and increased gravel supply being transported in a wave-like fashion similar to that discussed in Jacobson (1995) (Martin, 2001).

Despite the wealth of knowledge associated with the research discussed above, a watershed-scale geomorphic study that quantifies downstream trends, reach scale variability, and valley scale controls on channel morphology is presently lacking in the Ozarks. This thesis investigates the geomorphic relationships among drainage area, channel form, sediment size, and stream power in the James River basin (3,771 km^2) in the western portion of the Missouri Ozark Highlands.

CHAPTER 2

STUDY AREA

The James River basin (3,771 km^2) is located in southwest Missouri and is part of upper White River basin (Fig. 5). The White River empties into the Mississippi River in Desha County in southeast Arkansas. The James River is approximately 160 km long and flows northeast to southwest from its headwaters north of Seymour (elevation ~515 m, one of the highest points in Missouri) to the James River Arm of Table Rock Reservoir south of Galena (elevation ~280 m). Table Rock dam was completed in 1959 by the U.S. Army Corps of Engineers for flood control and power generation purposes. The James River was also dammed in 1957 near the city of Springfield, creating a 1.21 km^2 lake with an average depth of ~3 m used for cooling a coal-fired power plant at the southwest end of the lake (Tannehill, 2002). This dam has minimal influence on channel morphology (Legleiter, 1999). The Finley River (draining ~717 km^2) is the largest tributary to the James River and has three small 'run-of-river' dams on its main stem constructed during the period from 1870 to 1930 (Martin and Pavlowsky, 2011; MDC, 2012). This river and the possible effects of dams were not evaluated in this study. The James River drains the majority of the city of Springfield, the third largest city in Missouri (city population ~160,000, metro area ~437,000), and other urban and rural areas.

Figure 5. The James River basin in relation to the White River basin.

Geology

The James River drains the Ozark Highlands of southwest Missouri (Fig. 1). Geologically, the basin lies on the border of the dissected, Ordovician-aged (~470 Ma) Salem Plateau (southeast) and the younger, more gently rolling Mississippian-aged (~340 Ma) Springfield Plateau (northwest). Unlike rivers in glacial till in northern Missouri (the terminal moraine generally follows the Missouri River), the Ozarks were not glaciated in during the Pleistocene and are dominated by loess covered, fractured cherty carbonate rocks, characteristic of the uplifted region (Thomson, 1986) (Figure 6; Table 1). This geology allows for an abundance of karst features such as springs, caves, and sinkhole formations, as well as complicated movement of subsurface water (Adamski, 2000). Upland soils are generally composed of loess covered thick clayey residuum formed from cherty carbonates (Thomson, 1986, Hughes, 1982). Alluvial soils consist of silt loam over coarse gravel or gravelly loam (Hughes, 1982; Owen et al., 2011).

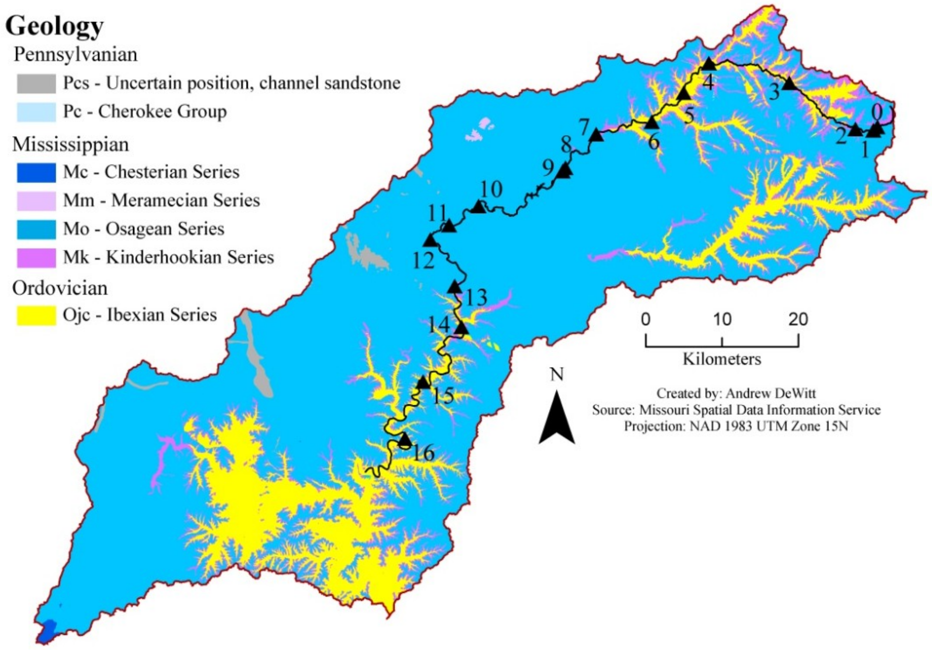


Figure 6. General geology of the James River basin and study sites.

Table 1. Geologic units and descriptions of the James River basin.

Period	Map Symbol	Series	Description
Pennsylvanian (Carboniferous)	Pcs	-	Uncertain stratigraphic position, channel sandstones
	Pc	Middle	Desmoinesian Stage, Cherokee Group, Cabaniss Subgroup -cyclic deposits, shale and limestone with sandstone, clay and several workable coal beds
Mississippian (Carboniferous)	Mc	Chesterian	Fayetteville Formation, Batesville Formation, and Hindsville Limestone -Limestone and shale deposits
	Mm	Meramecian	St. Louis Limestone, Salem Formation, Warsaw Formation -Limestone
	Mo	Osagean	Keokuk and Burlington Limestone, Elsey and Reeds Spring Formation, Pierson Limestone -Limestone (cherty)
	Mk	Kinderhookian	Northview Shale, Compton Limestone, Bachelor Formation -Limestone, shale, siltstone
Ordovician	Ojc	Ibexian	Smithville, Powell, Cotter, Jefferson City Dolomite -fine crystalline, silty, cherty dolomite, and oolitic chert with local sandstone beds.

Channel substrate of the James River is composed of primarily chert gravel and cobbles. The resistant, sub-angular chert clasts are the residual weathering product of the less resistant carbonate strata. As the less resistant carbonate rocks weather, chert gravel fragments remain and are abundant near the surface of residual soils (Hughes, 1982). Over time, colluvial and fluvial processes release this gravel to drainage networks where it is routed through streams and stored as channel bar deposits or within floodplains.

Large carbonate blocks may also be present on the channel bed, particularly where channels are adjacent to bluff walls. Mean annual suspended sediment yields are relatively low in the James River, ranging from 40 to 90 Mg/km^2 in the upper and middle James River, respectively, and 9.0 to 30.2 Mg/km^2 in its tributaries (Hutchison, 2010). Reported annual sediment yields for Ozark Plateaus rivers range from 1 to 89 Mg/km^2/yr with a median value of 23 Mg/km^2/yr (Davis et al., 1995). Low suspended sediment yields are likely a limiting factor in the construction of new alluvial features and floodplain development (Owen et al., 2011). The relative abundance of gravel and limited fine-grained sediment indicates a bed-load dominated system. In many reaches flat-lying (gently southwest dipping) carbonate rocks are exposed along the channel bottom, which limits down-cutting in the stream and influences flow resistance. Limestone bluffs in many portions of the study area limit lateral channel migration and sinuosity.

Climate and Hydrology

The climate of the study area is humid continental and receives approximately 105 cm of precipitation per year with an average annual temperature of ~15º C and a growing season of approximately 199 days (Thomson, 1986; Adamski et al., 1995; Jacobson and Gran, 1999; Adamski, 2000). Common intense rainfall events and relatively impermeable soils are responsible for flashy runoff events in the Ozarks (Jacobson and Gran, 1999). Information regarding gage data records as well as a discharge recurrence interval analysis for the James River will be explained in the methods section and presented in results as it relates to bankfull flows and channel form.

However, mean annual flows are 6.7, 15.2, and 28.3 m^3/s for gages located near Springfield (637 km^2), Boaz (1,197 km^2), and Galena (2,556 km^2), respectively. At the Springfield gage, the highest mean annual flow (15.9 m^3/s) occurred in 2008 and the lowest (1.5 m^3/s) occurred in 1956. At the Boaz gage, the highest mean annual flow (31.1 m^3/s) also occurred in 2008 and the lowest (4.7 m^3/s) occurred in 2006. Finally, at the Galena gage the highest mean annual flow (70.8 m^3/s) occurred in 1927 and the lowest (3.4 m^3/s) was recorded in 1954. Mean monthly flows are highest in March at the Boaz gage, and in April for the Springfield and Galena gages.

Land Use

The James River basin is 7.1 percent urban, 34.9 percent forest, 55.4 percent grassland/cropland, and 2.6 percent other (water, wetland, barren) (MSDIS, 2012) (Fig. 7). The most recent land use dataset (2005) from MSDIS was acquired and analyzed in ArcMap to determine the percent land use upstream of each of the sites used in this study (Fig. 8). Results indicate that crop/grassland is the dominant land use for each sub-watershed (>50%) followed by forest and urban, respectively. For graphical reasons, crop and grassland data were combined as commonly done in this region. The mean cropland percent for each of the sub-watersheds is 7.4 percent, ranging from 3.4 percent (site 16) to 19.7 percent (site 2). Urban land use percentages increase with proximity to the city of Springfield and peak below the Wilson Creek confluence (site 12), which drains a large portion of the city. Information regarding the history of settlement and land-use can be found in Rafferty (2001), Hutchison (2010), or Owen et al. (2011) and references therein.

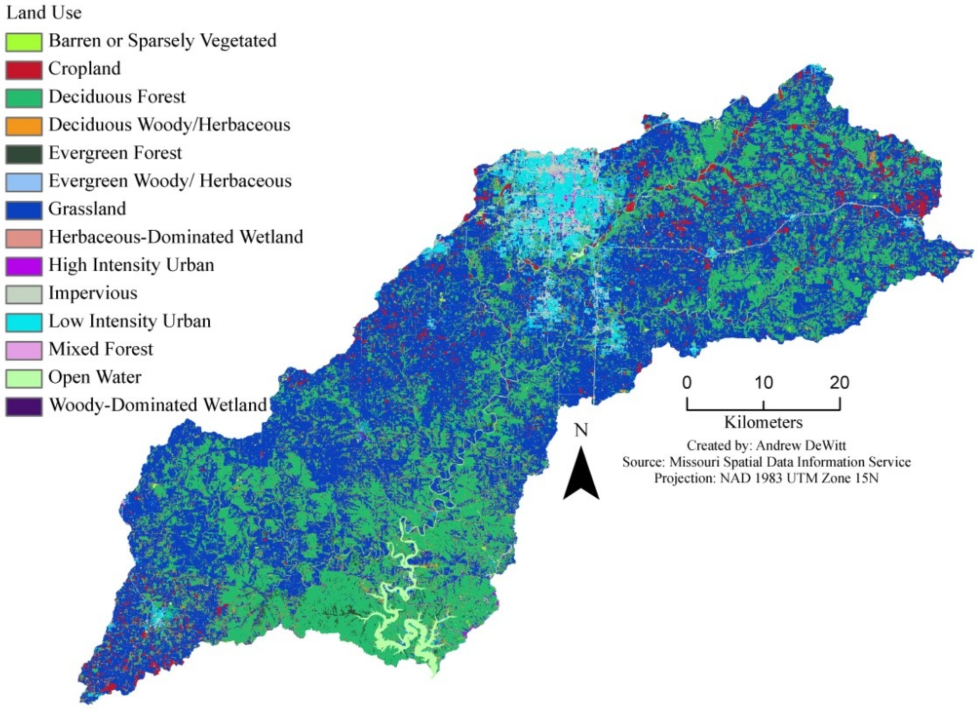


Figure 7. Land-use within the James River basin.

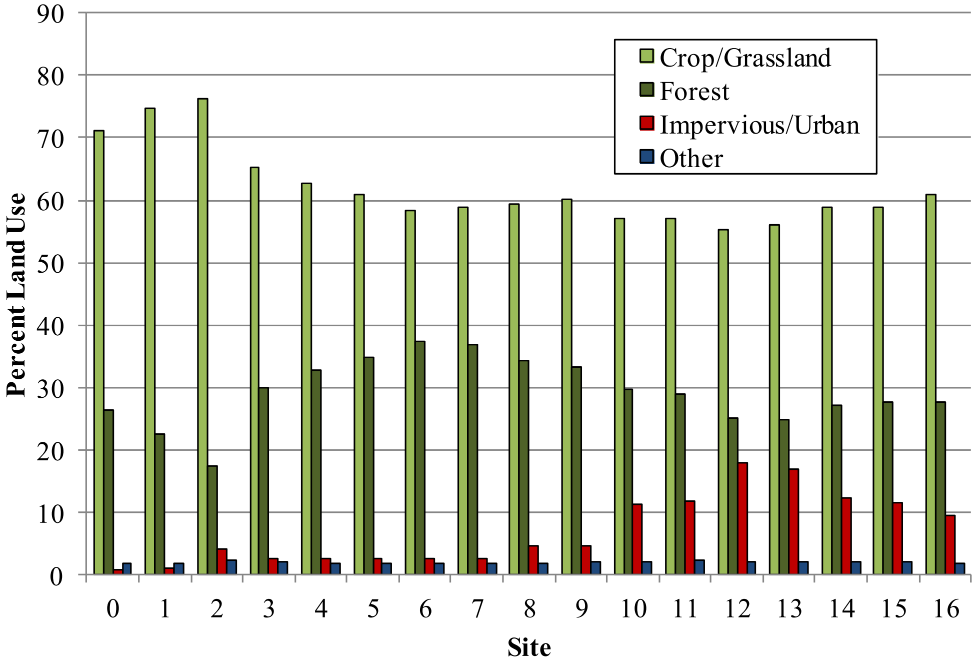


Figure 8: Land-use percentages upstream from each study site

CHAPTER 3

METHODS

Site Selections

Seventeen main stem sites (draining from 6.4 to 2,534 km^2) on the James River were located in segments between major tributary junctions (generally third-order or greater) where distinct changes in drainage area were determined using digital elevation models (DEMs) in ArcGIS and access permission was granted where applicable (Fig. 9, Table 2). Land owner permission was necessary for upper sites (0-7), but where use of canoes was necessary at lower sites (8-16), public launches and/or bridge crossings were used for access. Field reconnaissance and preliminary cross section measurements commenced in December 2010, and sites were revisited with field crews to complete more intensive assessments during the period from late May 2011 to mid July 2011. Duplicate measurements were completed at six sites (1, 2, 5, 9, 14, and 16) to assess the measurement error associated with field data collection methods.

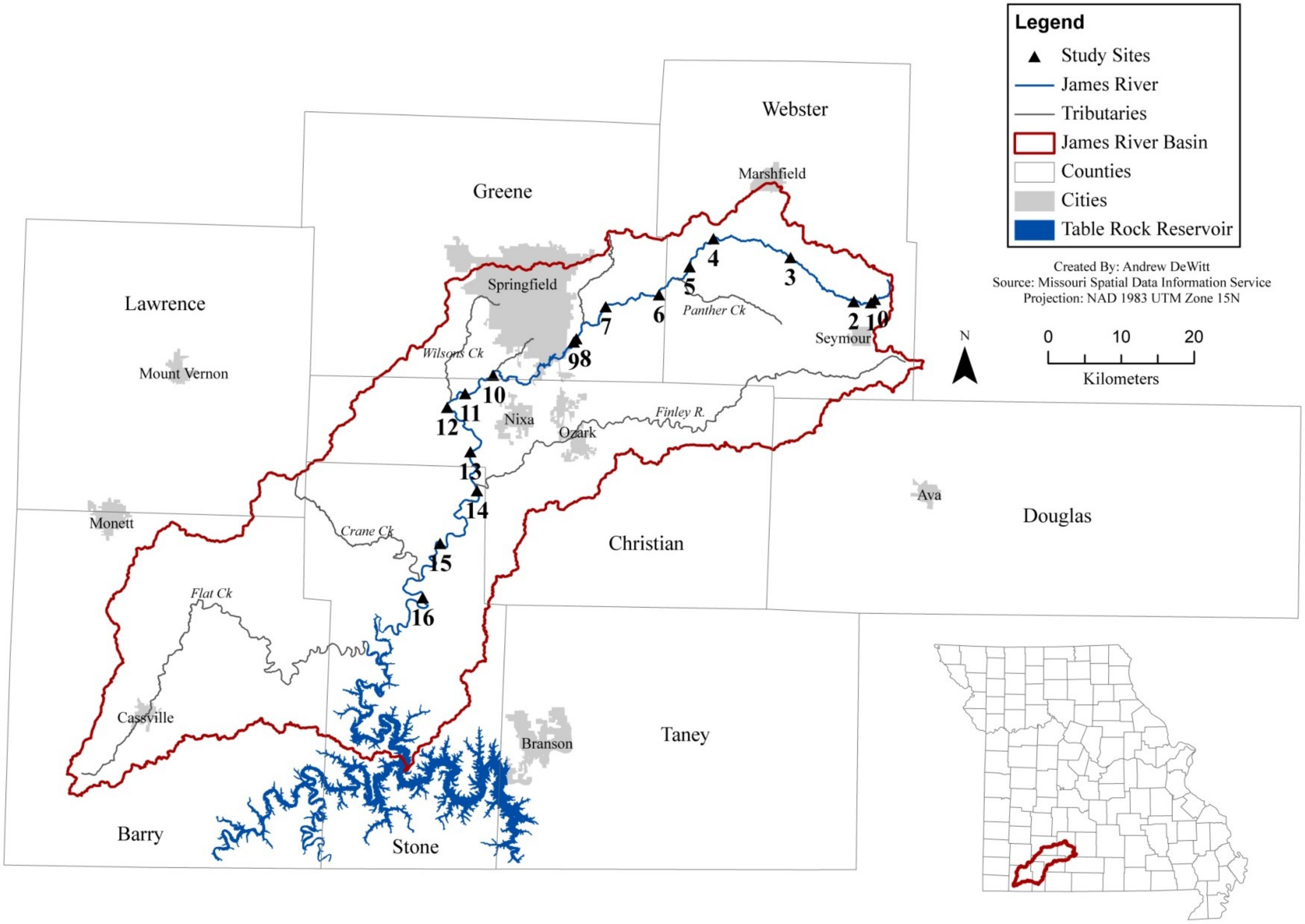


Figure 9. Study site locations within the James River basin.

Table 2. Study Site Descriptions and Coordinates[a]

Site Number	Location Description	A_d (km^2)	~Elevation (masl)	Northing	Easting
0	Downstream of Waldo Road crossing	6.4	466	495,203.34	1,568,698.06
1	Upstream of HWY C crossing	16.4	460	493,718.13	1,566,931.29
2	Upstream of Skyline Road crossing	41.3	447	494,307.24	1,559,206.70
3	Upstream of HWY A crossing	118.3	411	514,105.44	1,530,997.83
4	Southeast of Ridge Road and HWY B intersection	242.5	388	522,920.21	1,496,257.75
5	Northwest of Compton Hollow Road and HWY B	296.4	377	510,269.72	1,485,414.26
6	Downstream of Farm Road 134 crossing	437.0	368	497,842.45	1,471,649.59
7	Upstream of HWY D crossing	528.3	355	492,680.02	1,447,665.16
8	Downstream of Farm Road 164 crossing (gage station)	631.8	350	478,304.50	1,434,332.94
9	Downstream of Site 8 and Kinser Branch confluence	666.8	349	476,844.65	1,433,099.71
10	Rivercut Golf Course, south of Rivercut Parkway	817.3	331	462,072.51	1,396,769.80
11	Downstream of Nelson Mill Road	858.2	327	453,944.25	1,384,120.95
12	Upstream of Delaware Town Access	1,128.4	325	447,783.35	1,376,071.76
13	Upstream of Shelvin Rock Access (gage station)	1,194.8	314	427,804.94	1,386,462.44
14	Downstream of HWY M crossing (Finley confluence)	1,919.3	307	410,236.91	1,389,296.51
15	Downstream of McCall Bridge Road Access	2,081.2	297	386,538.42	1,372,828.66
16	At Kerr Access	2,534.4	284	362,455.20	1,364,788.39

[a]Coordinate System: GCS NAD 1983 State Plane, Missouri Central

Field Methods

Each of the 17 sites visited in this study represent an individual, continuous channel segment between major tributary junctions. Sites included 3 to 4 riffle crests and ranged from 9 to 34 bankfull channel widths in length with an average of ~19 bankfull widths in length (excluding site 2). This length generally falls within the 10 to 20 widths commonly used to relate channel morphology to process, response potential, and habitat (Montgomery and Buffington, 1997). Three sub-reaches were surveyed within each site to allow for averaged values to be used to generate CMEs, and also to assess natural variability among channel data at the segment scale.

Geomorphic data collected at each site (or segment) consisted of a longitudinal profile, three glide-riffle cross sections, Wolman (1954)-type pebble counts, and field notes. Longitudinal profiles (LPs) included at least three primary riffles (corresponding to the cross sections), and at least two complete pools. LPs were completed with a Topcon GTS-225 Total Station and TDS Ranger Data Logger, and points were taken in the thalweg and captured changes in bed topography. Each point was coded in the data logger for approximate substrate size, presence or absence of bedrock, bedform, and other pertinent information. Over 15 km of longitudinal profile data were collected for this study, not including duplicates, with a mean spacing of 7 m between survey points. Profiles ranged from 0.16 km to 2.8 km in length, with 7 of the 17 profiles over 1 km long. Survey data were spatially referenced using a Trimble GeoXH GPS receiver with a Zephyr antenna, allowing for all data to be plotted and stored on an aerial photo in a GIS after being spatially rendered in TDS Survey Works ForeSight DXM software.

From longitudinal profile data, riffle spacing was determined by averaging the horizontal distance between primary riffles surveyed at each site. Riffle slope was determined by fitting a trend line to the three primary riffle points of the LP, and the slope value of the trend line was used. Except where bedrock influence created anomalously deep or shallow pools, riffle, pool, and overall slopes were nearly parallel as expected. Residual pool depths were determined by taking the difference between the bed elevation at the riffle crest and the deepest point in the upstream pool. Pool length was determined as the distance from a pour point (riffle crest) to its intersection with the bed of the upstream glide or riffle.

Channel cross sections (at least 3 for each site) were completed at the glide-riffle channel unit because it is typically the most geomorphically stable unit in a stream channel and allows for inter/intra-site comparisons (Panfil and Jacobson, 2001). Cross sections were completed using a Topcon AT-G7 Auto Level and stadia rod or the total station. Channel features surveyed and noted included terrace elevations, floodplain and bankfull stage indicators, bars, benches below bankfull, edge of water, the thalweg, and the active channel bottom. The bankfull elevation was identified in the field most often and easily by topographic features such as the top of the active channel floodplain where a change in vertical bank to horizontal floodplain was identified (Lawlor, 2004). In some circumstances, the back of point bars, breaks in slope, and/or the highest scour line were used as bankfull indicators (Leopold, 1994; Castro and Jackson, 2001; Doll et al., 2002; Powell et al., 2004). Where these latter indicators were used, active floodplain surfaces were identified at similar elevations from the thalweg up or downstream of the cross section location. At some cross-sections carbonate valley walls formed the outside bank, in which case only one side of the channel displayed distinct bankfull indicators.

Wolman (1954)-type pebble counts were completed at each sub-reach and consisted of 30 samples each taken at the glide, riffle, bar-head, bar-middle, and bar tail using a standard gravelometer template. Channel unit stratified pebble counts can reduce errors introduced by mixing bedform populations (Buffington and Montgomery, 1999; Kondolf et al., 2003), and using a template allows for faster data acquisition and also reduces bias (Marcus et al., 1995). Pool sediment size data were not collected in this study due to non-wadeable conditions at many sites, similar to the pebble count protocol used in Panfil and Jacobson (2001). Pebble count grid spacing was scaled to capture the entire channel unit with 30 samples and was typically 1-4 m determined by pacing. Since the presence or absence of bedrock substrate is important in channel morphology and roughness calculations, blind touches in bedrock were recorded as part of the 30 samples in the channel unit. For calculations of roughness (Manning's n) for each sub-reach, bedrock was assigned a place-holder value of 2 mm. Bedrock touches were removed from the data set for site calculations of mobile bed sediment, so n=105 to 180 for combined glide and riffle touches, exceeding the number of 60, 70, and 100 counts proposed by Brush (1961), Mosley and Tindale (1985), and Wolman (1954), respectively. Maximum clasts were visually identified and measured with a folding ruler at the riffle crest (n=5), bar-middle (n=10), and largest blocks in the active channel (n=5) where observed, and these data were averaged for each site for analysis. Glide and riffle pebble counts were completed at each sub-reach, but in some instances bar forms were not observed and therefore not sampled. Bar counts at sites 4 and 10 yielded less than 60 pebbles due to lack of bar area.

Natural Variability and Measurement Error Analysis

Natural geomorphic variability of channel characteristics and measurement errors were assessed by calculating coefficients of variation (CV percent, calculated as the standard deviation divided by the mean, times 100) and relative percent differences (RPD, calculated as the absolute value of the difference of the values divided by the mean, times 100), respectively. Comparing natural variability to differences in duplicate measurements allows for an indication of field data collection precision and reliability. Measurement errors were calculated by determining the relative percent difference (RPD) between each measured value and its duplicate value at sites 1, 2, 5, 9, 14, and 16. CV percent was calculated using sub-reach (3) values for each site to compare geomorphic conditions among sub-reaches, indicating the total geomorphic variability and method error within a site. While calculating CV percent was possible for the three cross sectional values (one value for each cross section), three bedform values (i.e. riffle spacing or pool length) were not always attainable as LPs included a minimum of three riffle crests, not three complete pool forms. In these circumstances, RPD was calculated and used in error assessments. Field data and later conversations with a landowner indicate that site 2 of this study may be disturbed due to manipulations of the active channel and floodplain and results will display equations with and without this site included where necessary.

USGS Gage Calibration and Analysis

Bankfull channel dimensions and discharge (Q) values were obtained using HydraFlow Express software after importing cross section data, ‘filling’ the channel to its bankfull stage, and applying Manning's equation (Dunne and Leopold, 1978; Owen et al., 2011). Riffle slope determined from each LP was used in Manning's equation and the roughness coefficient (*n*) was calculated using methods after Pizzuto et al. (2000), a modified version of the Natural Resources Conservation Service method described by French (1985) and previously used in Ozarks streams by Martin (2001) and Owen et al. (2011). This method takes into account median (D_{50}) grain size (from pebble count data), mean residual pool depth (from LP), and sinuosity to determine roughness. Manning's *n,* bankfull velocity, and bankfull Q were determined individually at each glide-riffle cross section and averaged for each site. The *n* values were checked against roughness calculation methods described in Limerinos (1970), as well as back-calculating *n* from published field observation data for flows ranging from 1.1 to 2 year events at three USGS gage stations (USGS 07050700 - James River near Springfield; USGS 07052250 - James River near Boaz; USGS 07052500 - James River at Galena) (Table 3).

Gage data from these stations were also used to determine flood frequency of the field-determined bankfull flow using USGS's PeakFQ Bulletin 17b software (Flynn et al., 2006; Owen et al., 2011; Haucke and Clancy, 2011). This method uses historic peak flow data and suggests a minimum of 10 years to obtain return period values (USGS, 1982). At the time of publication, the gage near Springfield had annual peak flow records published from 1956-2010. The gage near Boaz had data published from 2002-2010, and 1973-1980. Finally, the gage at Galena had a continuous record published from 1922-2010. Gage records used for comparisons to bankfull discharge were truncated in this study to represent current flow regimes (Haucke and Clancy, 2011). As a result, peak flow data was retrieved for the time period 2010-1991 (20 peak flow records). However, since the gage near Boaz did not record data from 2001-1981, data was retrieved from 2010-2002 (9 records) and the record from 1980 was used to meet the 10 year suggestion for obtaining return period statistics (USGS, 1982; Haucke and Clancy, 2011).

Table 3. USGS gages and back-calculated roughness (*n*) values from published field observations for 1.1 to 2 year recurrence interval flows.

Name	Number	A_d (km^2)	Record	Mean *n*	Max *n*	Min *n*
James River near Springfield	USGS 07050700	637	2010-1956	0.039 (n=3)	0.044 (n=3)	0.033 (n=3)
James River near Boaz	USGS 07052250	1,197	2010-2001 & 1980-1973	0.022 (n=4)	0.024 (n=4)	0.016 (n=4)
James River at Galena	USGS 07052500	2,556	2010-1922	0.040 (n=6)	0.047 (n=6)	0.032 (n=6)

Geospatial Methods

Digital Elevation Models (DEMs). DEMs were used in this study to complete a variety of geospatial measurements and analyses. Drainage areas were calculated using Hydrology tools in ArcGIS after county level 30 m DEM data provided by the Missouri Spatial Data Information Service (MSDIS) were assembled as a mosaic (Fig. 10, Table 2). Sub-watershed areas (converted to shapefiles) were delineated upstream of the middle sub-reach (cross section 2) for each site. These sub-watershed shapefiles were also used to clip the land-use data set for determining land-use percentages upstream of each study site (Fig. 8).

Approximate relief factors were measured near each cross section using a 10 m DEM to determine differences in elevations between the upland surface and active channel bottom. These values were averaged and plotted for each site. Relief factors may vary by differences in valley geology and may have implications regarding tributary gradients, thus influencing sediment transport capacity and competency.

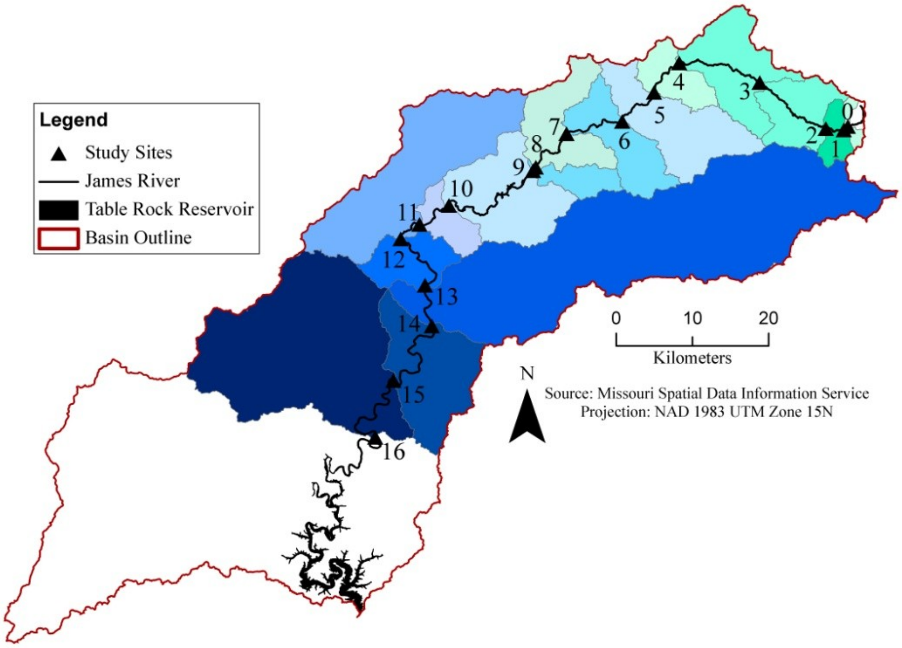
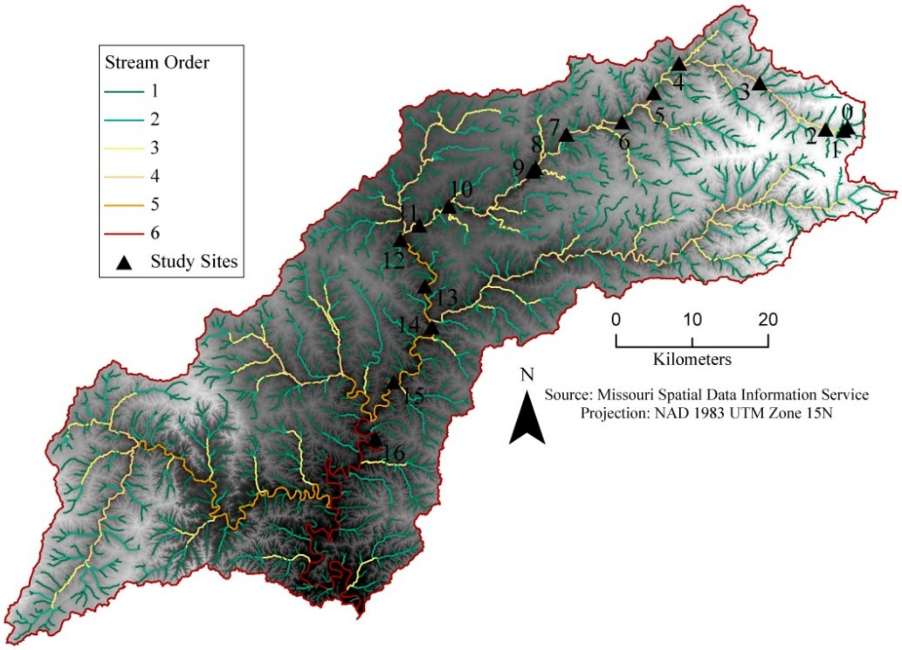


Figure 10. Delineated sub-watersheds upstream of study sites.

Finally, to assess the possible spatial influence of tributary inputs on downstream sediment size characteristics, tributary junctions were tallied within and five bankfull widths above each of the 17 study segments. Stream orders were calculated in James River basin using the 10 m DEM and ArcHydrology tools (Fig. 11). The input stream raster was created based on a generated flow accumulation dataset with first-order streams identified (using the Con raster function) as those draining at least 10,000 cells, or 1 km^2. This method thus only considers substantial tributary sediment sources, and although smaller feeder-streams do contribute gravel to the main-stem, these inputs are considered negligible in comparison to upstream sediment supply, especially at lower segments.



Source: Missouri Spatial Data Information Service
Projection: NAD 1983 UTM Zone 15N

Figure 11. Major tributaries to the James River.

Valley Width and Channel Sinuosity. Valley widths were determined in a GIS using USGS 7.5 minute quadrangle DRGs (topographic maps), similar to methods used in Shepherd et al. (2011), and an alluvium shapefile (created by the Missouri DNR, Geological Survey and Resource Assessment Division). Both of these datasets were made available by MSDIS. Valley widths were measured perpendicular to the longitudinal trend of the valley at each sub-reach cross section and at approximately every three bankfull widths along the study segment. Mean valley widths for each site were used in later analyses.

Sinuosity was calculated for each site as the ratio of thalweg length to valley length. Thalweg lengths were determined from the LP data, and valley lengths were measured in a GIS using quadrangle DRGs, aerial photos, and the alluvium shapefile.

Channel Morphology Equations

Cross-sectional, longitudinal, and channel substrate equations were generated using power function, log-log regression models. Site averaged channel morphology variables and median and maximum site sediment sizes were used to create channel morphology equations. Causative (x-axis) variables included drainage area, bankfull discharge, and valley confinement. Downstream cross-sectional and mean stream power relationships were also assessed using the equations previously discussed. Site averaged bankfull discharge, depth, and mean velocity were used in stream power calculations as well as riffle slope values determined from LP surveys. Recall that cross-sectional stream power, commonly referred to as total stream power, reflects the transport capacity or how much sediment a stream can potentially move. Mean stream power is the intensity of power at a cross-section and reflects the transport competence or the largest diameter that can be moved by a stream, and is commonly correlated with maximum sediment size.

CHAPTER 4

RESULTS AND DISCUSSION

Bankfull Discharge and Recurrence Intervals

Manning's roughness (*n*) values in this study ranged from 0.025 to 0.043 and yielded site-averaged bankfull velocity values ranging from 1.00 to 2.12 m/s. For comparison, Figure 12 shows back-calculated *n* values from USGS gage field observations for discharges associated with the 1.1 to 2 year recurrence interval events. These values range from to 0.016 at the smooth, carbonate bedrock slab at the Boaz gage to 0.047 at Galena (Table 3). Roughness values using the Limerinos (1970) method, although not used in this study, were generally similar and ranged from 0.033 to 0.044.

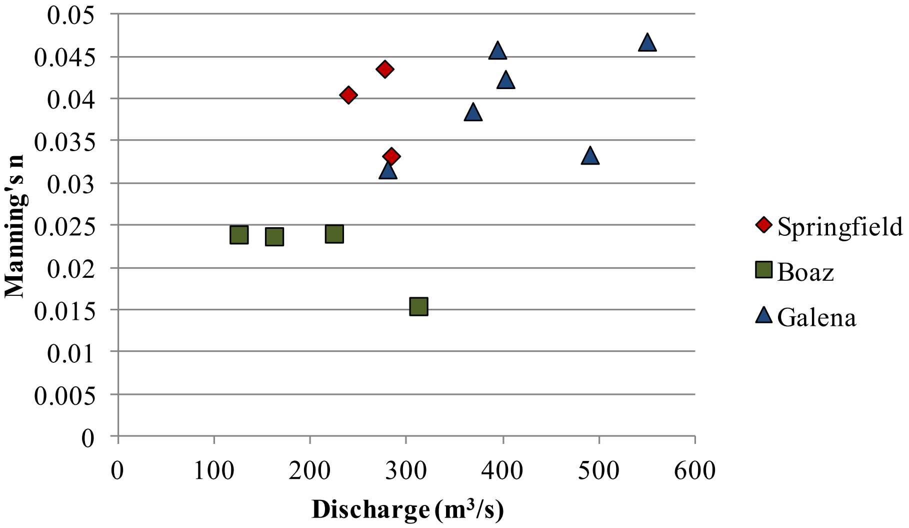


Figure 12. Roughness values calculated from USGS gage field observations.

Since bankfull discharge values commonly correspond the 1.5 year recurrence interval flow they are often compared to analyzed USGS gage data (where available) and may be used to determine validity of, or make comparisons to the field determined bankfull stage. In this study, bankfull discharge values (average for each site's three cross-sections) were compared to the 1.1, 1.25, and 1.5 year recurrence intervals (0.9, 0.8, and 0.67 annual-exceedance probabilities) for the three USGS gages on the James River. Also for comparison, 1.5 year return interval statistics for two tributaries to the James River (Pearson Creek with 12 years of peak flow data, and two gages on Wilsons Creek, both with 13 years of peak flow data) were analyzed. Results indicate that bankfull channels on the James River contain the 1.1 to 1.5 year flow (Fig. 13). The discharge data for the gage at Boaz (middle gage) appears to be slightly low for its drainage area when compared to the Springfield and Galena gages. These low values could be the result of the shorter, non-continuous record used for this gage as discussed previously. Nevertheless, in a study conducted near the Springfield gage, Owen et al. (2011) determined that for 8 sites with drainage areas of 531 to 669 km^2, mean bankfull discharge falls within the 1.25 and 1.5 year recurrence interval. Sites 6 and 7 in Owen et al. (2011) correspond approximately to sites 8 and 9 in this study, and although discharge values used in this study are the mean of three sub-reaches, bankfull discharge values for these sites are +20.5 and +15 percent of those reported in Owen et al. (2011).

The degree of historical variation in recurrence intervals was evaluated by comparing gage records and recurrence intervals during different time periods (Table 4). Recurrence interval statistics used for analysis date to 1956, the start of published records for the gage near Springfield. Since gage records likely transcend changes in land use, conservation practices, or even climate, records were arbitrarily divided into three time periods for comparison (Haucke and Clancy, 2011). Results suggest that, in general, lower flow discharges (1.1 to 2 year events) have decreased and higher flows (2.33+ year events) have increased over time. Although not the objective of this study, these results may have implications for understanding effects of climate change, land use changes, and/or the introduction of conservation practices on channel morphology and flow regimes (Haucke and Clancy, 2011; Owen et al., 2011). Some floodplain core data presented in Owen et al. (2011) indicate sedimentation rates in mid-basin locations decrease after 1963 and overbank flooding occurs less frequently, consistent with observed temporal changes in flood frequency presented here.

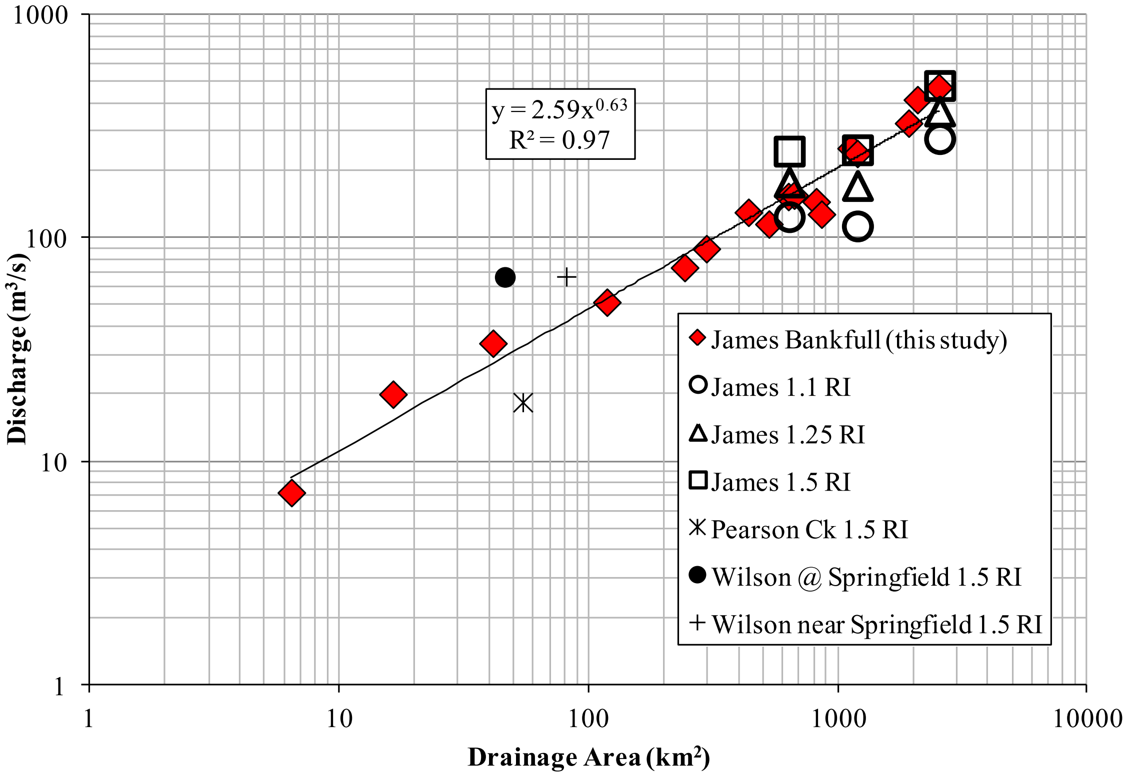


Figure 13. Bankfull discharge versus USGS gage determined recurrence intervals.

Table 4. Historical Changes in Recurrence Intervals on the James River[a]

Recurrence Interval	James River near Springfield, MO					James River at Galena, MO				
	Period 1[b] (m^3/s)	Period 2[c] (m^3/s)	Period 3[d] (m^3/s)	RPD P1 to P2	RPD P1 to P3	Period 1[b] (m^3/s)	Period 2[c] (m^3/s)	Period 3[d] (m^3/s)	RPD P1 to P2	RPD P1 to P3
1.11	123.8	191.3	132.1	-42.9	-6.5	276.8	311.2	228.0	-11.7	19.3
1.25	176.8	238.8	185.0	-29.8	-4.5	367.6	403.8	316.6	-9.4	14.9
1.5	243.3	290.8	247.1	-17.8	-1.6	478.3	509.5	422.3	-6.3	12.5
2	335.0	353.7	326.8	-5.4	2.5	629.6	642.9	559.9	-2.1	11.7
2.33	380.9	382.3	364.2	-0.4	4.5	705.5	705.7	625.9	0.0	12.0
5	601.0	503.0	526.2	17.8	13.3	1073.3	982.1	919.3	8.9	15.5
10	798.3	595.3	652.2	29.1	20.1	1415.7	1206.4	1158.0	16.0	20.0
25	1064.0	704.6	799.8	40.6	28.4	1898.9	1484.5	1451.4	24.5	26.7

[a] James River near Boaz, MO does not have sufficient record to be included. Recurrence intervals based on USGS Bulletin 17B estimates (Flynn et al., 2006).
[b] Data retrieval Period 1 – 2010-1991 (20 records)
[c] Data retrieval Period 2 – 1990-1971 (20 records)
[d] Data retrieval Period 3 – 1970-1956 (15 records)

Channel Morphology Equations

Cross sectional, longitudinal, and channel substrate equations as well as stream power relationships were generated using site averaged values for each variable. The cross sectional data used to create power function regression equations are shown in Fig. 14. Cross sectional equations for the James River are:

$A_{bkf} = 2.33A_d^{0.58}$ $r^2 = 0.97$
$Q_{bkf} = 2.59A_d^{0.63}$ $r^2 = 0.97$
$W_{bkf} = 8.12A_d^{0.28}$ $r^2 = 0.88$
$D_{bkf} = 0.29A_d^{0.30}$ $r^2 = 0.95$

where, A_{bkf} = bankfull cross-sectional area in square meters (m^2), A_d = watershed drainage area in square kilometers (km^2), Q_{bkf} = bankfull discharge in cubic meters per second (m^3/s), W_{bkf} = bankfull width in meters (m), and D_{bkf} = bankfull mean depth in meters (m). These equations explain a high percentage of the cross-sectional variability as shown by high coefficients of determination. Exponent (equation slope) values associated with width and depth equations show that depth increases at a rate only slightly greater than width does in the downstream direction. Therefore, width-depth ratios are relatively constant in the downstream direction with and without data from site 2 (Fig. 15).

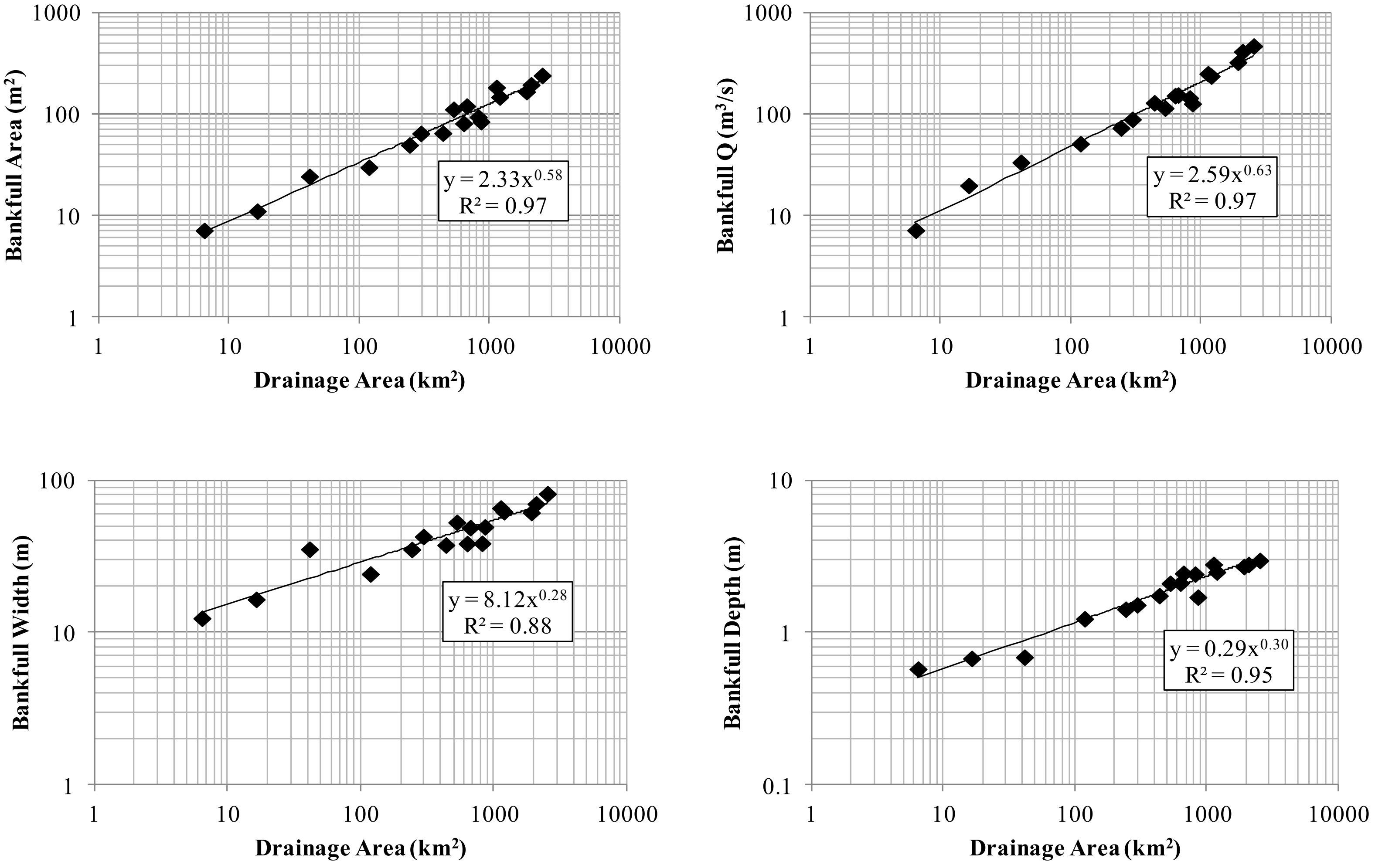


Figure 14: Downstream variations in bankfull morphology.

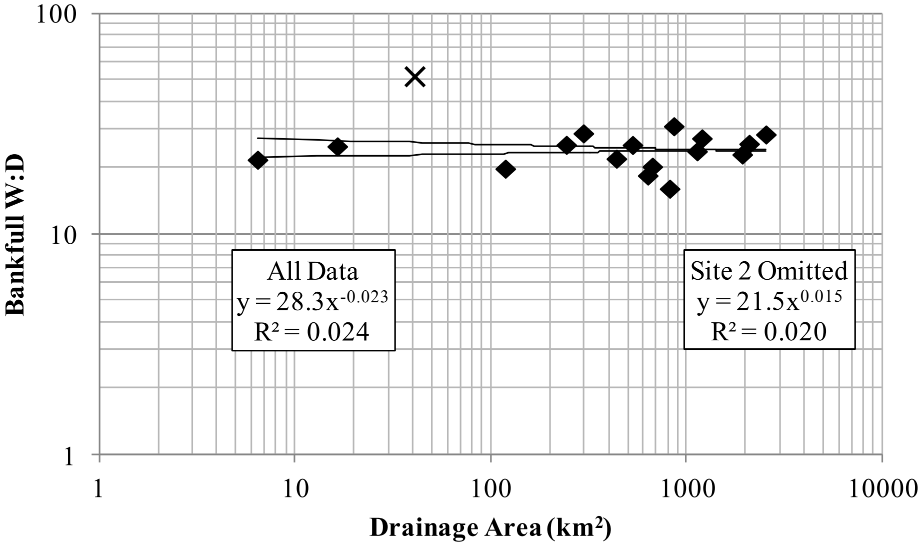


Figure 15. Bankfull W:D remains relatively constant with no downstream trend.

Downstream hydraulic geometry relationships relating field determined bankfull width, depth, and velocity to bankfull discharge were also determined for the James River following standard equations (Leopold and Maddock, 1953) (Figure 16):

$W_{bkf} = 5.38Q_{bkf}^{0.43}$ $r^2 = 0.90$
$D_{bkf} = 0.194Q_{bkf}^{0.47}$ $r^2 = 0.92$
$V_{bkf} = 0.954Q_{bkf}^{0.10}$ $r^2 = 0.24$

The product of the y-intercept values and the sum of the exponent values are both equal to one as expected (Leopold and Maddock, 1953; Rhodes, 1987). As do the drainage-area-based equations, the above relationships show relatively constant width-depth ratios with increasing Q (downstream). In contrast, Splinter et al. (2010), in a comparison of physical channel characteristics in the Boston Mountains, Ouachita Mountains, and Ozark Highlands in eastern Oklahoma, indicates a distinct increase in width-depth ratios in the Ozarks with increasing drainage area. Splinter et al. (2010) attributes this trend to aggrading higher-order channels, allowing for shallower depths and accelerated bank erosion (channel widening). Whereas the present study uses site averaged glide-riffle cross section data, Splinter et al. (2010) averaged data from two cross sections in pools and two in riffles when available. In the James River, relatively constant downstream width-depth ratios may be attributed to valley width controls and the influence of bedrock both in the channel substrate and banks. Valley confinement explains 48 percent of variability in width-depth ratios (Fig. 17).

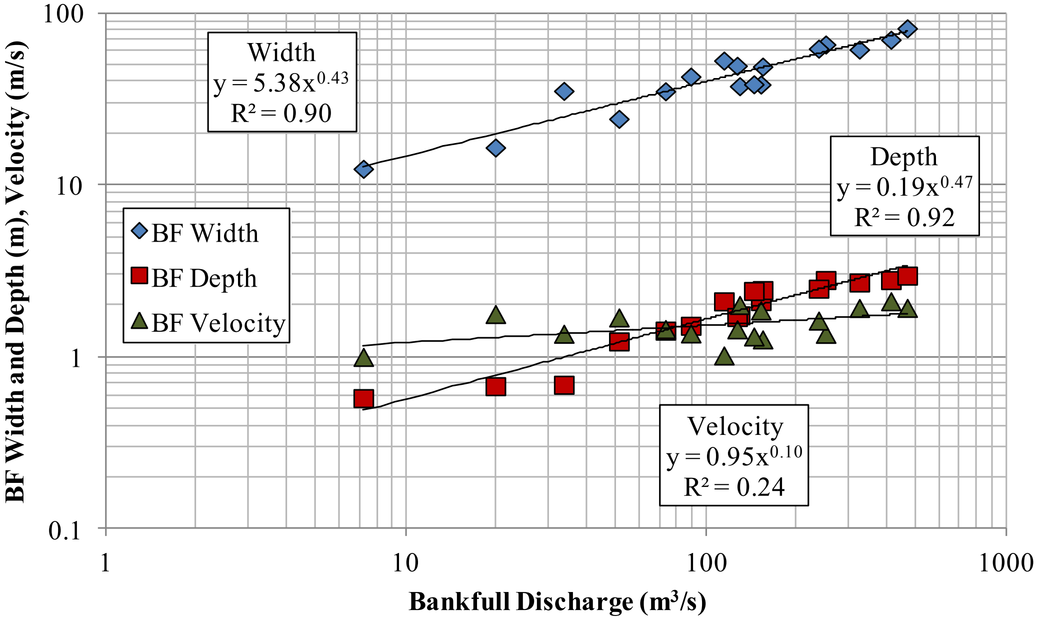


Figure 16: Hydraulic geometry relationships.

Downstream trends in slope and bedform were assessed using longitudinal profile data (Figs. 18 and 19). Interestingly, sites with drainage areas from ~500 to 1,150 km^2 (sites 7 to 12) generally possess lower slope values than their up and downstream counterparts. This is may be due to differences in the geologic units through which the James River flows (Fig. 6). Low riffle slope values at mid-basin locations presented here correspond to channel slope values determined using USGS 7.5 minute topographic maps and findings presented by MDC (2012).

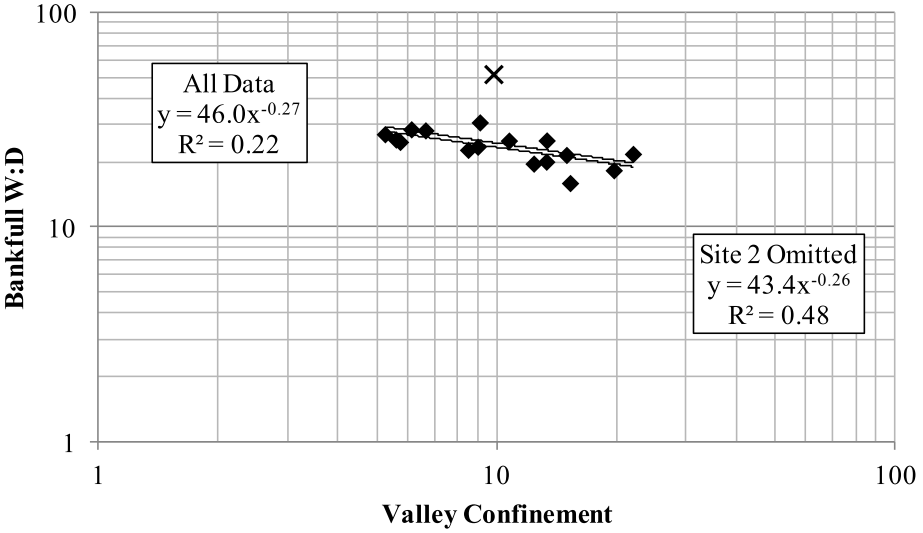


Figure 17: Bankfull W:D is weakly correlated with valley confinement.

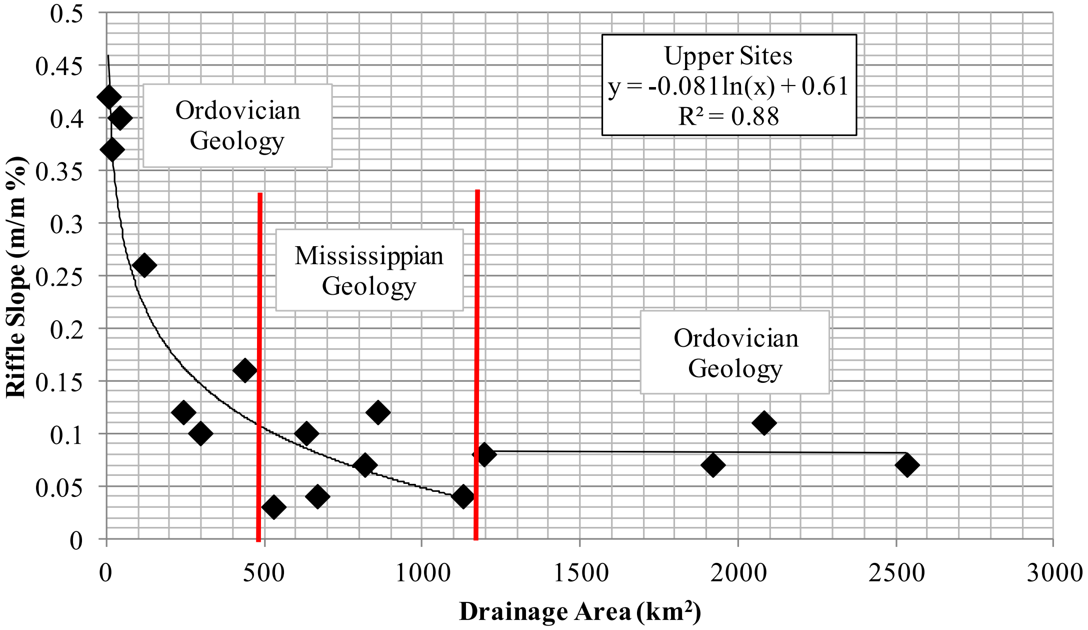


Figure 18: Downstream riffle slope trends.

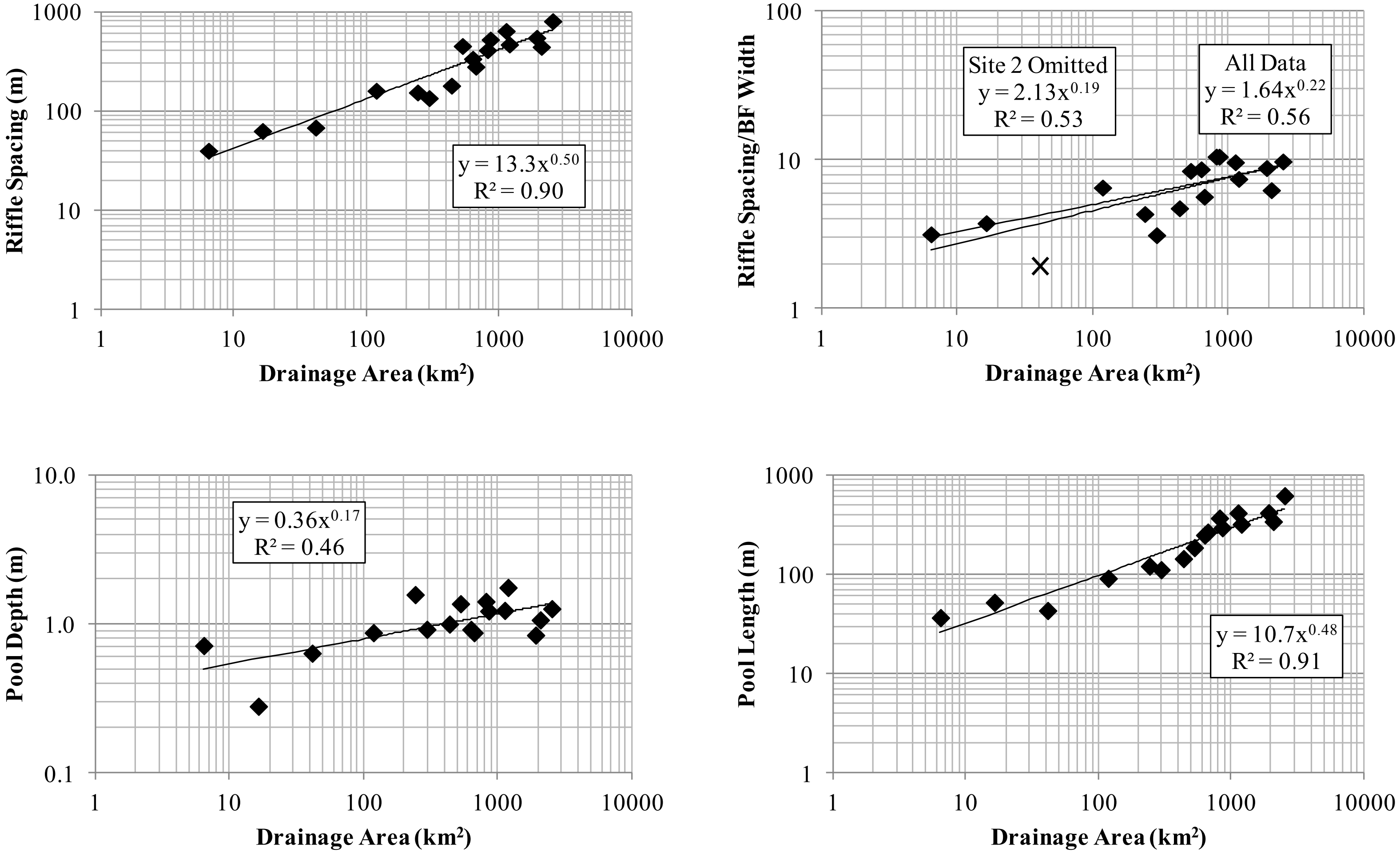


Figure 19. Downstream variations in channel bedform.

As expected, riffle spacing, pool depth, and pool length generally increase with drainage area (Fig. 19). Interestingly, riffle spacing to bankfull width ratios also tend to increase downstream, and at lower reaches some are higher than the 5-7 range proposed by Leopold and Wolman (1957) and Leopold et al. (1964) for alluvial rivers. This observed trend is likely the result of three occurrences typical of Ozark streams. First, in lower segments with relatively narrow valleys, where stream channels come in contact with their limestone valley walls meander radii are truncated and secondary flow circulations (helical) scour and deepen the channel into long, deep bluff pools (Rabeni and Jacobson, 1993; Knighton, 1998), thus increasing riffle spacing. Second, the prominence of bedrock in channel substrate may act to effectively reset local riffle spacing, particularly at upper segments. As will be later discussed, bluff pools and bedrock substrate may explain the low r^2 value associated with pool depth trends as well. Finally, field notes indicate that the effects of large-woody debris (LWD) may be more pronounced at upper sites, with ratios of wood volume to active channel volume being slightly greater at these segments. Although LWD does not influence segment scale trends in the James River, sediment transport mechanisms (small-scale bed scouring) associated with LWD and may influence riffle spacing at least locally in a case by case basis.

Channel Substrate Characteristics

Median substrate size in the James River ranges from medium to coarse gravel for both the glide-riffle and bar channel units with a slight trend of increasing size downstream (Fig. 20). Ratios of median and maximum glide-riffle sediment to bar sediment size indicate that riffle material is generally the same size as or slightly coarser than bar material (Fig. 21). These data reflect the homogeneity of substrate size both downstream and among channel units (glide-riffle versus bar). Bedrock presence from the LP surveys (recorded in the data logger) is generally higher than the glide-riffle pebble count percentages due to high frequency of bedrock exposed in deeper channel run and pool forms not evaluated by pebble counts (Fig. 22). It is important to note that LP bedrock percentages shown here are approximate as many pools, especially at lower sites, were too deep (non-wadeable) to determine bedrock presence with great accuracy, especially where large boulders were present. In these circumstances bed substrate was determined by 'feel' with the survey rod.

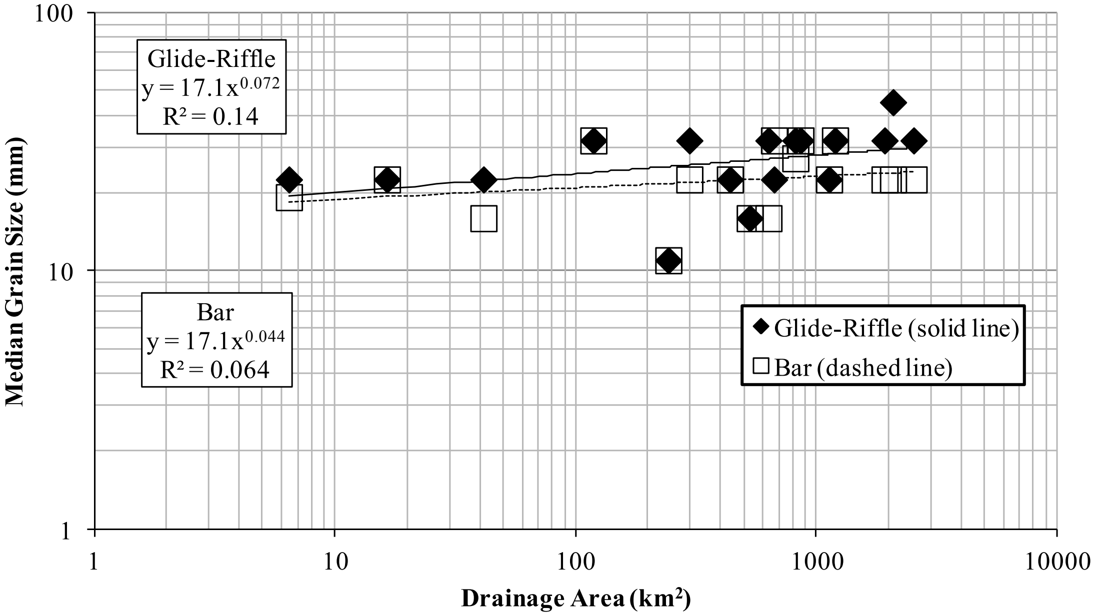


Figure 20: Downstream trends in median sediment size.

Figure 21: Riffle/Bar sediment size ratios.

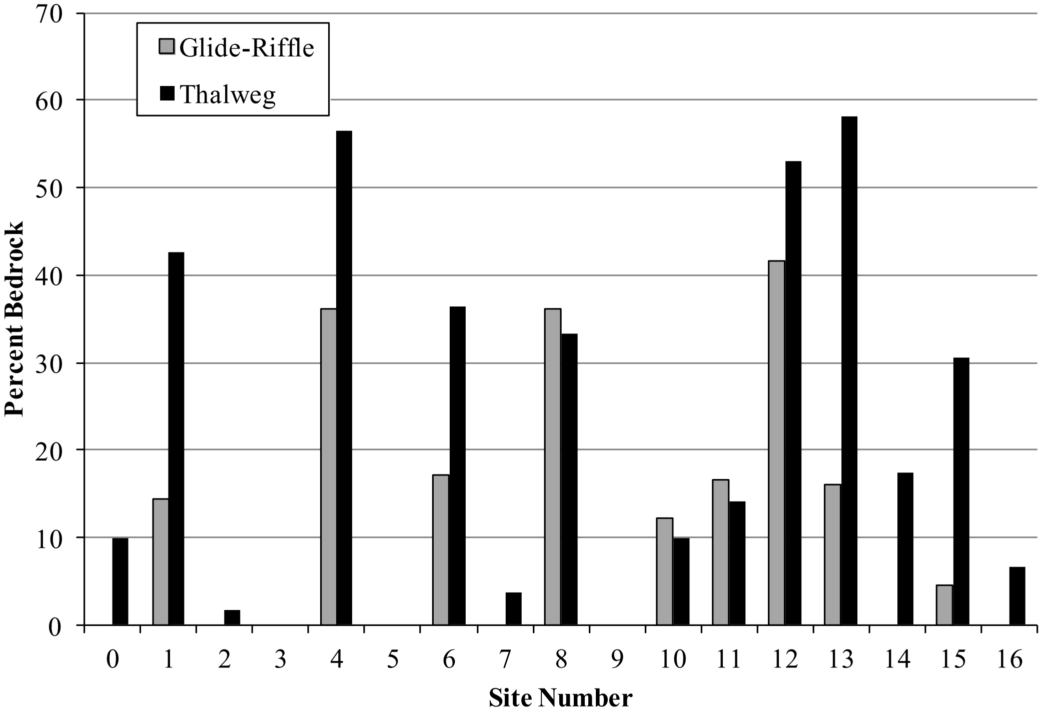


Figure 22: Bedrock frequency from glide-riffle pebble counts and thalweg survey.

The slight increase in median bed and bar sediment size in the downstream direction contradicts results from a variety of previous studies, including Sternberg's (1875) classic study of the Rhine River in Germany. In contrast to results presented here, downstream fining has been shown to occur in many river systems and flume studies due to a combination of particle abrasion (with time and downstream distance) and selective transport (Sternberg, 1875; Kodama, 1994; Ferguson et al., 1996; Seal et al., 1997; Gasparini et al., 1999; Chatanantavet et al., 2010). However, the present study as well as previous work in the Ozarks shows a slight increase in sediment size with increasing drainage area (Horton, 2003; Splinter et al., 2010). Field reconnaissance and unpublished pebble count data from tributaries to the James River have indicated homogeneity of gravel sizes (medium to coarse gravel), independent of drainage area, likely due to similarities in geology and erosive processes.

The observed downstream sediment size relationships are likely due to several phenomena. First, upland soils in the James River basin contain high amounts of chert and carbonate rock fragments. According to soil survey data approximately 0 to 20 percent of fragments in the upper 0.5 m of upland soils are coarser than 76 mm, and ~0 to 35 percent in sub-soils are coarser than 76 mm (Hughes, 1982; Dodd, 1985; Dodd, 1990; Gregg, 1995). Pebble count data in this study indicate that 0 to 15 percent of all measureable in-channel sediment is greater than 76 mm. Since the primary source (upland soils) of in-channel gravel is generally uniform in size this may explain uniform size characteristics in the active channel. Second, 12 of the 17 sites (71%) in this study have at least one tributary (defined in methods section) entering within or 5 bankfull widths upstream of the study segment, and relief factors increase down-valley (Fig. 23).

Although gravels in upland soils possess similar size characteristics, steeper downstream tributaries may be capable of transporting larger and greater amounts of material. Third, ratios of distance to nearest valley wall to bankfull width for the study sites indicate that 9 of the 17 sites are less than two bankfull widths from their valley walls (Fig. 24). This as well as bedrock presence in channel substrate allows for a direct source of coarse sediment in the form of chert gravel and larger carbonate blocks, and may also explain observed downstream sediment size characteristics. While the proximity of the active channel to bluff walls may influence sediment size, valley confinement (the ratio of valley width to bankfull width) does not explain a high percentage of maximum sediment size variability (Fig. 25). Finally, stream power relationships provide further insights regarding downstream sediment size characteristics.

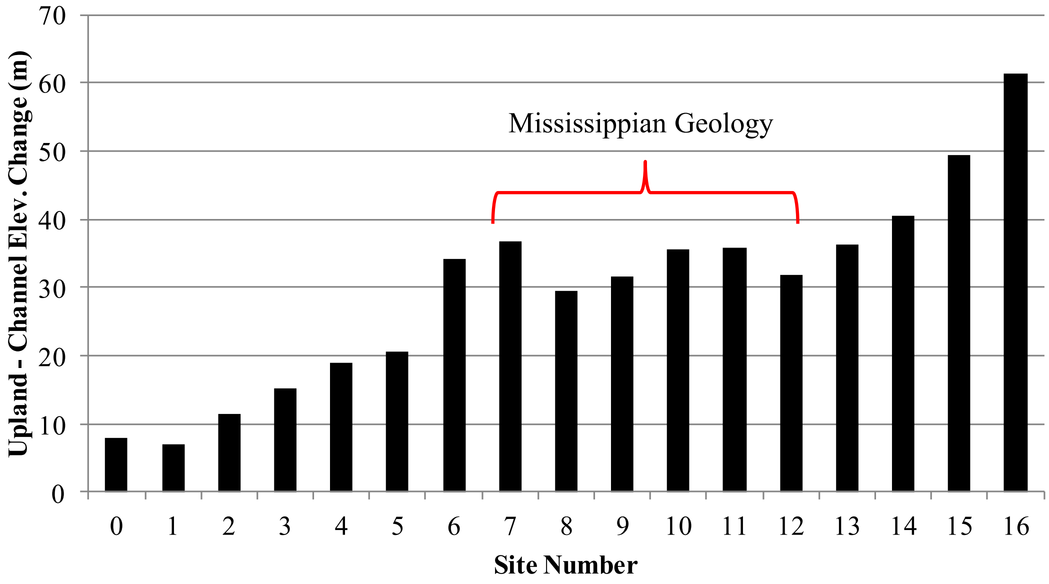


Figure 23. Relief factors by site.

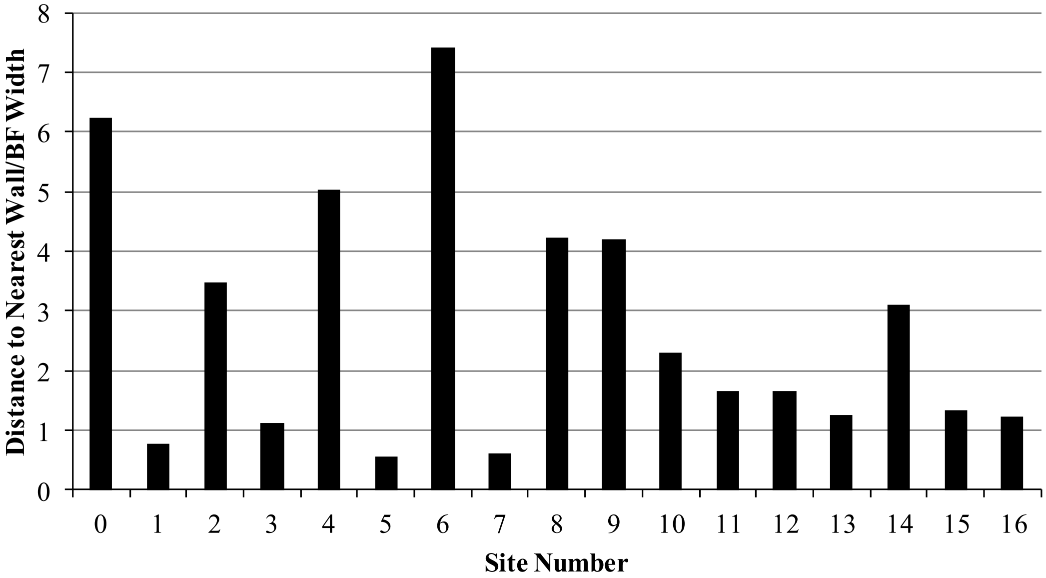


Figure 24: Ratios of distance to nearest valley wall to bankfull width.

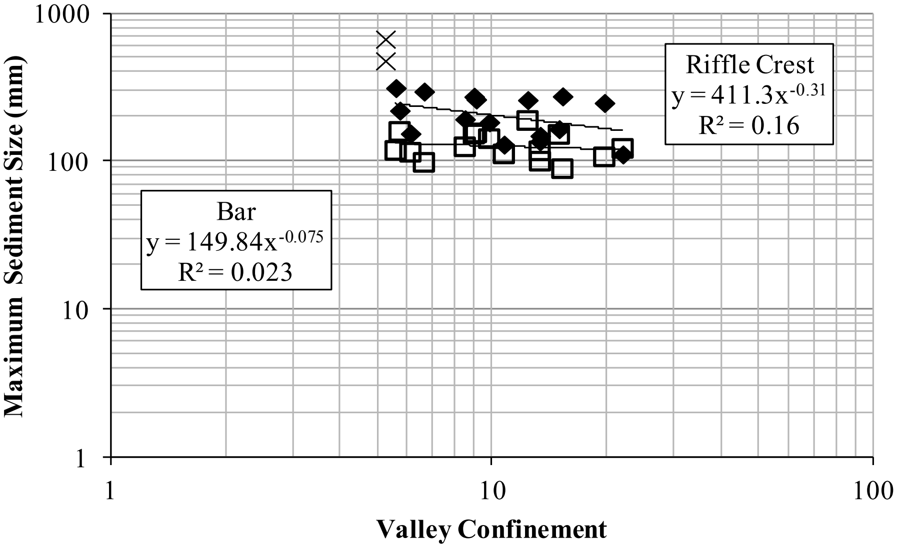


Figure 25: Maximum bar and riffle sediment size is not correlated to valley confinement.

Stream Power Relationships

Whereas Leece's (1997b) study of Wisconsin's Blue River determined greatest stream power values at mid-basin locations associated with increased channel gradients due to lithologic controls, the present study indicates a similar but opposite trend. Recall that slope values presented in this study lack distinct downstream concavity likely due to mid-basin sites (7-12) cutting through younger, Mississippian-age carbonates (Fig. 18). Intuitively, these sites display lower stream power values and the majority of them fall below the trend line (Figs. 26, 27).

Since stream power values have been shown to provide information regarding sediment characteristics including channel transport capacity and competency (Bagnold, 1966; Graf, 1983), it may be expected to observe trends relating stream power variables to sediment size. Mean stream power values, for example, indicate the high energy threshold of the channel and thus may correlate with maximum sediment size measurements. Although equations relating sediment size to mean stream power display positive exponent (equation slope) values, these equations show low coefficients of determination (Fig. 28). Therefore, it is likely that direct sediment sources (from steep tributaries, bluff walls, or rip-ups from channel substrate) have a greater effect on downstream sediment size characteristics than particle sorting and selective transport mechanisms.

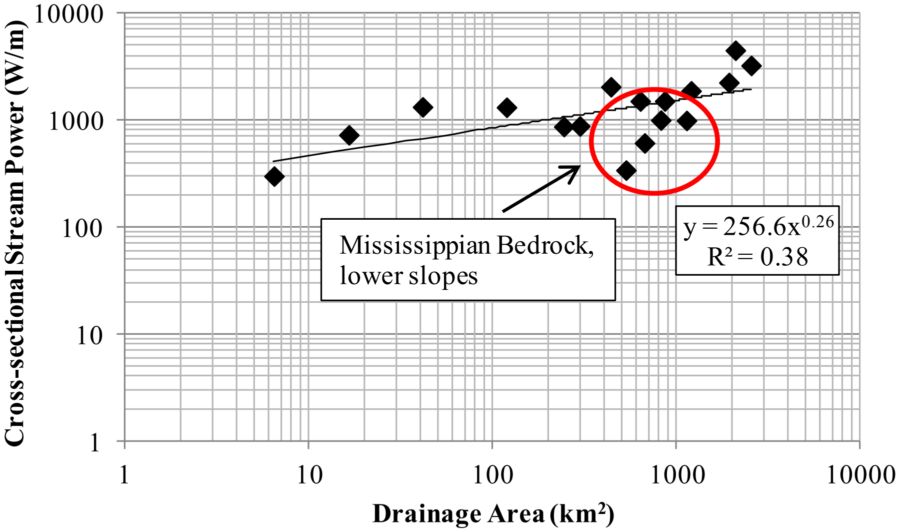


Figure 26. Downstream trends in cross-sectional stream power.

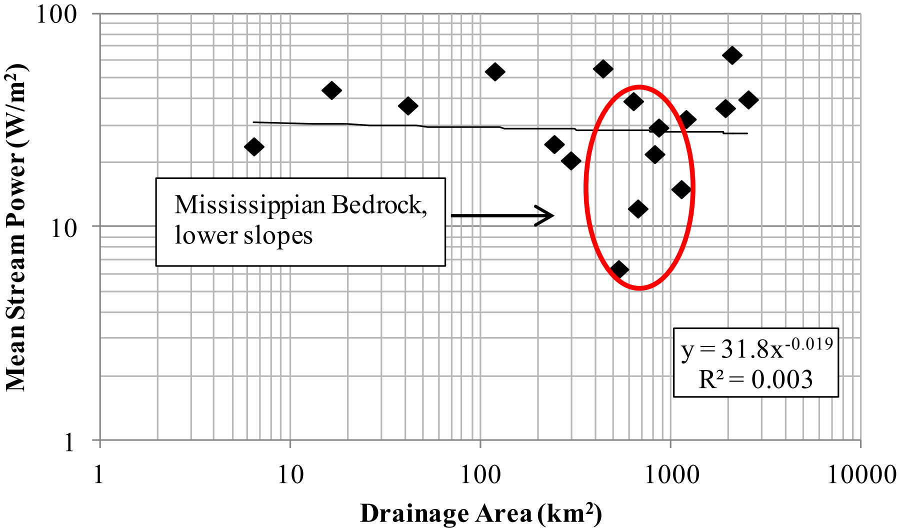


Figure 27. Downstream trends in mean stream power.

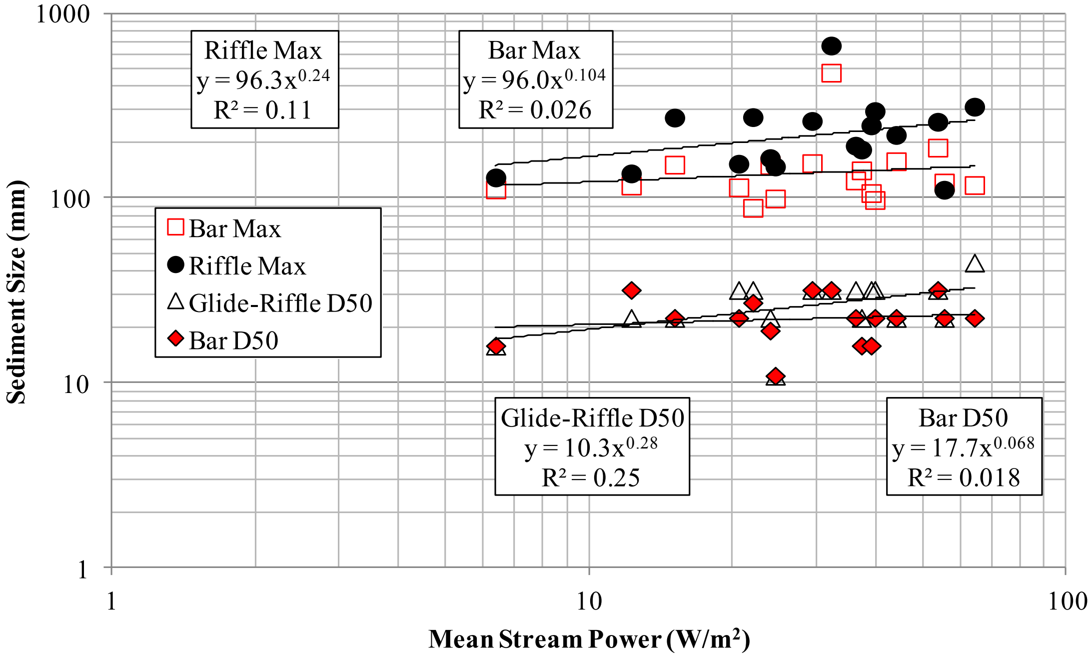


Figure 28. Sediment size characteristics in relation to mean stream power.

Variability of Channel Characteristics and Bedrock Influence

Median natural site variability (CV percent) ranged from 8 to 21 percent for measured cross sectional (bankfull discharge, area, width, depth, w:d, velocity) and median sediment size (glide-riffle and bar) variables. Median site variability for longitudinal forms (residual pool depth, pool length, riffle spacing), however, are much higher and ranged from 42 to 48 percent. Median sub-reach measurement errors (duplicate RPD) ranged from 2 to 19 percent and were lower than site variability values for any given variable (Fig. 29). Relatively low method duplicate errors compared to the higher level of "with-in reach" geomorphic variability encountered in the James River indicates that the field data collection methods used in this study had adequate precision required to measure differences among channel sites. The high natural variability associated with bedform measurements may be attributed to the influence of bedrock and bluff pools and may explain low coefficients of determination for riffle spacing and pool depth trends (Fig. 19). While the presentation of each of the 17 LPs is not appropriate here, Figure 30 displays two characteristic LPs that visually display the variability of bedform features in the James River, and shows how the bluff pools and bedrock may influence riffle spacing and pool depth. Future analyses of the James River or other Ozarks rivers need to better resolve the sub-reach scale influence of bedrock on channel morphology to better understand the interactions among flow regime, coarse sediment supply, and bedrock control and how they affect longitudinal trends.

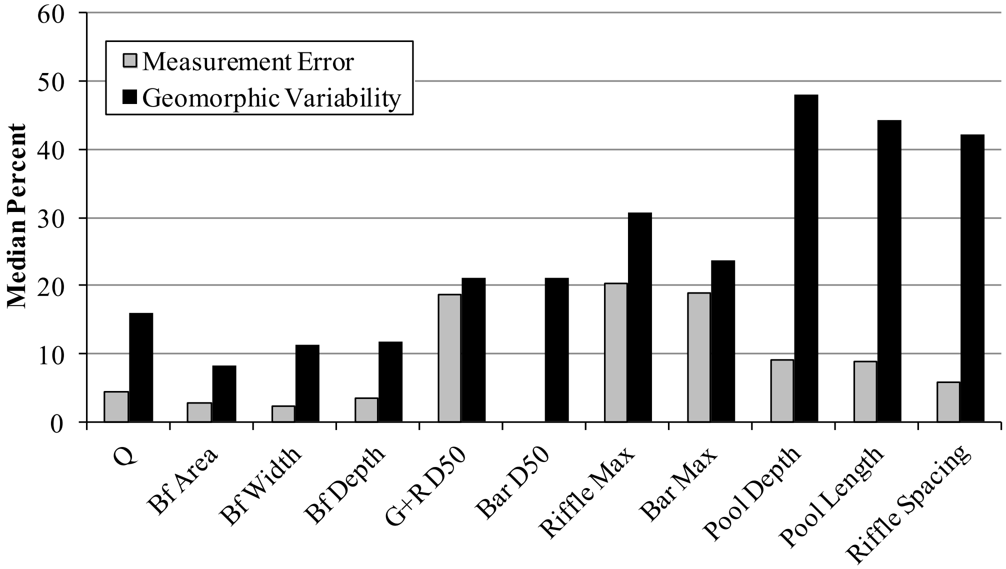


Figure 29: Median measurement errors and geomorphic variability for channel variables.

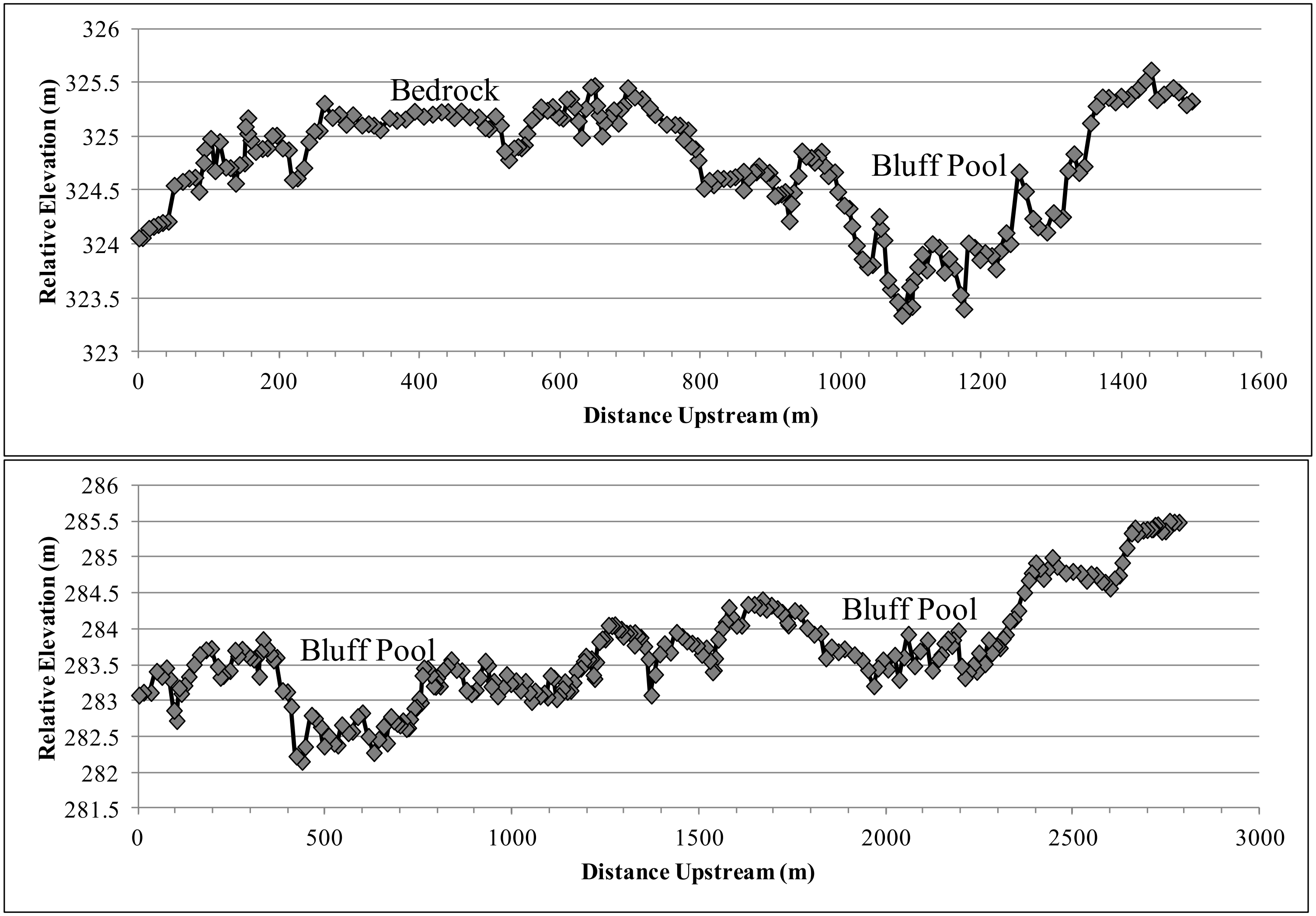


Figure 30: Longitudinal profiles for site 12 (top) and 16 (bottom) showing bedform variability due to bluff pools and bedrock.

CHAPTER 5

CONCLUSIONS

This study fills a gap in geomorphic knowledge by quantitatively describing an Ozarks river in terms of its downstream trends in cross sectional and longitudinal morphology, substrate characteristics, stream power, and natural geomorphic variability and bedrock control. This research has provided several key findings in regard to channel form and process mechanisms within an Ozarks river.

First, results of this work indicate that bankfull channels in the James River contain the 1.1 to 1.5 year return interval flow, consistent with previous work in the middle James River basin (Owen et al., 2011) as well numerous other studies including Dunne and Leopold's (1978) national study. Although bankfull surfaces were determined in the field without regard to discharge statistics, this finding also reflects a reasonable identification of the bankfull stage in the field. Recurrence interval statistics also indicate a decrease in lower flow discharges and an increase in higher flow discharges since the 1950s, possibly consistent with effects of climate change, land use changes, or the introduction of conservation practices on flow regimes.

Second, channel morphology equations were developed that can be used in stream and habitat restoration designs and making comparisons to other rivers in the Ozarks and elsewhere. Despite the frequent influence of bedrock substrate and bluff walls in close proximity to active channels, cross-sectional channel geometry may be accurately predicted by drainage area (and bankfull discharge) within limits of natural site variability (+/- 20 percent). Bankfull width-depth ratios are fairly constant downstream as shown by similar width and depth equation exponent values in both drainage area and discharge based equations. What little variability there is may be explained by valley confinement (r^2=48 percent), and local slope and substrate characteristics may influence this ratio as well.

Third, channel slope values do not display pronounced downstream concavity at drainage areas greater than 500 km^2, likely due to geologic controls, and these results are consistent with channel slopes determined using USGS 7.5 minute topographic maps (MDC, 2012). Further, substrate size equations display positive exponent values, indicating slight downstream coarsening of bed and bar material which is contrary to the expectation of downstream fining in self-forming alluvial rivers. This observation is explained by tributary inputs as well as bedrock bluffs in close proximity to active channels. Stream power-sediment size relationships suggest sediment inputs from tributaries and bluff walls have a greater influence on sediment size trends as opposed to well-published particle sorting or selective transport mechanisms in the downstream direction.

Finally, field data collection methods used in this study are considered reliable with duplicate measurement errors less than natural geomorphic variability at the segment scale (~9 to 34 bankfull widths in length) for any given variable. Sediment size data show fairly high geomorphic variability and the greatest measurement errors compared to other channel variables. However, bedform variables display the greatest geomorphic variability. This variability is due to the presence of bedrock substrate and bluff pools, which act to reset local riffle spacing and directly influence pool length and depth due to scouring and helical flow characteristics.

In closing, Ozark streams are unique in that they may be characterized as possessing ample gravel supply as well as bedrock exposures. In that regard, they may be classified somewhere near the middle of an alluvial-bedrock channel continuum. While this study has made progress in quantifying an interesting fluvial environment not previously studied in this manner, future studies must be completed to further grasp the influence of bedrock and draw conclusions regarding its influence in Ozarks streams in general. Also, a continuation of this work should involve quantifying gravel composition (chert versus carbonate), density, and transport, as well as classifying bed and bar material in relation to tributary inputs, bedrock bluffs, and presence/absence of bar vegetation. Future work could also apply Martin and Pavlowsky's (2011) historical planform classification scheme to cross sectional and longitudinal trends presented here.

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APPENDICES

Appendix A. Key to Appendices B and C

Notes Code	Description
Bf(s)	Bankfull stage
Bk	Bank
Blk	Blocks (large sediment)
Bot	Bottom
Bould	Boulders
Br	Bedrock
Brk	Bedrock
Cc	Chute channel
Cg	Coarse gravel
Ch(an)	Channel
Cmpt	Common point
Cobb	Cobble
Cs	Cross-section
Fg	Fine gravel
Fp	Floodplain
G	Glide
H bar	High bar
H Fp	High floodplain
Hist	Historical
Hol terr	Holocene terrace
HT	Hight terrace
L	Left
LT	Low terrace
Lwd	Large-woody-debris
Mid	Middle
N	Run
P(1)(2)	Pool (primary)(secondary)
R(1)	Riffle (primary)
Rc	Riffle crest
Rt	Right
Rk	Bedrock
SR	Sub-reach
Subveg	Submerged vegetation
T(h)(l)(w)	Thalweg
Ter(r)	Terrace
Tob	Top of bank
Trib	Tributary
We	Water edge
WL	Water level

Appendix B. Cross Section Data

Site 0 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.35	High Pleistocene Terrace, top
15.00	2.38	Hill Slope, top, left side
18.50	1.93	Hill Slope, bot
25.00	1.46	LT, left side
29.00	1.38	LT
37.00	1.60	LT
40.50	1.66	LT, top
42.70	1.32	Bank edge
43.30	0.44	WL
44.00	0.00	Bed, toe, th
46.00	0.23	Low Bar
47.60	0.43	Low Bar, wl
48.00	0.49	Low Bar
49.00	0.55	Bar
49.80	0.88	Bar
49.90	1.06	FP, right side
51.00	1.20	FP, right side
55.50	1.36	FP
58.00	1.33	FP
63.00	1.24	FP or LT
64.00	1.38	LT
70.00	1.47	LT
80.00	1.66	LT
93.00	1.36	LT
105.00	2.08	LT
110.00	2.36	LT

Appendix B Continued. Cross Section Data

Site 0 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	1.51	LT, left, base of sycamore
11.00	1.39	LT, spring 5m upstream
14.50	1.16	LT
20.00	1.49	LT, left, white oaks, dry
27.00	1.55	LT
32.00	1.54	LT
33.00	1.52	LT
33.60	1.10	scour bar/bench
35.00	0.92	Bench edge
35.20	0.48	WL
36.50	0.14	low bar
37.00	0.07	bed
37.50	0.00	bed, thalweg
38.00	0.09	bed
39.20	0.31	bar
40.10	0.46	Wl
41.00	0.60	bar
42.00	0.70	low bar, tail
43.40	1.12	FP, edge
46.00	1.30	FP
49.00	1.26	FP
51.80	1.25	base of stake for SR2, 1 m ds
55.00	1.75	LT
60.00	1.78	LT

Appendix B Continued. Cross Section Data

Site 0 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	1.40	LT, left, base of tree SR 2
9.00	1.14	LT, spring chute
13.00	1.30	LT
20.00	1.30	LT
21.50	1.49	LT, dry, white oak
25.00	1.42	LT
28.20	1.35	LT
29.40	1.35	LT, edge
29.70	1.16	FP/bench
31.00	1.16	FP/bench
32.50	0.80	low bench, young fp?
33.00	0.76	Bench edge
33.10	0.61	bar
33.60	0.50	bar
34.30	0.34	bar
35.70	0.07	bar/bed break
37.00	0.00	bed
37.70	0.03	bed
39.00	0.36	bed
40.00	1.08	FP, top
44.60	1.23	FP, scoured, lower elev.
48.00	1.41	LT
55.00	1.50	LT
135.00	1.50	Trib channel at this distance

Appendix B Continued. Cross Section Data

Site 1 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.07	Rk bluff, mon, left side
1.62	1.06	Rk bluff
2.56	0.53	Bluff toe
3.90	0.29	Brk shelf
5.29	0.31	Brk shelf
5.44	0.28	We
5.51	0.10	Toe
6.12	0.00	Ch bed
6.78	0.00	Ch bed
7.46	0.07	Ch bed brk
7.83	0.21	Low bar
8.25	0.09	toe
8.36	0.29	we
9.27	0.71	Root bench
10.38	0.64	Root bench
10.84	0.87	fp
13.13	0.99	fp
14.61	0.95	fp
16.10	0.97	fp
17.59	1.24	Base stake
18.99	1.35	High fp
20.26	1.28	High fp
21.76	1.51	High fp
22.22	1.60	highfp
23.14	1.23	shootslope
24.01	1.00	Fp chute
24.95	1.09	Fp chute
25.82	1.38	Shoot bank
27.21	1.78	Shoot bank
29.22	2.14	Hol terrace
30.37	2.13	Fence line, right side

Appendix B Continued. Cross Section Data

Site 1 – Sub-reach 1 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.77	Hill Slope, mid, soil, left side
1.10	2.05	Hill Slope, mid soil
2.10	1.55	Bench, top, boulder
2.50	1.55	Bench, edge
3.00	0.79	Base, break, bedrock
3.70	0.54	Bed, toe, bedrock
4.60	0.46	Step
5.40	0.29	Bed
6.00	0.29	Bed
6.50	0.22	Bed, WL
6.55	0.11	Bed
7.10	0.00	Bed, Thalweg
7.70	0.04	Bed
8.20	0.16	Bed
8.70	0.25	Bed
9.00	0.26	Bed
10.00	0.74	Bench, root scour
12.00	0.97	FP, edge
14.30	0.95	FP
15.70	1.09	LT/FP
16.80	1.25	LT, base stake SR 1
19.50	1.30	LT
20.90	1.53	LT
21.80	1.42	LT
22.60	1.06	LT
23.40	1.00	LT
24.20	1.19	LT, chute
25.40	1.64	HT
27.70	2.18	HT, top
29.00	2.22	HT, fence line, right side

Appendix B Continued. Cross Section Data

Site 1 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.46	Slope, left (bluff) side
2.02	1.67	Slope toe
3.86	1.43	H fp
6.42	1.30	H fp
8.07	0.96	Low fp
9.08	0.93	Low fp
10.06	0.46	Mid bank
10.77	0.24	Toe we
12.03	0.04	Toeb ed
12.88	0.00	tweg
14.69	0.03	bed
16.27	0.10	bed
17.63	0.26	we
19.13	0.46	toe
19.74	0.68	Mid bank
20.42	0.85	Low fp
21.97	0.96	Low fp
23.07	0.82	Fp chute
23.85	0.79	Fp chute
26.35	1.21	Mid bank
27.83	1.52	Bot stake
29.90	1.77	Hol terr
32.31	1.91	Holt err
35.27	1.83	Fence line, right side

Appendix B Continued. Cross Section Data

Site 1 – Sub-reach 2 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0	3.11	Hill Slope, mid, left (bluff)
1.3	2.46	Hill Slope
2.9	1.84	Slope Toe (LT)
5	1.56	FP (LT to FP)
8.8	1.12	FP ? Bank
10.1	0.86	FP ? Bank
10.8	0.62	Bank
11.5	0.39	Toe
11.9	0.31	Bed, WL
12.6	0.1	Bed
13.2	0	Bed, Thl
13.8	0.08	Bed
14.6	0.24	Bed
16.6	0.3	Bed, WL
17.5	0.37	Bar top
18.7	0.29	Bed
19.9	0.39	Bank
20.5	0.87	FP, edge
22.1	1.06	FP, top
24.1	0.83	FP, chute
24.7	0.89	FP, chute
26.6	1.24	LT
28.6	1.61	LT, base of stake SR 2
30.3	1.86	LT, mid
32.2	1.96	LT/HT, top
34	2.1	HT, edge
35.3	2.01	HT, fence t-post, flagging

Appendix B Continued. Cross Section Data

Site 1 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.50	Slump, left (bluff side)
2.20	0.91	Bluff toe
3.11	0.89	Rk bench
4.20	0.31	toe
5.19	0.34	Rk bench
5.20	0.15	toe
5.21	0.25	we
6.97	0.00	bed
8.70	0.03	bed
10.79	0.05	bed
12.15	0.12	Low bar
12.80	0.10	toe
13.01	0.25	we
13.22	0.61	Low bench
13.84	0.65	Low bench
14.27	0.82	Mid bench
15.07	1.00	Hist fp
15.84	1.15	Hist fp
16.71	1.37	Bot stake
18.20	1.57	Hol fp
20.00	1.60	Hol fp
24.80	1.92	Fence line, right side

Appendix B Continued. Cross Section Data

Site 1 – Sub-reach 3 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0	2.76	Hill Slope, top (bluff side)
1.5	2.85	Hill Slope, mid
2.8	1.055	Hill Slope, bot
3.6	0.86	Bench, bedrock
4.4	0.425	Bench/Bar
5.3	0.45	Low Bar
5.9	0.26	WL
6.7	0.205	Bar, toe
7.2	0.125	Bed
8.3	0.1	Bed
10.3	0	Bed, th
11.8	0.035	Bed
13.1	0.255	WL
13.3	0.73	Bench, root scour
13.8	0.73	Bench, root scour
14.5	1.14	narrow FP
15.2	1.14	narrow FP
16.9	1.53	FP?
18.4	1.74	LT, edge
20.3	1.76	LT, edge
22.3	1.845	HT
24.4	1.91	HT, fence line (right side)

Appendix B Continued. Cross Section Data

Site 2 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.45	fp
4.35	2.43	fp
7.43	2.39	fp
8.82	2.17	fp
9.79	1.98	fp
12.00	1.86	fp
13.86	1.66	tob-l
14.75	0.69	midbank
15.41	0.29	weleft
16.10	0.05	toet
17.66	0.00	bed
18.89	0.07	bed
20.44	0.13	bed
21.83	0.12	bed
23.22	0.20	bed
24.02	0.18	bed
25.28	0.32	we-r
27.09	0.74	bar
29.62	0.82	bar
32.75	0.91	bar
35.16	1.08	bench
37.64	1.33	bench
40.44	1.45	fp
43.22	1.42	fp
54.24	1.25	backswamp
57.78	1.11	backswamp
63.40	1.74	fp

Appendix B Continued. Cross Section Data

Site 2 – Sub-reach 1 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
1.15	2.10	FP, top
1.95	1.11	BK
2.90	0.53	WL, toe
4.50	0.50	BED
6.10	0.00	BED, th
7.60	0.02	BED
9.30	0.12	BED
11.00	0.32	BED
11.90	0.50	BK
12.15	0.80	BAR, bot
12.85	0.98	BAR
13.38	1.16	BAR
14.55	1.29	BAR
15.00	1.35	BAR, crest
16.00	1.33	BAR
16.65	1.22	BAR
18.15	1.10	BAR
18.85	1.18	CC
20.50	1.33	CC, top
22.25	1.26	CC
23.50	1.36	CC
24.10	1.72	FP
27.90	1.72	FP END

Appendix B Continued. Cross Section Data

Site 2 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.33	Fp, right
4.06	1.43	fp
5.97	1.34	fp
8.59	1.24	fp
12.13	1.57	fp
18.50	1.34	fp
22.65	1.51	bench
23.05	1.45	tobl
24.58	0.80	midbank
25.13	0.24	we-l
26.60	0.06	bed
27.37	0.00	tweg
30.52	0.12	bed
32.14	0.13	bed
34.24	0.16	bed
34.99	0.23	bed
36.80	0.32	we
38.32	0.49	bar
41.58	0.73	bar
45.72	0.77	bar
47.92	0.54	bakswamp
52.14	0.81	bakswamp
56.98	1.19	fp
62.74	2.13	Fp, left

Appendix B Continued. Cross Section Data

Site 2 – Sub-reach 2 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.40	1.83	FP
2.00	1.86	
3.40	1.84	
4.20	1.82	
4.70	1.52	SCOUR
6.00	0.99	
6.50	0.90	
7.00	1.16	
7.50	2.20	
8.00	1.43	TOB
8.50	1.10	
9.20	0.83	
9.80	0.05	WL
9.90	0.18	TOE
10.90	0.02	TH
12.00	0.09	
13.00	0.09	
14.00	0.09	
15.00	0.09	MID
16.00	0.20	
17.00	0.20	
20.00	0.00	THALWEG
21.50	0.33	BANK, WL
22.30	0.38	BANK
23.50	0.41	BANK
24.30	0.74	ROOT
25.50	1.09	ROOT
26.40	1.14	TOB
27.50	1.10	FP
28.50	0.94	
30.00	1.00	
31.20	0.96	
32.00	1.04	
33.00	1.04	
34.50	0.83	
35.00	0.64	
36.00	0.38	CHUTE

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Appendix B Continued. Cross Section Data

Site 2 – Sub-reach 2 DUPLICATE Continued

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
36.70	0.47	
37.30	0.79	
38.50	1.04	
39.80	1.17	
41.00	1.40	
42.00	1.57	
42.50	1.60	
43.50	2.00	

Appendix B Continued. Cross Section Data

Site 2 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0	2.95	fp
3.91	2.34	fp
7.40	1.83	fp
10.88	1.53	fp
15.70	1.37	fp
20.04	1.28	fp
24.75	1.24	fp
27.91	1.29	fp
30.54	1.28	bf
32.38	1.32	tobl
34.34	0.62	shoot
37.24	0.66	bar
38.12	0.63	we-l
40.46	0.45	bed
41.75	0.11	bed
42.96	0.01	tw
44.50	0.03	tw
45.02	0.00	toe
45.25	0.49	ledge
45.87	0.67	we-r
47.04	0.87	bench
48.43	1.22	bench
49.05	1.76	topbank
53.54	1.70	midbench
57.17	1.98	midbench
61.29	2.86	fp
66.98	2.80	fp

Appendix B Continued. Cross Section Data

Site 2 – Sub-reach 3 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.00	
1.20	1.88	BK, TOP
2.00	1.45	MID
2.70	0.83	TOE/WL
3.50	0.55	SCOUR
4.70	0.48	SOUR
5.30	0.72	TOE/WL
5.80	1.13	TOW/WL
7.00	1.52	MID BANK
8.70	1.61	BK
10.70	1.39	TOP BANK
12.00	1.19	MID
12.40	0.97	
12.75	0.66	WL/TOE
13.60	0.63	
13.90	0.67	
14.30	0.61	
14.40	0.58	
16.00	0.48	BED
18.00	0.45	
20.00	0.29	
21.00	0.18	
22.00	0.00	THALWEG
22.35	0.12	
24.00	0.20	
25.20	0.31	TOE
25.45	0.94	BK
26.00	0.94	
27.00	1.20	
28.00	1.48	FP
29.00	1.63	
30.00	1.81	
31.00	1.75	
32.00	1.76	
35.00	2.04	
36.00	2.17	
38.00	2.61	
39.00	2.86	

Appendix B Continued. Cross Section Data

Site 3 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.58	fp
0.18	2.03	fp
0.66	1.07	fp
1.30	0.19	TOE
2.01	0.10	CHAN
3.09	0.04	CHAN
4.97	0.08	CHAN
7.02	0.30	we
8.95	0.36	Lowbar
10.93	0.37	we
12.83	0.27	CHAN
14.07	0.20	CHAN
16.17	0.10	CHAN
18.80	0.13	tw
20.78	0.07	CHAN
21.95	0.00	CHAN
22.89	0.10	WSURFACE
23.03	0.69	TOE
23.35	1.18	bank
24.97	1.79	bankFUL
25.76	1.62	SHELF

Appendix B Continued. Cross Section Data

Site 3 – Sub-reach 1 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.20	2.41	Bank (left)
1.00	1.41	Bank
1.80	0.53	Bank
2.80	0.26	WL
4.40	0.15	Bed
6.40	0.11	Bed
8.40	0.10	Bed
10.40	0.10	Bed
12.00	0.02	Bed
13.30	0.01	Bed
14.10	0.06	Bed
15.50	0.12	Bed
16.80	0.09	Bed
18.20	0.06	Bed
19.00	0.01	Bed
20.30	0.00	Thalweg
21.00	0.07	Bed
21.80	0.10	Bed
23.70	0.26	Toe/WL
23.90	0.61	Bank
24.60	1.11	Bank
25.70	1.78	Bank
26.70	1.91	FP
27.00	1.86	FP
27.30	1.75	FP
27.80	1.73	FP
29.30	1.90	FP
30.00	1.90	FP
30.90	1.74	FP
32.50	1.87	FP, Bluff side (right)

Appendix B Continued. Cross Section Data

Site 3 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.17	FP
0.66	2.13	FP
1.51	1.99	FP
2.43	1.75	FP
3.05	1.52	FP
3.39	1.37	bank
3.82	1.34	bank
4.55	1.40	bank
5.09	1.30	bank
5.57	1.04	bank
6.56	1.24	bank
6.95	0.98	bar
7.47	0.77	toe
8.66	0.58	bar
9.59	0.53	bar
10.84	0.49	bar
11.65	0.26	WE
13.83	0.08	chan
16.08	0.00	chan
18.05	0.00	chan
19.97	0.02	chan
22.08	0.08	chan
24.06	0.26	WE
25.05	0.51	bar
25.54	0.60	toe
26.02	0.85	bank
26.82	1.30	bank
27.44	1.64	TOB
29.43	1.65	TOB

Appendix B Continued. Cross Section Data

Site 3 – Sub-reach 2 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
1.00	2.02	fp
1.65	1.77	Bk top
2.05	1.44	Bk mid
2.55	1.18	Hb toe
4.00	1.06	Hbar
5.00	1.22	Hbar
5.70	1.12	Hbar
5.90	0.91	Hbar
6.45	0.87	Hbar
8.20	0.72	Hbar
10.00	0.65	Lbar
11.00	0.48	Lbar
11.85	0.36	B, wl
13.00	0.21	Bed
13.60	0.09	Bed
14.15	0.02	Bed
15.00	0.12	Bed
17.00	0.04	Bed
18.30	0.09	Lbar, center
18.70	0.06	Lbar, center
19.20	0.00	Lbar, center
19.80	0.00	Lbar, center
20.75	0.02	Bed
22.00	0.02	Bed
24.00	0.07	Bed
24.50	0.35	Bed, toe, wl
25.00	0.56	Bk bot
26.00	0.61	Bk md
27.20	1.75	Bk top
29.00	1.86	fp
30.35	1.75	fp
30.90	1.61	cc
31.35	1.41	cc
33.00	1.56	cc
36.00	1.76	cc
37.75	1.61	cc

Appendix B Continued. Cross Section Data

Site 3 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	1.88	FP
0.89	1.69	BANK
1.44	1.55	TOB
2.29	1.18	BANK
3.28	0.89	BANKFL
3.97	0.60	BANK
4.44	0.26	WE_TOE
5.54	0.03	CHAN
7.80	0.08	CHAN
10.22	0.06	CHAN
12.70	0.03	CHAN
15.79	0.06	CHAN
18.88	0.20	CHAN
20.96	0.18	CHAN
22.53	0.00	CHAN
23.72	0.25	WE_TOE
23.87	0.35	BLUFF
23.99	0.98	BLUFF
24.74	1.47	BLUFF
25.29	1.73	BLUFF
25.66	1.88	BLUFF

Appendix B Continued. Cross Section Data

Site 3 – Sub-reach 4 (Alternate cross-section)

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.09	Fp (left bank)
2.00	1.98	fp
4.00	2.01	fp
5.00	2.01	stake
6.00	1.79	bk
7.25	1.34	bk
7.80	1.07	bk
8.45	0.00	toe
10.00	0.07	Wl, toe
13.00	0.08	b
16.00	0.05	b
18.80	0.05	b
20.00	0.10	b
22.00	0.17	b
24.00	0.08	b
25.40	0.18	b
25.60	0.40	b
26.60	0.50	Wl, toe
27.00	0.69	toe
27.40	1.19	Bk, mid
28.00	2.20	Bk, top
29.00	1.46	
32.00	1.48	edge of bluff (right side)

Appendix B Continued. Cross Section Data

Site 4 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	5.21	Ter (left)
2.17	4.83	slope
3.44	4.47	slope
4.86	3.78	slope
6.93	3.11	slope
9.20	2.46	bench
11.45	2.02	bankful
12.71	2.10	bankful
14.07	1.94	topbank
14.92	1.16	midbank
15.67	0.81	midbank
16.05	0.55	we
16.78	0.54	brkshoot
18.08	0.56	brkshoot
20.17	0.55	brkshoot
21.64	0.45	vegbar
22.92	0.28	brkchan
24.51	0.39	bar
25.84	0.54	bar
26.41	0.61	bar
27.04	0.58	bar
28.46	0.28	brkchan
30.20	0.15	brkchan
31.64	0.29	brkchan
33.81	0.28	brkchan
34.91	0.19	brkchan
36.53	0.00	brkchan
38.05	0.08	brkchan
40.39	0.24	brkchan
42.85	0.20	brkchan
43.35	0.35	toe
43.81	0.51	we
44.30	0.70	lowbench
45.44	0.68	lowbench
46.12	1.11	lowbench
47.47	1.57	lowbench
48.53	1.69	lowbench

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Appendix B Continued. Cross Section Data

Site 4 – Sub-reach 1 Continued

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
49.22	2.04	bkful
50.73	2.20	bench
52.03	1.81	humok
52.98	1.53	humok
54.05	1.53	humok
55.74	1.94	humok
60.42	2.09	fp
65.16	2.41	Fp (right)

Appendix B Continued. Cross Section Data

Site 4 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.39	Terr (left)
1.87	4.48	terr
3.61	3.91	terr
5.36	3.26	slope
7.12	2.74	slope
8.34	2.46	bankful
8.92	2.18	topbl
9.36	1.65	midbnkl
9.92	1.18	midbnkl
10.20	0.64	we
11.04	0.14	toe
12.93	0.15	chan
15.78	0.28	chan
18.50	0.12	chan
21.64	0.17	chan
23.90	0.17	chan
27.35	0.11	chan
30.60	0.00	chan
33.04	0.03	subveg
33.70	0.18	subveg
34.60	0.41	subveg
35.43	0.46	subveg
36.44	0.40	subveg
37.38	0.26	toe
37.93	0.60	we
38.16	1.18	midbank
38.59	1.87	topbk
39.20	2.09	topbk
39.90	1.87	topbk
40.22	1.33	n
40.27	0.62	we
41.45	0.04	trib
41.94	0.30	trib
42.41	0.63	we
43.11	1.25	midbank
43.93	1.84	midbank
46.75	2.37	topbank
50.13	2.39	Bankful, swamp (right)

Appendix B Continued. Cross Section Data

Site 4 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.89	Terr (left)
1.79	4.15	terr
3.24	4.06	terr
4.76	3.71	terr
5.87	3.11	slope
6.53	2.69	slope
7.03	1.95	bank
7.27	1.31	midbank
7.46	0.25	toe
8.92	0.09	chan
10.25	0.00	brkchan
11.38	0.19	brkchan
12.91	0.20	brkchan
14.30	0.43	brkchanveg
17.15	0.50	brkchanveg
19.78	0.52	brkchanveg
23.55	0.65	brkchanveg
27.55	0.58	brkchanveg
30.99	0.53	brkchanveg
32.42	0.64	toe
33.92	0.69	we
35.13	0.85	slope
35.47	1.35	midbank
36.61	1.95	topbank
38.47	2.07	topbank
40.72	1.96	bankful
43.23	1.73	fp
47.85	1.78	Fp (right)

Appendix B Continued. Cross Section Data

Site 5 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.04	Fence (right)
2.99	2.52	backswamp
4.96	1.71	backswamp
6.76	1.39	backswamp
9.91	1.87	backswamp
12.67	2.20	backswamp
15.23	2.31	bench
19.08	2.59	bench
21.99	2.67	bench
24.37	2.76	bench
27.45	2.79	bench
29.69	2.73	bkfull
31.16	2.33	bkfull
32.27	1.73	midbank
33.67	1.05	botbank
35.82	0.85	bar
37.69	0.98	bar
39.76	0.79	we
42.67	0.59	chan
45.17	0.43	chan
48.72	0.36	chan
51.76	0.34	chan
55.37	0.28	chan
59.20	0.36	chan
62.19	0.32	chan
65.01	0.48	chan
67.93	0.48	chan
70.34	0.26	chan
72.39	0.11	chan
74.10	0.00	scour
75.43	0.62	we
75.56	1.06	midbank
75.72	1.54	top
77.38	2.25	top
78.25	2.68	top
78.95	2.85	Top (left, bluff)

Appendix B Continued. Cross Section Data

Site 5 – Sub-reach 1 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.34	FP
1.00	3.34	FP
1.45	3.29	BK TOP
2.16	2.97	BK
2.75	2.59	
3.05	1.91	BK MID
3.50	1.80	BK BOT
4.00	1.06	TOE
4.90	0.45	CC
5.20	0.20	
6.40	0.00	
7.50	0.55	LB
8.60	0.90	
10.10	0.94	
11.00	0.97	
12.00	0.94	
13.00	0.87	
14.30	0.68	BED
15.50	0.67	
16.50	0.57	
18.00	0.45	
19.50	0.47	
21.00	0.54	
22.00	0.50	
23.00	0.55	
24.00	0.63	
25.00	0.65	
26.00	0.77	
27.00	0.75	
28.00	0.80	
29.00	0.90	
30.00	1.01	
31.00	1.09	
32.00	1.17	HB
33.40	1.27	WL
34.00	1.30	
35.00	1.37	

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Appendix B Continued. Cross Section Data

Site 5 – Sub-reach 1 DUPLICATE Continued

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
36.00	1.39	
37.00	1.39	
38.00	1.33	
39.00	1.28	
40.00	1.28	
41.00	1.32	
42.00	1.28	
43.40	1.47	BK BOT
44.80	2.13	BK MID
46.40	3.14	BK TOP
47.20	3.33	MON
48.00	3.39	FP
49.00	3.36	FP
50.00	3.34	FP

Appendix B Continued. Cross Section Data

Site 5 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.23	Fp (right)
2.29	1.84	backswamp
4.03	1.54	backswamp
7.68	1.85	bench
12.13	2.06	bench
15.98	2.01	bkful
18.82	1.80	bkful
20.86	1.35	midbank
22.21	1.04	botbank
24.05	0.77	bar
25.35	0.92	bar
26.56	0.73	bar
28.10	0.61	we
31.04	0.48	chan
33.22	0.28	chan
35.25	0.18	chan
38.26	0.10	chan
42.21	0.00	chan
44.35	0.11	chan
45.68	0.24	chan
48.88	0.37	chan
51.82	0.51	chan
55.57	0.52	chan
57.54	0.66	we
58.25	1.18	midbank
59.56	1.88	bankful
60.12	2.59	bankful
61.56	3.08	bluff
62.94	3.28	Bluff (left)

Appendix B Continued. Cross Section Data

Site 5 – Sub-reach 2 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	1.65	Fp (right)
2.83	1.79	fp
5.54	1.75	fp
7.37	1.89	fp
9.41	1.99	fp
10.84	1.89	Top bank rt
13.46	1.11	Bot bank rt
15.34	1.15	bar
16.60	0.97	bar
18.80	0.54	bar
19.59	0.52	we
22.68	0.34	bed
25.16	0.19	bed
27.65	0.04	bed
29.42	0.00	bed
31.59	0.01	bed
34.49	0.09	bed
37.74	0.20	bed
41.45	0.31	bed
43.05	0.32	bed
43.86	0.27	bed
45.28	0.32	toe
45.62	0.48	we
46.66	1.48	Mid bank
48.12	2.67	Top left (bluff)

Appendix B Continued. Cross Section Data

Site 5 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.52	Terr (right)
2.11	3.53	terr
4.27	3.29	bench
5.49	2.93	bench
7.06	2.88	bench
8.66	2.22	bankful
10.32	1.77	midbank
11.60	1.17	midbank
12.89	0.75	shoot
14.14	0.80	shoot
15.70	1.07	bar
18.56	1.09	bar
20.64	0.92	bar
22.77	0.81	bar
24.90	0.52	we
26.74	0.44	chan
28.34	0.34	chan
30.08	0.40	chan
32.21	0.27	chan
34.83	0.10	chan
36.85	0.15	chan
38.72	0.09	chan
40.67	0.00	chan
41.26	0.02	belowwood
42.38	0.10	belowwood
43.15	0.20	chan
43.34	0.14	basebluff
43.43	0.61	we
43.47	1.00	bluff
43.50	1.77	bluff
44.20	2.87	Bluff (left)

Appendix B Continued. Cross Section Data

Site 5 – Sub-reach 3 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.40	Terrace (right)
0.50	2.28	Terrace
1.00	1.77	Bank
2.00	1.50	Bank
3.00	1.30	Bank
3.50	1.00	Bank
5.50	0.76	Toe
8.00	0.98	Bar
11.00	1.38	Bar
14.00	1.39	Bar
16.50	1.28	Bar
17.50	0.60	Bar
20.50	0.46	Bed
22.00	0.56	Bed
24.00	0.34	Bed
27.50	0.00	Bed
29.00	0.18	Bed
31.50	0.11	Bed
34.00	0.30	Bed
34.58	3.35	Bluff (left)

Appendix B Continued. Cross Section Data

Site 6 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.70	fp left
9.74	3.88	fp
15.14	4.18	fp
18.20	4.00	fp
19.52	3.63	fp
20.27	3.31	fp
21.64	3.33	fp
22.96	3.06	tobl
24.27	2.15	midbk
26.00	0.91	we
26.11	0.61	toe
26.15	0.33	bed
29.41	0.24	bed
31.83	0.00	brk
34.61	0.01	brk
36.74	0.09	brk
38.89	0.29	brk
42.09	0.41	brk
45.12	0.44	brk
47.02	0.50	brk
50.42	0.53	brk
53.17	0.83	wer
54.94	2.49	midbk
56.21	3.92	tobr
58.78	4.01	fp
63.44	4.16	fp right
77.81	4.13	Fence (right)

Appendix B Continued. Cross Section Data

Site 6 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.32	fp left
4.36	3.14	fp left
6.15	1.53	backswamp
8.52	1.16	backswamp
11.63	1.67	backswamp
16.31	1.94	backswamp
18.08	2.22	top
21.84	2.06	top
24.43	2.18	top
27.49	2.28	topbnk
30.59	2.26	tobl
31.53	1.73	midbank
32.31	0.67	we
32.57	0.58	toe
33.55	0.31	bed
35.10	0.09	bed
37.42	0.00	bed
39.92	0.06	bed
42.69	0.08	bed
45.98	0.01	bed
49.14	0.05	bed
52.30	0.29	bed
54.87	0.37	bed
58.24	0.53	bed
59.37	0.72	we
62.02	1.00	bar
64.51	1.31	bank
66.65	2.13	midbank
67.92	3.36	topbank
72.80	3.47	fp
77.80	3.48	Fp right

Appendix B Continued. Cross Section Data

Site 6 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.42	fp left
3.79	2.30	fp
6.38	2.18	fp
7.60	2.06	tobl
8.47	1.53	midbk
9.18	0.70	we
9.32	0.38	toe
10.42	0.37	bed
12.27	0.44	bed
14.58	0.37	bed
16.57	0.34	bed
18.73	0.38	bed
20.76	0.36	bed
23.19	0.18	bed
25.40	0.05	bed
27.22	0.00	bed
29.43	0.10	bed
31.62	0.15	bed
33.39	0.11	bed
35.25	0.02	bed
36.90	0.10	bed
38.74	0.27	bed
40.51	0.52	bed
41.71	0.69	we
44.21	0.88	bar
45.83	1.13	bar
46.86	1.18	bar
48.24	1.45	bar
49.31	1.70	bar
51.34	1.83	fp right
54.25	2.41	fp
60.07	2.47	Fp (right)

Appendix B Continued. Cross Section Data

Site 7 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.52	Fpl (left)
2.73	2.86	fpl
6.54	3.05	fpl
8.61	2.83	fpl
10.37	2.56	fpl
11.75	2.71	topbankl
13.19	2.16	midbank
14.25	1.61	midbank
15.78	0.72	botbank
16.08	0.63	we
16.70	0.10	backswamp
17.73	0.00	backswamp
19.39	0.06	backswamp
20.83	0.30	backswamp
22.88	0.63	we
25.04	0.80	bar
27.39	0.85	bar
29.22	0.65	we
30.98	0.41	chan
36.29	0.22	chan
41.67	0.16	chan
47.10	0.02	chan
50.35	0.37	subveg
53.11	0.36	subvegfines
56.27	0.26	subvegfines
58.05	0.68	we
58.99	1.13	slope
61.11	2.07	bluff
62.03	2.81	Bluff (right)

Appendix B Continued. Cross Section Data

Site 7 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.48	Fptrail (right)
4.02	2.74	fptrail
6.86	2.16	bankful
8.04	2.24	slope
10.22	1.85	slope
11.90	1.59	slope
13.13	1.26	midbank
14.09	0.68	botbank
14.79	0.60	bar
15.87	0.72	bar
18.30	0.78	bar
20.69	0.76	bar
21.56	0.72	we
23.47	0.58	chan
25.79	0.44	chan
28.97	0.26	chan
31.27	0.09	chan
34.04	0.00	chan
38.21	0.06	chan
40.98	0.21	chan
44.73	0.14	chan
48.29	0.12	chan
50.78	0.24	chan
52.17	0.34	chan
52.72	0.66	we
53.71	1.20	midbank
54.37	1.62	topbank
55.72	2.08	topbank
57.44	2.36	fp
58.75	2.24	fp
60.53	2.73	fp
63.40	2.79	fp
66.29	2.79	Fp (left)

Appendix B Continued. Cross Section Data

Site 7 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.81	Fpl (left)
3.04	3.11	fpl
6.11	3.18	fpl
8.35	3.18	fpl
9.79	2.81	fpl
11.37	2.25	tbl
11.94	1.62	midbank
12.95	0.88	we
13.67	0.63	bed
15.24	0.55	bed
16.73	0.38	bed
18.58	0.47	bed
20.56	0.72	bed
22.68	0.43	bed
26.18	0.34	bed
29.91	0.30	bed
33.91	0.18	bed
37.49	0.13	bed
40.35	0.11	bed
44.47	0.05	bed
48.28	0.06	bed
50.86	0.00	bed
52.23	0.08	bed
52.71	0.39	botbr
53.87	1.82	topbankr
54.95	2.10	bnkfulr
56.02	2.31	fp
57.22	2.85	bluff
58.29	3.60	Bluff (right)

Appendix B Continued. Cross Section Data

Site 8 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.52	fp
1.60	2.52	shelf
2.29	2.35	bank
3.70	1.67	bank
4.81	1.27	toe
6.70	0.87	edgebar
7.62	0.60	watredge
9.68	0.41	scour
12.31	0.52	scour
13.69	0.66	watredge
14.91	0.68	bar
16.06	0.75	bar
16.42	0.63	watredge
18.69	0.31	ch
20.74	0.16	thalweg
23.82	0.00	ch
27.02	0.10	ch
30.09	0.20	ch
31.51	0.20	ch
33.32	0.37	ch
34.92	0.49	ch
36.85	0.49	ch
38.48	0.68	we
39.05	0.82	toe
39.35	1.08	slump
40.17	1.23	slump
40.83	1.70	bank
41.16	2.06	bank
41.80	2.61	topbank
42.75	3.00	floodpl
43.99	3.10	floodpl
46.15	3.52	floodpl
47.06	3.52	floodpl

Appendix B Continued. Cross Section Data

Site 8 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.13	fp
0.43	3.05	topbank
1.02	1.94	topbank
2.34	1.08	bank
3.28	0.55	toe\we
4.65	0.12	ch
7.44	0.00	ch
9.86	0.10	ch
12.42	0.04	ch
15.31	0.02	ch
17.65	0.01	ch
19.91	0.39	ch
21.14	0.52	we
23.51	0.67	bar
26.23	0.80	bar
28.67	1.25	bar
30.26	1.45	banktoe
31.74	1.93	bank
33.35	2.39	shelf
36.06	2.36	shelf
38.19	2.93	secdary
41.68	3.36	fp
44.65	3.41	fp

Appendix B Continued. Cross Section Data

Site 8 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.51	floodplain
1.70	3.37	floodplain
2.51	3.32	topofbank
3.41	2.66	bfs
4.06	2.41	shelf
5.15	1.87	shelf
5.40	1.39	bank
6.14	1.12	toe
6.88	1.17	bar
8.66	0.84	bar
9.85	0.77	bar
10.44	0.65	we
11.81	0.50	ch
13.23	0.32	ch
15.43	0.14	ch
17.23	0.29	ch
18.99	0.00	tw
21.31	0.11	ch
22.73	0.31	ch
24.71	0.50	brslabch
26.25	0.66	we
27.73	0.72	bar
29.02	0.69	toe
29.86	0.91	topresidum
31.53	2.43	topburriedbar
31.99	2.91	bfs
33.62	3.41	floodplain
35.79	3.67	floodplain
38.10	3.54	floodplain

Appendix B Continued. Cross Section Data

Site 8 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.51	floodplain
1.70	3.37	floodplain
2.51	3.32	topofbank
3.41	2.66	bfs
4.06	2.41	shelf
5.15	1.87	shelf
5.40	1.39	bank
6.14	1.12	toe
6.88	1.17	bar
8.66	0.84	bar
9.85	0.77	bar
10.44	0.65	we
11.81	0.50	ch
13.23	0.32	ch
15.43	0.14	ch
17.23	0.29	ch
18.99	0.00	tw
21.31	0.11	ch
22.73	0.31	ch
24.71	0.50	brslabch
26.25	0.66	we
27.73	0.72	bar
29.02	0.69	toe
29.86	0.91	topresidum
31.53	2.43	topburriedbar
31.99	2.91	bfs
33.62	3.41	floodplain
35.79	3.67	floodplain
38.10	3.54	floodplain

Appendix B Continued. Cross Section Data

Site 9 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.10	fp
1.23	3.95	topbank
2.39	2.30	slumpbank
3.58	1.02	toe
3.95	0.90	we
6.01	0.52	ch
7.58	0.50	ch
9.24	0.31	ch
12.33	0.10	tw
15.54	0.00	tw
18.72	0.05	tw
22.20	0.18	tw
26.01	0.28	ch
29.55	0.63	ch
33.59	0.93	we
37.60	1.21	bar
43.83	1.60	bar
45.24	1.56	bar
49.51	2.17	bar
53.01	2.55	bar
54.97	2.30	toe
56.56	2.85	bank
58.34	3.33	bank
61.50	3.69	shelf
62.48	3.59	fp

Appendix B Continued. Cross Section Data

Site 9 – Sub-reach 1 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.47	FP
7.00	4.47	BK
8.00	3.77	BK
13.50	3.07	BK
14.00	2.60	BK
16.00	2.09	Bed
19.00	1.72	Bed
22.00	1.38	Bed
23.00	0.83	Bed
30.00	0.40	Bed
32.00	0.30	Bed
35.00	0.00	Bed
42.00	0.12	Bed
48.00	0.31	Bed
50.00	0.67	Bed
53.00	1.06	Bar
55.50	1.35	BK
56.00	1.68	BK
56.50	1.96	BK
57.00	2.48	BK
59.00	4.74	FP
60.50	4.83	FP

Appendix B Continued. Cross Section Data

Site 9 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.19	fp1
1.50	4.36	fp1
2.29	4.50	fp1
3.77	4.05	fp1
5.82	3.48	fp1
8.45	2.75	bfs
10.64	2.58	bfs
12.27	2.18	bfs
13.83	2.31	bfs
14.87	1.94	bfs
16.16	1.47	toe
16.70	1.45	bar
18.49	1.30	bar
19.95	1.18	bar
21.59	0.92	we
23.45	0.61	ch
26.44	0.40	ch
29.67	0.08	tw
31.15	0.38	tw
34.19	0.04	tw
37.08	0.00	tw
40.65	0.44	tw
42.57	0.65	tw
43.87	0.94	we
44.86	1.27	toe
45.18	2.11	topburiedbar
45.32	2.74	slumpbank
47.00	4.11	slumpbank
47.91	4.93	topofbank
48.60	5.00	holterr
49.29	5.19	holterr

Appendix B Continued. Cross Section Data

Site 9 – Sub-reach 2 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.74	BK
1.00	2.40	BK MID
2.50	2.08	BKMID
3.00	2.13	BKMID
5.00	1.60	BK
6.50	1.28	BK
7.50	1.07	BK TOE
8.50	0.96	BK WL
12.00	0.69	Bed
15.00	0.35	Bed
17.00	0.19	Bed
20.00	0.07	Bed
23.00	0.07	Bed
26.00	0.00	Bed THALWEG
29.00	0.15	Bed
30.50	0.65	BK WL
34.00	0.68	BK
35.05	1.52	BK
36.58	3.66	BK TOP

Appendix B Continued. Cross Section Data

Site 9 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.83	fp
2.48	2.55	fp
3.83	2.15	shelf
6.27	0.67	toe
6.74	0.55	we
8.35	0.30	ch
11.73	0.12	ch
14.75	0.07	ch
17.58	0.00	ch-tw
20.68	0.17	ch
23.71	0.18	ch
26.91	0.20	ch
29.68	0.30	ch
30.55	0.49	ch
31.92	0.62	we
32.95	0.78	bar
34.72	0.87	bar
37.23	0.94	bar
39.08	0.89	toe
39.70	1.00	slump
40.63	1.13	slump
41.49	1.19	botfp
42.46	1.99	bfs
42.89	2.56	tob
44.28	2.92	fp
46.79	3.37	fp
49.56	3.50	fp
52.24	3.51	fp

Appendix B Continued. Cross Section Data

Site 9 – Sub-reach 3 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.03	CC
1.00	2.86	BK
2.50	2.78	BK
3.80	2.28	BK
5.00	1.52	BK
6.10	1.36	BK
7.30	0.89	BK
8.00	0.72	BK WL
9.50	0.32	Bed
10.80	0.22	Bed
12.80	0.06	Bed
14.80	0.00	Bed THALWEG
17.40	0.03	Bed
19.80	0.23	Bed
22.00	0.33	Bed
24.40	0.51	Bed
26.70	0.57	Bed
29.20	0.63	Bed
31.00	0.69	Bar WL
33.50	0.95	Bar BOT
35.80	1.16	Bar MID
38.20	1.16	CC TOP
39.40	1.06	CC BOT
41.00	1.10	CC BOT
42.50	1.22	BK TOE
43.00	1.64	BK MID
43.60	2.73	BK TOP
44.30	3.02	BK MID
46.60	3.35	FP
60.00	3.35	TERRACE

Appendix B Continued. Cross Section Data

Site 10 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.26	FP right
0.50	2.26	FP
1.00	2.33	BK top
1.50	1.31	BK mid
2.00	0.79	BK toe
5.00	0.62	BK wl
6.00	0.15	Bed
8.00	0.11	Bed
10.00	0.15	Bed
12.00	0.13	Bed
13.50	0.06	Bed
15.50	0.18	Bed
17.00	0.10	Bed
20.00	0.00	Bed thalweg
21.50	0.01	Bed
24.50	0.09	Bed
27.00	0.13	Bed
29.50	0.21	Bed
31.30	0.65	BK WL
31.50	0.31	Bed
36.00	1.04	BK toe
37.00	1.47	BK mid
38.50	1.82	BK mid
41.00	2.14	BK top
45.00	3.58	BK top left (bluff-like)

Appendix B Continued. Cross Section Data

Site 10 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.71	TB right
2.00	2.79	Mid bank
3.00	1.73	BK
3.50	1.45	Bk
4.50	1.30	BK
5.00	0.89	Bed
5.50	0.36	Bed
7.50	0.30	Bed
10.50	0.23	Bed
14.50	0.00	Bed
17.00	0.00	Bed
20.50	0.36	Bed
23.00	0.70	Bed
25.00	0.62	Bed
25.50	0.86	Bed
26.00	1.06	Bar
28.50	1.42	Bar
31.50	1.19	Bar
32.50	2.04	
33.50	2.56	
35.50	2.48	Bk
37.50	2.89	FP
39.50	2.92	FP left

Appendix B Continued. Cross Section Data

Site 10 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.70	BK (right)
0.50	4.17	BK top
1.50	3.08	BK med
2.00	2.24	BK
2.50	2.16	BK top of slump
2.50	1.74	Bed bank slump
3.50	0.76	Bed toe
5.00	0.66	Bed
7.50	0.56	Bed
9.50	0.71	Bed
11.50	0.00	Bed thalweg
16.50	0.13	Bed
20.50	0.25	Bed
23.50	0.27	Bed
27.50	0.18	Bed
31.50	0.18	Bed
34.50	0.48	Bed
36.50	0.65	Bed
38.50	0.96	BK toe / wl
39.00	2.69	BK edge
40.50	3.78	BK top
41.00	3.44	BK (left)

Appendix B Continued. Cross Section Data

Site 11 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	1.66	FP
2.00	1.85	FP
5.50	1.70	FP
6.00	1.49	BK top
7.00	1.31	BK mid
7.00	0.78	BK toe
7.50	0.68	BKwl
9.00	0.41	Bed
10.00	0.34	Bed
11.50	0.21	Bed
14.00	0.09	Bed
17.00	0.00	Bed
20.00	0.00	Bed
24.00	0.15	Bed
27.00	0.11	Bed
26.00	0.12	Bed
33.00	0.11	Bed
36.00	0.20	Bed
39.00	0.24	Bed
41.00	0.39	Bed
43.00	0.69	Bar WL
45.00	1.03	Bar mid
49.00	1.30	Bar mid
53.00	1.65	Bar top
54.00	1.60	Bar
54.00	1.35	CC
56.00	1.33	CC
55.00	1.40	CC
56.00	1.61	
57.00	1.76	Bar
59.00	1.91	FP
75.00	1.91	

Appendix B Continued. Cross Section Data

Site 11 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
1.00	4.80	BK Top Left
2.00	2.03	BK Mid
4.00	1.45	BK Mid
6.00	0.72	BK toe
10.00	0.37	CC Mid
12.00	0.46	CC Top
15.00	0.57	Bar
17.00	0.92	Bar
18.00	2.13	Bar
20.00	1.45	Bar
27.00	1.05	Bar
31.00	0.59	Bar WL
33.00	0.13	Bed
37.00	0.01	Bed
40.00	0.00	Bed Thalweg
42.00	0.16	Bed
43.00	0.37	Bed
48.00	0.42	Bed
50.00	0.51	Bed
52.00	0.66	BK WL
55.00	1.28	BK Mid
56.00	2.43	BK Mid
57.00	2.73	BK Top
58.00	2.99	
60.00	2.55	FP
63.00	2.65	FP Right

Appendix B Continued. Cross Section Data

Site 11 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.63	Bench edge right
0.00	2.83	
0.50	2.48	Bench top
1.00	2.51	Bar toe
3.00	1.41	Bar toe
5.50	1.11	Bed wl
6.00	0.79	Bed
6.50	0.09	Bed
7.50	0.01	Bed
8.50	0.00	Bed
10.50	0.14	Bed
12.50	0.30	Bed
13.50	0.50	Bed
14.50	0.65	Bed
16.50	0.79	Bed
18.00	0.87	Bed
18.50	0.93	Bed
25.50	0.97	Bed
26.50	1.02	Bed
27.50	0.94	Bed
28.50	0.90	Bed
30.00	0.85	Bed
31.50	1.12	Bar Wl
32.50	1.42	Bar mid
33.50	1.52	Bar top
34.50	1.87	Bench mid
36.00	2.81	BK top
49.50	3.15	Bankful left

Appendix B Continued. Cross Section Data

Site 12 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.00	Bank Top
0.00	1.52	Bench top
0.50	0.98	Bench
1.00	0.55	Bed WL
1.50	0.32	Bed Toe
3.00	0.32	Bed
5.00	0.50	Bed
6.00	0.50	Bed
11.50	0.34	Bed
13.50	0.17	Bed
15.50	0.09	Bed
22.00	0.09	Bed
24.00	0.18	Bed
27.50	0.06	Bed
29.00	0.00	Bed Thalweg
31.50	0.11	Bed
32.50	0.21	Bed
39.50	0.15	Bed
42.50	0.28	Bed toe
43.50	0.54	Bank WL
45.00	1.19	Bank Mid
46.00	2.05	Bank Top
53.00	2.37	Bank Top

Appendix B Continued. Cross Section Data

Site 12 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
1.00	3.87	LT (right)
2.00	2.66	TOB
3.00	1.44	Mid Bank
3.50	0.46	BK W
7.50	0.38	
9.50	0.31	
17.50	0.23	
21.00	0.11	
24.00	0.19	
27.50	0.19	
31.00	0.21	
34.50	0.19	
35.00	0.00	Thalweg
36.00	0.18	CHANNEL
37.00	0.41	WL
38.00	0.69	
39.00	1.36	Center bar
40.00	1.41	HB, Center bar
42.00	1.16	Center bar
43.00	0.93	LB
49.00	0.02	WL
51.00	0.13	
53.00	0.08	
59.50	0.07	
64.00	0.03	CHANNEL
67.00	0.09	WL
68.00	1.26	
72.50	2.81	BK Top (Left)

Appendix B Continued. Cross Section Data

Site 12 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	5.11	Terrace, TOB (Left)
1.50	3.90	Bk mid
3.00	1.70	Bk bot
8.00	1.22	Bench bot
9.00	0.85	Bed WL
13.00	0.66	Bed Bedrock
14.50	0.80	Bed Bedrock
19.00	0.65	Bed Bedrock
25.00	0.64	Bed Bedrock
32.00	0.57	Bed Bedrock
38.00	0.63	Bed Bedrock
40.00	0.35	Bed Gravel
41.50	0.17	bed
43.50	0.04	bed
45.00	0.00	Bed Thalweg
48.50	0.04	bed
49.00	1.22	Bar
51.00	0.79	bar
53.00	0.83	bar
55.00	0.89	bar
57.00	0.83	bar
59.00	0.53	bed
60.00	0.53	bed
62.00	0.79	Bed WL, Toe
63.00	0.84	Bank, top, floodplain
65.00	0.96	Mon
68.00	2.30	Bluff bottom
70.00	5.00	Bluff (Right)

Appendix B Continued. Cross Section Data

Site 13 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.11	BK Top
1.00	3.18	BK Mid
5.00	2.88	BK Mid
7.00	2.50	BK Mid
8.00	2.17	BK Mid
9.00	0.61	BK Mid
9.50	0.30	BK Bot
11.50	0.22	BK Toe/Wl
12.00	0.21	BED
16.00	0.11	BED
22.00	0.15	BED
26.00	0.14	BED
27.00	0.00	BED, Thalweg
35.00	0.03	BED
39.00	0.10	BED
44.00	0.12	BED
48.00	0.18	BED
49.00	0.93	BED
49.00	0.61	BED
50.00	1.64	BK, Tow, Wl
50.50	1.76	BK, Bot
52.00	2.68	BK, Mid
54.00	2.93	BK, Mid
56.00	3.77	BK, Mid
58.00	3.87	BK, Top

Appendix B Continued. Cross Section Data

Site 13 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	8.84	High Terrace Left
1.00	5.34	Terrace
6.00	5.34	Terrace
10.00	4.91	Terrace
10.50	4.05	Slump
11.00	3.31	Slump
15.00	2.92	Bankfull?
19.00	3.32	Bank
22.00	2.26	Bed
24.00	0.62	Bed
24.00	0.94	Bed
26.00	0.21	Bed
28.00	0.13	Bed
31.00	0.05	Bed
32.00	0.30	Bed
32.50	0.38	Bed
33.00	0.11	Bed
39.00	0.31	Bed
41.00	0.00	Bed, Thalweg
45.00	0.11	Bed
46.00	0.25	Bed
55.00	0.58	Bed
55.00	0.48	Bed
56.00	0.71	Bed
58.00	0.99	Bed
62.00	1.16	Bar
66.00	1.37	Bar
68.00	1.62	Bar
68.00	1.51	Bar
70.00	1.54	Bar
72.00	1.69	Bar
75.00	1.63	Bar
78.00	1.83	Bar
78.00	1.57	Bar
82.00	1.85	Bar
86.00	2.05	Bar
90.00	2.17	Bar

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Appendix B Continued. Cross Section Data

Site 13 – Sub-reach 2 Continued

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
91.00	2.07	Bar
100.00	2.07	Bar
101.00	2.11	Bar
110.15	8.84	Bluff, Right, Trib

Appendix B Continued. Cross Section Data

Site 13 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	6.85	TER
1.00	3.85	TER MID
1.00	3.65	TER BOT
3.50	3.44	BK TOP
4.00	1.25	BK MID
4.50	1.13	BK MID
6.50	0.85	BK
9.00	0.60	BEN
11.50	0.56	BEN
13.50	0.37	TOE
14.00	0.39	BED
19.00	0.12	BED
23.00	0.16	BED
26.50	0.11	BED
27.50	0.14	BED
30.00	0.00	BED, Thalweg
32.00	0.00	BED, Thalweg
37.50	0.12	BED
40.00	0.24	BED
41.00	0.37	BED
42.00	0.75	BED
43.00	0.87	BED
44.00	0.87	BED
45.00	3.72	BED
49.50	3.72	TOE
50.00	4.12	BEN
51.00	4.40	BEN
53.00	4.55	FP Top
58.00	4.54	FP

Appendix B Continued. Cross Section Data

Site 14 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.72	Terrace, Right
10.00	4.72	Terrace
19.40	4.72	Terrace
19.50	5.07	Terrace
20.00	5.01	AT INSTRUMENT
22.50	4.25	Bank
24.00	3.56	Bank
26.00	2.27	BANKFULL?
27.00	1.57	TOP SLUMP
27.50	1.42	WATER EDGE
28.00	0.70	TOE
29.00	0.36	BED
33.00	0.26	BED
36.50	0.11	BED
42.00	0.06	BED
43.00	0.03	BED
48.00	0.00	BED, Thalweg
56.50	0.13	BED
59.00	0.12	BED
62.50	0.24	BED
65.00	0.41	BED
67.00	0.49	BED
71.00	0.56	BED
72.00	0.43	BED
75.00	0.15	BED
77.00	0.12	BED
80.00	0.22	BED
85.00	2.22	BANKFULL?
89.00	3.35	BANK
91	4.18	FP, LEFT

Appendix B Continued. Cross Section Data

Site 14 – Sub-reach 1 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.61	BK
2.50	2.40	BK
4.00	1.36	BK
5.00	0.26	BK
5.50	0.01	BK
9.00	0.00	bed
14.50	0.01	bed
18.00	0.05	bed
23.50	0.22	bed
28.50	0.48	bed
34.00	0.62	bed
41.00	0.96	bed
47.00	1.43	bed
51.00	1.29	bed
55.50	1.18	bed
58.00	1.46	bed
60.00	1.84	BK
63.00	3.42	BK
66.00	4.79	BK
68.00	5.56	BK

Appendix B Continued. Cross Section Data

Site 14 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	2.85	fp
1.50	2.14	fp
2.50	1.42	fp
4.50	0.77	WL
8.00	0.57	side channel
11.00	0.54	side channel
13.50	0.36	side channel
16.50	0.62	bar
19.50	0.75	bar
20.00	0.86	bar
21.50	0.78	bar
22.00	0.67	bar
22.50	0.65	bar
23.50	0.89	bar
23.50	0.75	bar
24.00	0.76	bar
25.50	0.58	bar
27.00	0.55	bed
30.00	0.30	bed
35.00	0.14	bed
38.50	0.02	bed
42.50	0.00	TH
47.00	0.03	TH
49.50	0.14	bed
53.50	0.32	bed
59.00	0.79	Bar, WL
59.00	0.50	bar
62.00	0.99	bar
63.00	1.30	toe
63.50	2.99	edge of fp terrace
64.00	3.24	bank
64.50	3.44	bank
65.00	3.51	Low Fp Terrace

Appendix B Continued. Cross Section Data

Site 14 – Sub-reach 2 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.99	lowter rt
2.41	4.21	lowter rt
4.51	4.37	lowter rt
6.22	4.21	lowter rt
7.16	3.96	lowter rt
7.90	3.56	bnkful bench
9.06	3.42	bnkful bench
10.46	3.37	bnkful bench
11.67	3.11	topbank r
12.58	1.88	midbank r
13.27	1.10	botbank r
13.74	0.99	bar r
14.98	0.94	bar r
16.53	0.76	we
17.93	0.48	bed
21.60	0.39	bed
24.40	0.23	bed
27.41	0.12	bed
29.99	0.06	bed thwg
32.98	0.03	bed thwg
35.72	0.00	bed thwg
38.57	0.04	bed
41.38	0.17	bed
44.20	0.27	bed
47.27	0.39	bed
49.61	0.53	bed
51.23	0.59	bar
52.08	0.79	bar
52.84	0.72	bar
53.80	0.68	bar
54.56	0.77	bar
55.50	0.88	bar
56.47	0.75	bar we
58.50	0.73	bar we
59.71	0.60	chute
61.42	0.47	chute
62.94	0.38	chute

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Appendix B Continued. Cross Section Data

Site 14 – Sub-reach 2 DUPLICATE Continued

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
64.30	0.44	chute
66.12	0.53	chute
68.46	0.55	chute
70.49	0.62	chute
71.76	0.77	chute we
73.16	1.60	mid bank
73.79	2.03	mid bank
75.85	2.81	top bank
77.74	3.14	top bank
80.46	3.42	low terrace

Appendix B Continued. Cross Section Data

Site 14 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.54	Top Bank (left)
1.50	4.08	Bank
4.00	3.15	Bank Mid
5.00	1.90	Bank Mid
7.50	1.37	Bank Bot
7.50	0.81	
11.50	0.80	
13.50	0.90	Bed
14.50	1.04	Bed
18.50	1.13	Bed
19.00	1.19	Bed
20.50	0.98	Bed
22.00	0.75	Bed
24.00	0.69	Bed
25.00	0.45	Bed
33.00	0.49	Bed
36.50	0.48	Bed
39.50	0.39	Bed
41.00	0.13	Bed
42.00	0.00	Bed
45.00	0.11	Bed
47.50	0.27	Bed
48.00	0.33	Bed
53.00	0.80	Bank
53.00	0.48	Bank
54.00	1.21	Bank
55.50	1.36	Bank
56.00	1.65	Bank
57.00	2.41	Bank
58.50	3.96	Bank Top (right)

Appendix B Continued. Cross Section Data

Site 14 – Sub-reach 3 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.09	Top Bank (left)
2.00	3.10	Bank
3.00	2.32	Bank Mid
5.00	1.66	Bank Mid
7.00	0.72	Bank Bot
8.50	0.81	Toe
11.00	0.73	Bed
11.50	0.83	Bed
13.00	1.04	Bed
15.80	1.05	Bed
17.00	1.11	Bed
19.00	0.94	Bed
21.50	0.65	Bed
23.00	0.60	Bed
23.50	0.45	Bed
24.50	0.36	Bed
27.50	0.36	Bed
30.50	0.42	Bed
32.50	0.47	Bed
35.00	0.40	Bed
38.00	0.40	Bed
40.50	0.12	Bed
43.50	0.00	Bed
44.50	0.19	Bank
46.50	0.21	Bank
50.00	0.34	Bank
52.50	0.80	Bank
53.00	1.21	Bank
54.00	1.56	Bank
56.00	4.03	Bank Top (right)
56.50	4.72	FP (right)

Appendix B Continued. Cross Section Data

Site 15 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	3.57	BK, top, Right
1.00	2.96	BK, WL
2.00	0.88	BK, Toe
3.50	0.55	bed
5.00	0.35	bed
8.00	0.09	bed
9.00	0.10	bed
12.00	0.26	bed
15.50	0.34	bed
20.00	0.30	bed
27.00	0.18	bed
34.50	0.20	bed
37.00	0.43	bed
39.50	0.16	bed
41.50	0.25	bed
44.00	0.09	bed
44.50	0.15	bed
45.50	0.32	bed
46.00	0.00	Bed, thalweg
48.00	0.08	bed
50.00	0.18	bed
52.00	0.20	bed
55.00	0.24	bed
56.00	0.28	BK
56.50	0.44	BK, toe
57.00	0.53	BK, WL
60.00	2.06	BK top
60.00	0.93	BK mid
60.00	3.31	LT mid
62.00	3.69	LT top
64.00	3.98	LT LEFT

Appendix B Continued. Cross Section Data

Site 15 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.10	3.74	Bank Right
0.10	5.24	Bank Right
2.60	3.74	Bank Right
4.60	3.34	bench
5.10	1.76	BK
6.10	0.79	BK
6.10	1.08	BK
7.60	0.58	bed
8.60	0.55	bed
9.60	0.45	bed
10.10	0.17	bed
12.10	0.14	bed
14.10	0.11	bed
16.10	0.05	bed
19.60	0.00	bed
21.60	0.04	bed
23.60	0.07	bed
27.10	0.06	bed
30.10	0.09	bed
33.10	0.08	bed
35.60	0.13	bed
39.10	0.18	bed
40.60	0.23	bed
42.60	0.35	bed
43.60	0.53	bed
46.60	0.61	bed
50.10	0.65	bed
51.60	0.68	bed
53.10	0.59	bed
55.60	0.43	bed
57.60	0.33	bed
59.10	0.44	bed
62.60	0.48	bed
64.60	0.41	bed
65.60	0.31	bed
66.60	0.85	bed
67.10	1.51	BK

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Appendix B Continued. Cross Section Data

Site 15 – Sub-reach 2 Continued

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
68.60	1.84	BK
69.60	2.41	BK
69.60	2.73	BK
70.60	3.07	LT
73.00	4.50	LT, Left

Appendix B Continued. Cross Section Data

Site 15 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.03	fp left
3.78	3.69	fp
6.95	3.21	topbnk left
9.28	2.78	midbnk left
11.70	2.06	midbnk
13.17	1.59	botbnk
17.02	1.36	bar
18.53	1.30	bar
20.13	1.29	bar
23.48	1.27	bar
25.97	1.17	bar
26.71	1.21	bar
27.51	1.39	bar
28.34	1.56	bar
30.19	1.47	bar
31.87	1.33	bar
33.19	1.13	bar
34.25	1.00	bar
35.37	0.93	bar
36.93	0.64	we
38.26	0.32	bed
38.90	0.21	bed
39.85	0.10	bed
40.67	0.04	tweg
41.61	0.04	tweg
42.52	0.03	tweg
43.39	0.02	tweg
44.31	0.10	bed
46.27	0.13	bed
47.79	0.16	bed
48.44	0.12	bed
49.16	0.01	bed
49.84	0.05	bed
51.31	0.12	bed
53.63	0.12	bed
55.89	0.06	bed
58.29	0.09	bed

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Appendix B Continued. Cross Section Data

Site 15 – Sub-reach 3 Continued

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
62.05	0.12	bed
65.70	0.03	bed
67.12	0.02	bed
68.85	0.00	bed
70.42	0.12	bed
72.44	0.38	bed
73.82	0.64	we
75.34	0.87	midbar
77.09	1.12	topbar
78.47	0.93	midbar
79.41	0.66	we
80.06	0.33	shoot
80.94	0.25	shoot
81.64	0.33	shoot
82.41	0.65	we
83.20	1.52	midbnk right
84.47	2.33	topbnk bnch
86.27	2.62	bench
87.31	2.71	bench
90.47	4.38	bluff
93.36	6.53	bluff

Appendix B Continued. Cross Section Data

Site 16 – Sub-reach 0

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.60	Top, Left side
3.00	4.01	BK
8.00	3.67	Bottom
16.50	3.27	BENCH
21.50	3.06	edge
24.00	2.69	BK
26.00	2.83	TOE
26.50	3.09	BED
34.00	3.09	BED
39.00	3.41	BED
40.00	2.74	BED
42.00	1.34	BED
44.50	0.37	BED
46.00	0.27	BED
46.50	0.04	BED
53.00	0.00	BED
56.50	0.01	BED
60.00	0.21	BK
62.00	0.39	BK
64.00	0.70	ISLAND
65.00	1.64	ISLAND
71.00	3.22	ISLAND
72.00	3.66	BK
74.00	3.77	BK
78.00	3.68	TOE
81.00	3.09	
82.00	1.79	BED
83.00	0.66	BED
85.50	0.55	BED
92.50	0.53	BED
101.00	0.37	BED
110.00	0.33	BED
120.00	0.28	BK
126.00	0.12	BK
129.00	0.07	BK
134.00	0.06	LT
135.00	0.25	LT

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Appendix B Continued. Cross Section Data

Site 16 – Sub-reach 0 Continued

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
136.00	0.68	CC, top
137.00	1.39	CC, mid
137.50	2.14	CC, edge
138.00	2.39	LT
139.00	2.63	LT
140.00	3.13	LT End
142.00	3.85	SLOPE, Right side

Appendix B Continued. Cross Section Data

Site 16 – Sub-reach 1

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	5.61	LT right
5.00	5.20	FP
9.00	5.06	FP
16.00	5.10	FP
22.00	4.95	bank
25.00	4.91	bank
26.00	4.86	bank
27.00	3.74	bank
30.00	1.06	bed
32.00	0.83	bed
34.50	0.51	bed
37.50	0.71	bed
45.00	0.58	bed
53.00	0.36	bed
60.00	0.31	bed
65.50	0.14	bed
70.00	0.00	bed
74.00	0.04	bed
80.00	0.19	bed
85.00	0.25	bed
90.50	0.50	bed
95.00	0.81	wl
95.50	1.04	toe
97.00	1.46	bank
98.00	4.22	bank
98.50	4.28	bank
101.00	5.17	Bluff base, left

Appendix B Continued. Cross Section Data

Site 16 – Sub-reach 1 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	5.65	FP Right
9.50	5.28	FP Right
12.50	5.18	FP Right
20.50	5.09	FP Right
22.50	4.86	FP Right
26.00	2.71	Bank top
27.50	1.71	bank mid
31.50	0.86	bank
33.50	0.65	toe
34.50	0.59	bed
36.00	0.73	bed
38.50	0.61	bed
43.50	0.56	bed
49.00	0.50	bed
53.50	0.41	bed
57.00	0.36	bed
60.50	0.29	bed
63.50	0.21	bed
66.00	0.15	bed
69.50	0.00	bed, thalweg
71.00	0.01	bed
75.00	0.15	bed
78.00	0.13	bed
84.50	0.30	bed
85.00	0.34	bed
88.50	0.35	bed
90.00	0.64	bed
92.00	0.76	bed
93.50	0.84	bank bot
97.50	4.14	bank
100.50	5.92	bank top
102.50	6.00	Bluff, Right

Appendix B Continued. Cross Section Data

Site 16 – Sub-reach 2

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.94	Terrace, right
20.00	2.94	fp
30.00	3.43	fp
40.00	3.60	fp
45.00	3.30	fp
55.00	3.76	fp
60.00	3.83	fp
65.00	3.65	fp
70.00	3.99	fp
71.00	4.00	fp
72.50	3.80	bank right
73.70	3.54	bank right
74.00	1.67	bank right
76.00	0.85	bank right
76.50	0.57	bank right
82.00	0.41	toe
85.50	0.26	bed
90.00	0.40	bed
98.00	0.53	bed
106.00	0.43	bed
113.00	0.27	bed
117.00	0.03	bed
122.00	0.05	bed
127.00	0.00	bed
131.00	0.12	bed
136.00	0.34	toe
138.00	0.85	bank left
140.00	2.71	bank left
141.00	3.38	bank left
143.00	4.23	bank left
153.00	3.64	Floodplain, left

Appendix B Continued. Cross Section Data

Site 16 – Sub-reach 2 DUPLICATE

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	4.77	Terrace Right
7.00	2.95	FP right
10.00	3.05	FP
12.50	3.23	FP
23.50	3.72	FP
39.50	3.53	FP
64.00	3.87	FP
66.00	3.54	Bank Top
66.50	1.57	Bank Mid
69.50	0.77	Bank Bot
70.00	0.50	Toe
72.50	0.38	Bed
75.50	0.33	Bed
78.50	0.23	Bed
82.50	0.40	Bed
89.50	0.47	Bed
92.50	0.48	Bed
96.00	0.44	Bed
102.50	0.34	Bed
106.00	0.22	Bed
109.00	0.09	Bed
112.00	0.06	Bed
116.00	0.07	Bed
120.00	0.00	Bed
124.00	0.11	Toe
128.00	0.30	Bank Bot
129.00	0.73	Bank Bot
130.00	2.90	Bank Mid
133.50	4.46	Bank top
135.00	5.05	Bluff Left

Appendix B Continued. Cross Section Data

Site 16 – Sub-reach 3

Distance Across Channel (m)	Height Above Thalweg (m)	Notes
0.00	5.83	LT
2.00	5.74	LT
7.50	2.54	FP
14.00	2.58	FP
23.50	2.59	FP
25.00	2.00	BK
29.00	1.83	BK
29.00	1.03	BK
31.00	0.79	Ben
32.00	0.72	bed
36.00	0.39	bed
40.50	0.04	bed
44.50	0.01	bed
49.00	0.00	bed, thalweg
56.00	0.22	bed
66.00	0.30	bed
74.00	0.25	bed
79.00	0.11	bed
83.00	0.08	bed
88.00	0.34	bed
91.00	0.10	BK
92.00	0.75	BK
92.50	1.26	BK
94.00	3.58	BK
97.00	3.77	FP
99.00	4.27	FP/bluff

Appendix C. Longitudinal Profile Data

Site 0 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	464.74	rcobbcg	96.08	464.81	pcobb
2.80	465.00	rcobbcg	97.44	464.68	pcobb
5.34	465.04	rcobbcg	99.19	464.78	pcgfg tree
10.01	465.08	rcobbcg	100.60	464.71	pcgfg tree
13.00	465.17	rcobbcg	102.03	464.62	pcgfg
15.12	465.28	rcobbcg	103.06	465.03	ncgfg
17.32	465.24	rcobbcg	103.85	465.32	ncgfg
19.88	465.20	rcobbcg	104.56	465.62	rcgfg
21.30	465.14	gcobbfgcg	106.01	465.70	rcgfg
23.68	465.02	gcobbfgcg	109.79	465.68	rcgfg
26.74	464.87	gfgcg	113.70	465.67	gcgfg
28.34	464.76	pfgcg	117.16	465.58	gcgfg
31.20	464.74	pfgcg	119.16	465.33	pcgcobb xs2
35.00	464.73	pfg cflunce	123.47	465.08	pbrk
36.91	464.68	pfg cflunce	125.49	464.98	pbrk
37.00	464.68	pfg cflunce	126.83	464.92	pcgcobb
38.70	464.74	pcgcobb cflu	128.88	464.96	ncgcobb
40.46	464.92	rcgcobb cflu	130.30	465.14	ncgcobb
42.14	465.04	rcgcobb cflu	131.46	465.52	ncgcobb
44.85	465.23	rcgcobb cflu	132.87	465.86	rcgcobb
50.71	465.62	rcgcobb cflu	134.78	465.85	rcgcobb
55.24	465.61	rcgcobb	137.34	465.76	rcgcobb
58.69	465.57	rcgcobb	140.69	465.73	gcgcobb
62.04	465.63	rcgcobb	142.84	465.56	gcgcobb
64.27	465.59	rcgcobb	144.65	465.46	gcgcobb xs1
66.67	465.62	rcgcobb	147.86	465.55	gcgcobb
69.58	465.60	rcgcobb	151.37	465.51	gcgcobb
72.55	465.56	rcgcobb	153.20	465.53	gcobb
75.80	465.54	rcgcobb	154.60	465.52	gbrk
78.83	465.46	gcgcobb	155.45	465.45	pbrk
82.12	465.37	gcgcobb	157.20	465.54	pbrk
85.05	465.22	gcg xs3	161.25	465.60	pbrk
86.94	465.17	gcg	164.65	465.52	pbrk
88.74	465.18	gcg			
90.52	465.32	pcgfines			
92.51	465.06	pcgfines			
93.57	464.97	pcgcobb			
94.74	464.84	pcobb			

Appendix C Continued. Longitudinal Profile Data

Site 1 Longitudinal Profile

Distance Upstream (m)	Relative Elevation (m)	Notes	Distance Upstream (m)	Relative Elevation (m)	Notes
0.00	0.65	p	147.30	0.31	n
3.83	0.73	r	149.40	0.37	r
8.55	0.79	n	151.47	0.33	rc
17.60	0.83	r	152.47	0.31	scourp
25.34	0.78	rc	154.85	0.31	g
27.20	0.71	g	157.46	0.23	pool
31.47	0.65	xs3			
37.04	0.75	g			
42.52	0.69	p			
48.97	0.64	p			
56.35	0.56	pr			
62.60	0.61	pr			
65.38	0.43	pr			
67.80	0.50	n			
71.15	0.52	n			
75.37	0.58	r			
77.25	0.45	r			
79.56	0.44	r			
82.01	0.54	gr			
83.66	0.60	g			
85.93	0.41	pr			
91.16	0.43	pr			
97.23	0.45	p			
102.36	0.41	p			
105.02	0.44	rr			
110.50	0.58	pr			
117.44	0.62	pr			
120.10	0.43	pr			
121.32	0.54	riff			
123.84	0.31	g			
125.25	0.25	pr			
127.86	0.11	p			
130.04	0.00	brkriffle			
132.63	0.19	n			
135.83	0.17	r			
140.51	0.09	r			
143.02	0.15	rc			
144.65	0.26	pool			

Appendix C Continued. Longitudinal Profile Data

Site 1 DUPLICATE Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	460.05	rbrkbridge	140.08	460.80	pcg
2.47	460.07	rcg	143.15	460.81	pcg
4.68	460.40	rcg	145.37	460.65	pcg
9.94	460.50	rcg	146.99	460.69	pcobb
15.36	460.59	gcg	148.54	460.92	pbrk
23.50	460.66	gcg	151.37	460.88	nbrk
27.75	460.66	gcg	156.27	460.81	nbrk
30.75	460.69	gcg	159.40	460.78	rbrk
33.35	460.65	gcg	161.94	460.78	rbrk
38.44	460.66	gcg	164.28	460.75	rbrk
46.03	460.67	gcg	166.01	460.91	gcobbcg
54.08	460.60	gcg	167.96	460.87	gcobbcg
61.37	460.55	gcg	169.23	460.91	gbrk
66.16	460.60	gcg	171.50	460.82	gbrk xs1
72.19	460.50	gcg xs3	173.14	460.78	gbrk
75.49	460.45	gcg cobb	174.26	460.90	gcg
80.08	460.35	gcg cobb	176.27	460.85	gbrk
82.78	460.44	pbrk	177.61	460.91	gcobb cg
85.48	460.46	pbrk	181.02	461.02	gcg
90.59	460.45	pbrk	184.98	461.13	gcg
94.35	460.50	pcobb	188.98	461.20	gcg
97.95	460.45	nbrk	193.64	461.10	gfg
100.37	460.51	nbrk	196.93	461.06	gfg
103.63	460.40	nbrk	200.53	461.07	gcg
107.26	460.46	rbrk	203.60	460.98	gcg
110.81	460.62	rcobb	207.32	460.99	gcg
113.79	460.74	rcobb	209.40	461.01	rcg
116.28	460.83	rcobb	212.53	460.97	rbrk
119.47	460.80	rcobb	214.79	461.07	rcgcobb
123.05	460.93	gbrk	216.93	461.08	rbrk
125.25	460.81	gbrk xs 2			
126.74	460.64	gbrk			
127.34	460.73	gbrk			
128.06	460.93	gbrk			
128.80	460.78	gbrk			
130.85	460.75	gbrk			
134.03	460.83	gbrk			
137.89	460.83	pbrk			

Appendix C Continued. Longitudinal Profile Data

Site 2 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	446.48	p1 cg 1	112.04	447.42	r c 1
3.34	446.30	n cg 1	114.89	447.44	r cg 1
9.62	446.56	n cg 1	117.87	447.44	c1 cg 1
17.43	446.96	n cg 1	120.89	447.41	c1 cg 1
20.19	446.84	r c 1	125.68	447.50	g cg 1 xs2
24.97	447.01	r cg 1	128.59	447.48	g cg 1
28.49	446.84	r cg 1	131.92	447.44	g cg 1
36.06	446.94	c1 cg 1	134.73	447.39	g cg 1
38.97	446.98	g cg 1	137.68	447.34	g cg 0
43.19	446.65	g cg 1 xs3	140.34	447.31	p1 cg 0
44.72	446.78	g cg 1	144.36	447.27	p1 cg 0
47.79	446.54	g cg 1	147.19	447.21	p1 cg 0
50.41	446.55	g f 1	151.18	447.31	n cg 0
52.67	446.38	p2 f 1	154.94	447.29	n c 1
55.13	446.44	p2 f 1	158.66	447.21	r c 1
58.21	446.34	p2 f 1	161.43	447.47	r c 1
60.73	446.43	p2 cg 1	164.20	447.47	r cg 1
65.06	446.12	p2 cg 1	167.15	447.47	g cg 1
66.67	446.41	p2 cg 1	169.97	447.40	g cg 1
69.45	446.45	p2 cg 1	172.39	447.35	g cg 1
71.08	446.65	p2 cg 1	178.82	447.18	g cg 1
73.44	446.63	n cg 1	182.74	447.09	p1 cg 1
75.48	446.96	n cg 1	192.26	446.75	p1 r
78.69	446.95	r cg 1			
81.84	447.33	r cg 1			
83.51	446.90	r cg 1			
84.72	446.78	p2 cg 1			
86.34	446.49	p2 cg 1 lwd			
88.46	446.41	p2 cg 1 lwd			
93.19	446.86	p2 cg 1 lwd			
94.39	447.01	p2 cg 1			
98.68	446.94	p2 cg 1			
100.69	446.50	p2 cg 1			
103.05	446.50	p2 cg 1			
104.07	446.71	p2 cg 1			
105.53	446.78	p2 c 1			
107.00	446.75	p2 c 1			
108.42	447.22	n c 1			

Appendix C Continued. Longitudinal Profile Data

Site 2 DUPLICATE Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	445.91	rcg
4.69	446.25	rcg
8.48	446.19	rcg
12.40	446.06	rcg
17.74	446.23	rcg
21.61	446.20	rcg
26.66	446.33	c1cg
30.89	446.14	gcg
34.94	445.89	gcg
38.54	445.95	p1fg
41.13	445.81	p1f
44.99	445.74	p1f
49.08	445.76	p1f
52.34	445.72	p1f
56.41	445.46	p1cg
59.33	445.69	p1cg
62.97	445.93	p1cg
65.82	446.15	c2cg
69.77	446.30	c2cg
72.83	446.44	c2cg
76.50	445.69	p1cg
78.26	445.64	p1cg
81.25	445.95	p1cg
82.34	445.92	p1cg
84.43	446.35	c2cg
87.20	446.30	p1cg
90.21	445.82	p1cg
91.99	445.74	p1cg
94.84	446.06	p1cg
96.71	445.98	p1cg
98.51	446.51	rcg
101.65	446.60	rcg
104.67	446.69	rcg
107.53	446.63	c1cg
112.20	446.59	gcg
114.63	446.56	gcg
118.23	446.59	gcg
121.75	446.43	p2cg
125.36	446.58	gcg
128.44	446.63	gcg
137.43	446.58	ncg
141.57	446.56	ncg
144.89	446.48	ncg
148.97	446.62	ncg
151.97	446.59	rcg
155.60	446.50	rcg
158.32	446.30	p2cg
162.22	446.73	rcg
165.12	446.73	c1cg
168.51	446.71	gcg
171.96	446.61	gcg
175.93	446.58	gcg
179.03	446.46	p1cg
183.84	446.33	p1cg
186.34	446.02	p1cg
190.10	445.98	p1brk
192.54	445.99	p1brk
196.61	446.13	p1brk
199.64	446.01	p1brk
205.42	445.95	p1brk

Appendix C Continued. Longitudinal Profile Data

Site 3 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	411.29	g cg	380.30	411.37	r cg 1
12.10	411.28	g cg	385.57	411.92	c1 cg 1
22.21	411.07	g cg	398.04	411.95	r cg 1
30.07	411.00	g cg	409.98	411.97	r c 1
41.85	410.91	g cg	446.38	412.05	r cg 1
49.46	410.72	p1 cg c	457.39	412.40	r cg 1
56.84	410.50	p1 cg c	473.58	412.38	r cg
61.78	410.03	p1 cg c	477.43	412.29	c1 c
66.61	409.89	p1 cg c	488.93	412.55	g cg
73.51	409.96	p1 cg c	493.75	412.58	xs0 cp
80.08	410.07	p1 cg c	506.52	412.11	g cg
89.43	409.97	p1 cg c	518.91	412.13	g cg
96.25	410.20	p1 cg c			
103.45	410.13	p1 cg c			
112.09	410.36	p1 cg c			
118.27	410.71	p1 cg c			
126.22	411.06	p1 cg			
134.36	411.48	n cg 1			
145.61	411.27	n cg 1			
153.75	411.38	n cg 1			
164.47	411.44	n cg 1			
178.62	411.64	n cg 1			
189.41	411.54	n cg			
206.09	411.64	c1 cg 1			
216.30	411.65	c1 cg 1			
230.75	411.85	c1 fg			
232.64	411.69	xs2 cg 1			
253.38	411.39	g cg			
263.15	411.41	p1 cg			
274.04	411.43	p1 cg			
287.95	411.27	p1 cg			
300.12	411.03	p2 cg			
314.12	411.84	c2 fg			
328.35	411.81	r cg			
337.69	411.60	p1 c			
350.50	411.61	r cg b			
362.95	411.53	r cg b			
371.87	411.61	r cg b			

Appendix C Continued. Longitudinal Profile Data

Site 4 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	380.81	p1-r	218.04	382.62	r-g
4.17	380.89	p1-r	223.21	382.50	g-g xs2
8.49	381.00	p1-r	229.73	382.21	g-g
14.49	381.41	p1-r	236.73	382.10	g-g
18.42	381.81	p1-r	242.97	382.14	g-g
24.72	381.77	p1-r	250.28	381.67	n-g
31.70	381.94	p1-r	256.62	381.55	n-g
37.50	381.93	p1-r	264.75	381.40	n-g
42.05	381.86	p1-r	268.67	381.20	p-f
48.30	381.86	n-r	277.11	381.35	p-f
54.44	381.71	n-r	282.96	381.22	p-cg
58.30	381.92	n-r	289.83	381.17	p-cg
62.43	381.62	n-r	295.15	381.14	p-cg
65.70	381.76	n-r	300.79	380.97	p-cg
70.97	382.32	r-r	307.18	381.06	p-cg
76.28	382.33	r-r	313.76	380.76	p-cg
78.53	382.53	r-r	318.18	380.95	p-cg
82.05	382.56	r-r	323.36	380.93	n-cg
88.07	382.73	r-r	325.20	380.80	n-cg
91.56	382.63	r-r	328.88	380.42	n-cg
96.10	382.82	rc-r	332.42	381.50	n-cg
99.15	382.54	r-r	335.31	382.19	r-r
102.60	382.45	r-r xs3	335.93	382.25	r-r
107.88	382.54	p2-cg	339.74	382.71	r-r
112.51	382.43	p2-cg	340.16	382.70	r-r
119.35	382.06	p2-r	348.20	382.82	r-r
125.13	382.11	p2-g	351.55	382.84	r-r
129.54	381.90	p2-r	358.82	382.68	r-r
133.89	381.90	p2-r	367.94	382.66	r-r
138.50	381.88	n-r	378.54	382.88	rc-r
143.37	382.02	n-g	404.95	383.14	G-r
149.51	382.20	n-g			
157.04	382.15	n-r			
164.89	382.32	n-g			
174.79	382.16	n-g			
186.55	382.43	r-g			
197.47	382.51	r-g			
208.02	382.52	r-g			

Appendix C Continued. Longitudinal Profile Data

Site 5 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	377.03	rcg	243.95	377.27	r2cgscour
9.71	376.97	rcg	247.94	377.70	r2cg
16.41	376.66	rcg	251.35	377.39	r2cg
23.66	376.96	rcg	254.29	377.03	r2cg
30.97	376.45	rcg	265.54	377.12	p2cg
34.32	377.24	rcg	273.02	377.54	p2cg
40.40	377.15	rcg	279.36	376.94	p2cg
47.74	377.08	gcg	283.38	376.85	p2cg
55.68	376.89	gcg xs3	287.94	376.82	p2cg
60.64	376.69	gcg	290.39	376.67	p2cg
64.96	376.38	pcg boulders	293.48	377.01	p2cg
69.30	376.14	pcg boulders	298.89	377.17	gcg
73.64	376.06	pcg	304.49	377.17	gcg
77.26	375.80	pcg	311.10	377.42	gcg
80.79	375.89	pcg	318.98	377.25	gcg
85.14	376.10	pcg boulders	325.42	377.14	gcg
88.60	376.24	pcg boulders	331.84	376.89	gcg
92.80	376.63	pcg	340.32	377.22	gcg
104.13	376.82	ncg	344.19	377.18	gcgxs1 19m
110.27	376.60	ncg	349.30	377.17	gcg
116.14	376.86	ncg boulders	356.88	377.17	p1cg
123.35	377.18	rcc	362.75	377.22	p1cg
131.32	377.29	rcc	367.35	377.16	p1cg
138.97	377.28	rcg	370.49	376.95	p1cg
147.91	377.25	rcg	375.14	376.83	p1cg
156.18	377.24	rcg	378.32	376.68	p1cg
164.62	377.47	rcg	381.20	376.72	p1cg
171.75	377.42	rcg xs2	384.59	376.73	p1cg
177.92	377.28	rcg			
183.97	377.20	gcg			
189.94	377.27	gcg			
197.97	377.20	gcg			
204.85	377.46	gcg			
215.68	377.52	p2cg			
223.28	377.45	p2cg			
229.92	377.30	p2cg			
235.78	377.29	r2cgscour			
240.93	377.23	r2cgscour			

Appendix C Continued. Longitudinal Profile Data

Site 5 DUPLICATE Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	376.32	rcg	123.97	377.33	rcg
1.73	376.22	rcg	129.48	377.36	rcg cobble
3.48	375.99	rcg	133.29	377.34	rcg cobble
5.22	376.59	rcg	136.30	377.50	rcg cobble
5.97	377.11	rcg	140.84	377.55	rcg cobble
8.05	377.27	rcg	145.62	377.52	rcg cobble
11.29	377.32	rcg xs3	150.00	377.56	rcg cobble
16.46	377.14	gcg xs3	154.19	377.39	gcg
21.78	377.08	gcg xs3	157.87	377.38	gcg
26.58	377.10	gcg xs3	161.53	377.30	gcg
29.32	377.00	pcg	166.25	377.45	gcg
33.10	376.85	pcg	167.83	377.43	gcg xs2
35.80	376.74	pcg	172.73	377.42	gcg
37.94	376.50	pcg	177.27	377.39	gcg
40.80	376.36	pcg	181.33	377.50	gcg
43.15	376.26	pcg	188.26	377.63	gcg
47.40	376.07	pcg	195.79	377.64	gcg
50.34	375.90	pcg	201.40	377.54	rcg
53.50	375.94	pcg	208.23	377.42	rcg
55.60	375.97	pcg	212.49	377.30	rcg
57.24	376.19	pcg	215.74	377.42	rcg
60.18	376.17	pcg	219.19	377.42	rcg
61.19	376.28	pcg	221.63	377.31	rcg
63.92	376.49	pcg	224.68	377.40	rcg
66.03	376.93	ncg	229.91	377.51	rcg
70.01	376.87	ncg	232.07	377.26	rcg
74.77	377.05	ncg	239.96	377.19	p2cg
79.44	376.93	ncg	243.81	377.26	p2cg
84.07	376.79	ncg	245.35	377.55	p2cg
87.11	376.67	ncg	248.07	377.42	p2cg
89.81	376.84	ncg	249.74	377.39	p2cg
92.78	376.71	ncg	251.70	377.50	p2cg
95.55	377.03	ncg	254.69	377.50	p2cg
101.21	377.25	rcg	256.47	377.24	p2cg
107.49	377.42	rcg	258.15	376.81	p2cg
112.48	377.36	rcg	262.74	376.89	p2cg
116.74	377.35	rcg	267.03	376.74	p2cg
120.05	377.38	rcg	269.23	376.83	p2cg

Appendix C Continued. Longitudinal Profile Data

Site 5 DUPLICATE Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
271.77	377.15	gcg			
275.86	377.27	gcg			
280.83	377.39	gcg			
283.27	377.61	gcg			
287.80	377.51	gcg			
292.55	377.33	gcg			
297.43	377.31	gcg			
301.76	377.20	gcg			
307.27	377.08	gcg			
309.95	377.34	p1cg			
313.57	377.46	p1cg xs1			
316.18	377.30	p1cg			
321.06	377.22	p1cg			
324.17	377.23	p1cg			
327.76	377.23	p1cg			
330.76	377.19	p1cg			
334.14	377.17	p1cg			
338.83	377.35	p1cg			
340.85	377.29	p1cg			
342.94	377.24	p1cg			
344.78	377.12	p1cg			
347.09	377.06	p1cg			
350.38	376.95	p1cg			
353.24	376.94	p1cg			
356.67	376.94	p1cg			
360.47	376.82	p1cg			
363.65	376.78	p1cg			
367.82	376.73	p1cg			

Appendix C Continued. Longitudinal Profile Data

Site 6 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	365.88	r2brkscour	179.27	366.44	r1cg xs2
3.06	365.87	rbrkscour	186.46	366.30	r1cg xs2
7.22	365.89	rbrkscour	191.44	366.32	r1cg xs2
11.26	365.92	rbrkscour	196.90	366.51	g1cg xs2
14.70	365.85	rbrkscour	201.18	366.56	g1cg
17.46	365.85	rcgscour	207.49	366.43	g1cg
19.84	366.47	rcg	212.18	366.23	g1cg
22.68	366.78	rcg	218.05	366.11	g1cg
26.66	366.68	ggg	224.57	366.12	g1cg
29.92	366.46	ggg xs3	229.13	366.16	g1cg
34.46	366.09	ggg	238.03	366.49	g1cg
38.10	365.92	ggg	244.39	366.39	g1cg
42.10	365.48	ggg	250.64	366.26	g1cg
47.64	365.14	p1brk	255.43	366.27	g1cg
52.94	365.18	p1brk	260.22	366.21	g1cg
58.74	365.20	p1brk	264.80	366.11	g1cg
68.18	365.15	p1cg	269.12	366.01	g1cg
73.47	365.25	p1cg	277.83	366.09	g1cg
78.88	365.23	p1cg	281.71	366.00	g1cg
83.29	365.29	p1cg	286.22	366.02	g1cg
87.98	365.24	p1cg	291.36	366.12	g1cg
92.58	365.09	p1cg	296.96	366.12	p1cg
99.71	365.26	p1cg	300.75	366.01	p1cg
103.81	365.28	p1cg	304.78	365.89	p1cg
107.65	365.28	p1cg	307.57	365.81	p1cg
111.31	365.27	p1cg	310.15	365.63	p1cg
116.28	365.11	p1cg	312.63	365.56	p1cgbrk
120.20	365.17	p1cg	315.05	365.55	p1cgbrk
123.63	365.35	p1cg	318.98	365.64	p1cgbrk
126.98	365.69	p1cg	321.81	365.60	p1cgbrk
131.58	365.96	p1cg	323.47	365.54	p1cgbrk
137.04	366.10	p1cg	325.54	365.54	p1cgbrk
144.35	366.17	n1cg xs2	327.99	365.61	p1cgbrk
150.71	366.30	r1cg xs2	332.07	365.74	p1cgbrk
156.16	366.34	r1cg xs2	335.91	365.54	p1cgbrk
161.09	366.36	r1cg xs2	338.41	365.54	p1cg
166.76	366.47	r1cg xs2	341.33	365.55	p1cg
173.89	366.57	r1cg xs2	343.67	365.57	p1cg

Appendix C Continued. Longitudinal Profile Data

Site 6 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
346.85	365.57	nbrkcg			
349.19	365.64	nbrkcg			
349.29	365.64	nbrkcg			
352.54	365.77	nbrkcg			
355.03	365.77	nbrkcg			
358.32	365.89	nbrkcg			
358.33	365.88	nbrkcg			
362.62	366.05	nbrkcg			
366.22	365.93	nbrkcg			
369.18	366.00	nbrk			
373.02	366.37	rbrk			
377.87	366.44	rbrk			
382.32	366.42	rbrk			
386.15	366.53	rbrk			
390.31	366.53	rbrk			
395.73	366.69	rbrk			
400.13	366.56	rbrk			
404.50	366.55	rbrk			
408.83	366.67	gbrk			
413.48	366.56	gbrk xs1			
417.16	366.41	gbrk			
421.87	366.43	gbrk			
426.39	366.39	gbrk			
431.19	366.44	gbrk			
435.71	366.38	gbrk			
441.30	366.37	gbrk			
446.02	366.38	gbrk			
450.54	366.52	gbrk			
454.69	366.52	p1brk			
454.89	366.24	p1brk			
457.95	366.25	p1brk			
462.76	366.42	p1brk			
467.85	366.41	p1cg			
474.12	366.35	p1cg			

Appendix C Continued. Longitudinal Profile Data

Site 7 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	353.51	p1cg	316.65	354.19	scourcg
13.16	353.82	p1cg	320.29	354.04	scourcg
22.71	353.70	p1cg	324.11	353.94	scourcg
32.27	353.95	p1cg	327.23	353.84	scourcg
40.57	354.25	gcg	330.54	353.73	scourcg
48.62	354.03	gcg	332.32	353.69	scourcg
58.48	354.13	gcg	339.17	354.84	ncg
66.80	354.27	ncg	346.55	354.84	ncg
76.72	354.49	ncg	352.94	354.87	ncg
91.59	354.38	rcg	359.77	354.89	ncg
99.68	354.31	rcg	368.21	354.89	rcg
106.72	354.38	rcg xs3	379.18	354.98	rcg
112.38	354.19	gcg	388.68	355.04	rcg
120.39	354.27	gcg	396.50	354.64	gcg xs2
127.74	354.27	gcg	406.21	354.59	gcg
133.07	354.08	gcg	414.51	354.57	gcg
140.22	354.11	gcg	424.35	354.24	gcg
146.72	354.19	gcg	433.74	354.15	gcg
154.46	354.24	gcg	439.96	353.95	gcg
164.90	354.23	gcg	449.56	353.90	gcg
174.58	354.36	gcg	457.31	353.91	gcg
184.60	354.34	gcg	463.30	353.84	gcg
190.91	354.38	gcg	483.06	353.53	gcg
197.60	354.27	gcg	487.51	353.87	p1cgfines
207.88	354.22	gcg	494.07	353.93	p1cgfines
216.01	354.07	p1cg	499.97	353.94	p1cgfines
224.80	354.11	p1cg	506.48	354.11	p1cgfines
230.89	354.12	p1cg	513.14	353.80	p1cgfines
240.52	354.17	scourpcg	517.70	353.87	p1cgfines
244.86	354.22	scourpcg	525.98	354.16	p1cg
253.29	353.96	scourpcg	535.39	354.01	p1cg
260.21	353.88	p1cg	540.81	353.62	p1cg
279.39	354.24	p1cg	544.85	354.22	p1cg
284.82	354.52	p1cg	554.36	353.87	p1cg
291.43	354.49	p1cg	559.66	353.60	p1cg
297.50	354.52	p1cg	565.67	353.51	p1cg
306.38	354.49	p1cg	573.73	353.14	p1cg
310.62	354.54	p1cg	581.27	352.99	p1cg

Appendix C Continued. Longitudinal Profile Data

Site 7 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
590.18	353.31	p1cg	909.90	354.56	ncgfines
597.85	352.84	p1cg	919.88	354.52	ncg
607.81	353.73	p1cg	928.70	354.47	ncg
620.12	353.07	p1cg	939.11	354.58	rcg
628.60	353.69	p1cg	949.98	354.60	rcg
638.52	353.44	p1cg	959.73	354.53	rcg
648.24	353.42	p1cg	965.40	354.49	rcg
656.92	353.77	p1cg	976.98	354.68	rcg
668.78	353.43	p1cg	984.50	354.85	rcg
682.02	353.89	p1cg	993.18	354.79	gcg xs1
693.04	354.18	p1cg	1002.19	354.79	gcg
698.99	353.58	p1cg	1010.76	354.67	gcg
707.53	353.65	p1cg	1018.30	354.63	gcg
714.35	353.62	p1cg	1025.21	354.56	gcg
728.82	353.58	p1cg	1032.55	354.53	gcg
739.93	353.64	p1muckbloc	1036.89	354.34	gcg
746.98	353.64	p1finesblock	1041.97	354.45	gcg
753.97	353.72	p1finesblock	1050.10	354.28	gcg
761.82	353.80	p1finesblock	1056.17	354.29	gcg
767.11	353.85	p1finesblock	1063.08	354.28	gbrk
776.88	354.04	p1finesblock	1069.24	354.28	p1brk
783.83	354.05	p1finesblock	1074.31	354.32	p1brk
791.40	354.14	p1fines	1077.78	354.40	p1brk
798.11	354.18	p1fines	1082.82	354.54	p1brk
806.67	354.30	p1fines			
811.09	354.17	p1fines			
821.20	354.55	ncg			
832.83	354.43	ncgfines			
842.76	354.31	ncgfines			
849.45	354.33	scourcgfines			
854.11	354.17	scourcgfines			
862.04	354.21	ncgfines			
867.86	354.12	ncgfines			
875.16	354.10	ncgfines			
882.46	354.16	ncgfines			
886.85	354.26	ncgfines			
894.19	354.43	ncgfines			
901.89	354.43	ncgfines			

Appendix C Continued. Longitudinal Profile Data

Site 8 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	351.11	gcg	284.76	350.51	ncobb
5.56	350.70	gcg	291.55	350.58	ncobb
8.99	350.31	pcg	292.79	350.64	ncg
11.56	349.87	pcg	299.85	350.58	ncg
16.09	349.03	pcg	303.61	350.54	nbrkshelf
20.67	348.64	pcg	309.57	351.13	nbrkshelf
27.46	348.28	pcg	315.96	351.18	nbrkshelf
34.56	348.86	pcg	320.76	351.43	ncobb
43.66	349.57	pcg	327.47	351.29	ncobb
47.90	350.07	rcg	336.06	351.15	nbrk
53.85	350.50	rbrk	346.98	351.28	rbrk
64.05	350.87	rbrk	354.17	351.21	rbrk
71.76	350.88	rbrk	362.17	351.16	rbrk
83.07	350.96	rbrk	367.76	351.05	rbrk
96.75	350.97	rbrk	374.44	351.10	rbrk
106.83	350.78	rbrk	384.65	351.10	rbrk
116.96	350.84	rbrk	392.78	351.36	rbrk
123.65	351.06	rcg	399.84	351.34	rbrk
129.61	351.01	rcg	405.38	351.05	rbrk
141.44	351.10	rcg	410.50	351.08	rcgboul
153.57	350.92	rbold	417.32	351.10	rcgboul
163.01	350.92	rbold	420.89	351.09	rbould
170.73	350.84	rbrk	426.21	351.30	rcobble
180.67	351.01	gbrk	431.90	351.50	rcobble
188.67	350.85	gbrk xs	435.76	351.42	rcobble
190.44	350.89	gbrk	440.58	351.30	rbrk
197.22	350.57	gbrk	445.96	351.31	gbrk
203.59	350.53	pbrkgrav	449.29	351.21	gbrk
208.62	350.71	pbrk	454.25	351.01	gbrk xs2
215.75	350.69	pbrk	464.10	350.92	gcg boulders
220.04	350.45	pcute	474.02	350.61	gcg boulders
228.39	350.67	pcute	484.08	350.57	gcg boulders
235.78	350.51	pcute	494.47	350.50	gcg boulders
241.96	350.43	pcg	502.07	350.36	gbrk
250.32	350.33	pcg	506.52	350.57	gbrk
259.82	350.29	pcg	516.20	350.80	p1brk
268.91	350.31	ncute	520.07	351.05	p1brk
277.61	350.55	ncute	529.45	351.05	p1brk

Appendix C Continued. Longitudinal Profile Data

Site 8 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
542.17	350.85	p1brk bould	810.41	351.80	rcg
553.66	350.76	p1brk	814.25	351.78	rcg
565.18	350.64	p1brk	819.06	351.43	rcg
576.02	350.42	p1brk	824.25	351.43	gcg
586.55	350.43	p1brkcg	832.58	351.47	gcg xs1
596.09	350.31	p1boulders	837.39	351.40	gcg
603.36	350.41	p1cutearth	841.34	351.28	gcg
609.43	350.38	p1cutearth	848.43	351.16	gcg
614.07	350.42	p1cutearth	853.67	351.09	gcg
617.02	350.47	p1cutearth	858.48	351.10	gcg
626.98	350.76	ncg	865.27	351.10	gcg
629.75	350.87	ncg			
635.36	350.88	ncg			
641.00	351.12	ncg			
648.55	351.40	ncg			
661.08	351.15	ncg			
673.40	351.24	ncg			
686.06	351.31	ncg			
696.74	351.33	ncg			
705.80	350.75	ncg lwd scr			
709.19	350.28	ncg lwd scr			
712.43	350.18	ncg lwd scr			
716.62	350.28	ncg lwd scr			
721.51	350.38	ncg			
726.49	350.39	ncg			
731.67	350.57	rcg			
734.74	351.05	rcg			
739.72	351.13	rcg			
745.66	351.18	rcg			
752.21	351.31	rcg			
758.78	351.45	rcg			
770.54	351.47	rcg			
780.91	351.48	rcg			
787.53	351.46	rcg			
794.10	351.32	rcg			
797.84	350.91	rcg-scour			
799.99	350.91	rcg			
804.77	351.58	rcg			

Appendix C Continued. Longitudinal Profile Data

Site 9 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	346.64	ncg	237.40	346.54	p1cg
6.40	346.86	ncg	244.12	346.63	p1cg
12.67	346.96	ncg	250.09	346.68	n1cg
18.87	347.21	ncg	258.58	346.85	n1cg
27.09	347.17	ncg	266.84	346.89	r1cg
35.19	347.18	ncg	275.39	346.90	r1cg
41.92	347.13	ncg	281.58	346.78	g1cg xs2
41.93	347.19	ncg	288.28	346.75	g1cg cobles
41.99	347.18	ncg	293.05	346.79	g1cg cobles
50.08	347.19	ncg	298.00	346.60	g1cg cobles
54.45	347.32	rcg	305.97	346.48	p1cg cobles
58.62	346.96	rcg	310.87	346.61	p1cg cobles
63.44	347.01	rcg	315.40	346.55	p1cg cobles
69.91	347.01	rcg	320.24	346.55	p1cg cobles
74.61	347.10	rcg	325.58	346.49	p1cg cobles
80.93	347.06	rcg	333.80	346.64	p1cg
89.17	346.94	gcg xs3	341.59	346.74	p1cg
94.34	346.70	gcg	345.62	346.77	p1cg
100.73	346.62	gcg	350.14	346.76	p1cg
108.19	346.68	gcg	354.90	346.78	n2 cutearth
113.83	346.71	p1cg	357.86	346.89	n2 cutearth
119.54	346.75	p1cg	362.02	346.80	n2 cg
125.75	346.72	p1cg	366.88	346.85	n2 cg
133.52	346.95	p1cg	369.50	346.86	n2 cg
141.66	346.92	p1cg	376.84	346.98	r2 cg
148.46	346.90	p1cg	383.06	347.30	r2 cg
157.31	346.77	p1cg	389.10	347.28	r2 cg
164.28	346.83	p1cg	395.22	347.27	r2 cg
170.59	346.66	p1cg	397.88	347.04	r2 cg
176.68	346.67	p1cg	400.75	346.64	r2 cg
182.72	346.54	p1cg	403.67	346.39	g2 cg
188.03	346.54	p1cg	407.49	346.62	g2 cg
194.63	346.51	p1cg	410.67	346.63	g2 cg
202.78	346.54	p1cg	412.80	346.98	g2 cg
209.85	346.54	p1cg	415.46	347.05	p2cg
217.34	346.47	p1cg	416.60	346.91	p2cg
224.01	346.60	p1cg	420.69	346.98	n2cg
231.40	346.61	p1cg	423.66	346.99	n2cg

Appendix C Continued. Longitudinal Profile Data

Site 9 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
425.85	346.69	n2cg	602.69	347.56	rcg
428.65	347.08	n2cg	610.52	347.35	rcg
430.82	346.49	n2cg scour	615.58	347.55	gcg xs1
433.47	346.23	n2cg scour	619.44	347.11	gcg
436.82	346.92	r2cg scour			
444.32	347.29	r2cg scour			
450.41	347.39	r2cg scour			
454.12	347.04	g2cg scour			
456.84	346.72	g2cg scour			
459.31	346.34	p1cg scour			
460.86	346.14	p1cg			
462.41	346.12	p1cg fines			
466.10	345.87	p1cg fines			
473.14	345.90	p1cg fines			
481.64	345.88	p1cg fines			
485.87	345.93	p1cg fines			
489.68	346.09	p1cg fines			
493.29	346.27	p1cg			
497.58	346.53	p1cg			
502.10	346.51	p1cg			
505.81	346.56	p1cg			
511.68	346.81	p1cg			
517.32	346.84	p1cg			
524.14	347.00	ncg			
530.87	347.19	ncg			
537.38	347.29	ncg			
542.77	346.93	ncg			
546.67	346.62	ncg			
551.40	346.39	p2cg			
555.82	346.41	p2cg			
559.30	346.40	p2cg			
566.51	346.49	p2cg			
570.79	346.62	ncg			
574.64	346.77	ncg			
581.76	347.12	ncg			
586.23	347.26	ncg			
590.54	347.39	ncg			
595.80	347.19	rcg			

Appendix C Continued. Longitudinal Profile Data

Site 9 DUPLICATE Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	346.76	ncg	339.26	346.68	p1cutearth
10.17	346.48	ncg	343.65	346.59	p1cutearth
16.19	346.79	ncg	348.04	346.71	p1cutearth
24.74	346.98	ncg	352.80	346.69	p1cutearth
34.89	347.23	r1cg	358.68	346.84	p1cutearth
47.05	347.26	r1cg	374.90	346.92	p1cutearth
56.92	347.16	r1cg	381.43	346.91	p1cutearth
68.57	347.18	r1cg	386.88	346.84	n2cg
77.67	346.90	r1cg	392.75	346.92	r2cg
86.79	347.07	r1cg	399.82	347.16	g2cg
94.81	347.18	gcg	409.66	347.31	g2cg
104.16	346.99	gcg xs3	418.78	347.32	g2cg
110.67	346.69	gcg	426.39	347.11	g2cg
119.17	346.65	gcg	431.06	346.53	n2cg
128.27	346.73	gcg	442.29	346.79	n2cg
137.99	346.73	gcg	445.17	346.92	g2cg
150.47	346.92	gcg	450.68	347.08	r2cg
165.01	346.75	gcg	454.45	347.33	r2cg
177.08	346.88	p1cg	458.20	346.45	p2cg
190.46	346.69	p1cg	460.86	346.43	p2cg
202.64	346.60	p1cg	464.20	347.34	r2cg
212.33	346.55	p1cg	468.97	347.25	r2cg
220.69	346.58	p1cg	474.71	347.34	p1cg lwd
228.30	346.42	p1cg	481.05	346.88	p1cg lwd
235.78	346.51	ncg	485.49	346.40	p1cg lwd
243.51	346.56	ncg	489.73	346.21	p1cg lwd
250.91	346.61	rcg	491.26	345.90	p1cg lwd
259.16	346.66	rcg xs2	492.99	345.89	p1cg
266.00	346.62	rcg xs2	495.15	345.97	p1cg
273.01	346.92	rcg xs2	501.89	345.73	p1cg
281.03	346.95	gcg xs2	505.51	345.49	p1cg
288.62	346.96	gcg xs2	509.61	345.72	p1cg
297.55	346.99	gcg xs2	514.03	345.90	p1cg
305.42	346.78	gcg	517.77	346.15	p1cg
311.31	346.87	p1cgcutearth	520.33	346.33	p1cg
321.54	346.57	p1cgcutearth	523.48	346.57	p1cg
328.72	346.66	p1cgcutearth	527.68	346.47	p1cg
334.50	346.51	p1cutearth	530.95	346.49	p1cg

Appendix C Continued. Longitudinal Profile Data

Site 9 DUPLICATE Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
534.06	346.57	p1cg			
538.90	346.93	ncg			
544.10	346.93	ncg			
549.51	347.05	ncg			
555.42	347.24	ncg			
559.51	347.35	ncg			
567.19	347.00	ncg			
572.22	346.72	ncg			
577.12	346.44	ncg			
580.69	346.39	ncg			
584.79	346.26	ncg			
588.77	346.04	ncg			
592.50	346.02	ncg			
594.79	346.66	ncg			
598.69	346.73	ncg			
601.24	346.74	ncg			
604.67	347.04	ncg			
609.69	347.20	ncg			
613.98	347.33	ncg			
619.71	347.20	ncg			
624.06	347.11	rcg			
628.77	347.24	rcg			
631.95	347.37	gcg			
638.75	347.52	gcg			
643.40	347.32	gcg xs1			

Appendix C Continued. Longitudinal Profile Data

Site 10 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	331.56	ncg	371.99	330.32	p1cg
7.49	331.83	ncg	377.00	330.44	p1cg
19.19	331.82	rcg	383.21	330.46	p1cg
28.46	332.08	rcg	389.87	330.44	p1cg
37.46	331.79	gcg	395.68	330.65	p1cg
46.41	331.87	gcg	399.88	330.79	p1cg
57.19	331.61	gcg xs3	405.50	330.66	p1cg
58.91	331.67	gcg	420.26	330.92	p1cg
73.95	331.72	gcg	424.81	331.03	p1cg
86.18	331.69	gcg	436.66	331.22	p1cg
96.69	331.49	gcg	449.77	331.22	p1cg
107.64	331.66	gcg	461.76	331.14	p1cg
117.15	331.70	gcg	465.80	331.38	p1cg
127.18	331.47	gcg	470.90	331.59	ncg
137.20	331.58	gcg	476.55	331.81	ncg
147.47	331.70	gcg	483.23	331.87	ncg
161.77	331.69	gcg	492.98	331.78	ncg
170.21	331.67	gcg	502.06	331.87	rcg
181.08	331.62	gcg	514.74	331.85	rcg
190.83	331.49	gcg	525.44	332.10	rcg
200.30	331.30	gcg	543.64	331.67	rcg xs2
207.15	331.19	gcg	554.90	331.51	gcg
212.58	330.89	gcg	567.56	331.60	gcg
219.66	330.88	gcg	578.41	331.24	gcg
232.50	330.97	gcg	591.06	331.25	pcg
239.89	331.28	gcg	601.06	331.37	pcg
250.67	331.20	p1cg	608.54	331.52	pcg
258.75	331.31	p1cg	616.96	331.63	pcg
267.99	331.27	p1cg	627.73	331.73	pcg
277.70	331.38	p1cg	633.61	331.47	p1cg
288.43	331.27	p1cg	639.68	331.47	p1cg
296.94	331.21	p1cg	646.12	331.41	p1cg
304.93	331.30	p1cg	653.33	331.37	p1cg
313.60	331.06	p1cg	657.31	331.57	p1cg
339.45	330.33	p1cg	662.18	331.90	p1cg
346.50	330.29	p1cg	670.28	331.74	p1cg
353.84	330.36	p1cg	677.92	331.63	p1cg
368.36	330.32	p1cg	684.76	331.42	p1cg

Appendix C Continued. Longitudinal Profile Data

Site 10 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
691.89	331.47	p1cg			
698.07	331.75	p1cg			
707.60	331.79	p1cg			
724.02	331.85	n1cg			
731.28	331.43	n1cg			
736.64	331.20	n1cg			
743.99	331.02	p2cg			
753.12	331.34	p2cg			
760.17	331.88	p2cg			
769.22	332.42	rcg			
776.26	332.43	rcg			
791.70	332.66	rcg			
802.80	332.58	rcg			
816.71	332.41	rcg			
822.74	332.40	rcg			
840.31	332.72	rcg			
852.48	332.74	rcg			
857.53	332.61	rcg			

Appendix C Continued. Longitudinal Profile Data

Site 11 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	324.49	ncg	321.03	324.62	p1cg
14.65	324.58	ncg	331.72	324.62	p1cg
21.22	324.68	rcg	345.16	324.92	ncg
38.12	324.39	gcg xs3	372.06	324.95	ncg
49.85	324.36	gcg	384.29	324.82	ncg
58.07	324.51	gbrk	396.66	324.83	ncg
65.18	324.81	gbrk	407.20	324.84	rcg cobbles
77.24	324.86	gbrk	418.12	324.59	rcg cobbles
83.85	324.61	gbrk	427.48	325.32	rcg cobbles
90.65	324.56	gbrk	434.92	324.31	rcg cobbles
97.75	324.58	gbrk	444.50	324.65	rcg cobbles
111.67	324.73	gbrk	452.60	324.73	gcg xs2
120.90	324.79	gbrk	459.79	324.01	gcg scour
136.67	324.85	gbrk	465.74	323.67	gcg scour
142.16	324.41	gbrk	485.47	323.59	gcg scour
147.44	324.75	gcg	497.44	324.03	gcg scour
152.58	324.99	gcg pipeline	503.07	323.93	pcg scour
155.45	324.04	gcg pipeline	512.85	323.90	pcg scour
156.96	324.51	gcg pipeline	521.81	323.99	pcg scour
157.80	325.01	gcg pipeline	531.77	324.30	pcg scour
163.53	324.15	gcg pipeline	543.75	323.91	pcg scour
166.92	324.15	pcg pipeline	552.23	324.22	pcg scour
172.72	324.37	pcg pipeline	554.48	324.30	p1cg
182.80	324.32	pcg pipeline	563.16	324.50	p1cg
188.19	324.34	pcg pipeline	573.41	324.63	p1cg
193.90	324.59	pcg pipeline	579.75	324.39	p1cg
201.82	324.57	pcg cobbles	586.79	324.27	p1cg
204.52	324.27	pcg cobbles	595.18	324.09	p1cg
208.14	324.46	pcg cobbles	600.31	323.92	p1cg
218.52	324.64	pcg cobbles	609.88	323.95	p1cg
229.46	324.58	pcg cobbles	621.67	323.82	p1cg
237.92	324.66	pcg cobbles	630.72	323.73	p1cg
246.30	324.88	p1cg	641.19	323.89	p1cg
264.86	324.69	p1cg	645.78	324.15	p1cg
277.90	324.65	p1cg	655.79	324.06	p1cg
289.04	324.64	p1cg	664.33	324.01	p1cg
299.71	324.55	p1cg	673.31	323.66	p1cg
309.38	324.61	p1cg	683.61	324.20	p1cg

Appendix C Continued. Longitudinal Profile Data

Site 11 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
691.67	324.68	p1cg	1016.78	325.83	n2cgcobbles
701.36	324.77	p1cg	1018.97	325.73	n2cgcobbles
712.49	324.66	n2cg	1025.79	325.69	n2cgcobbles
719.35	324.57	n2cg	1033.64	325.67	n2cgcobbles
727.53	325.10	n2cg	1040.03	325.66	n2cgcobbles
736.55	325.25	n2cg	1049.60	325.67	n2cgbrk
746.88	325.52	r2cg	1060.47	325.71	n2cgbrk
756.41	325.37	r2cg	1073.84	325.83	n2cgbrk
763.71	325.65	r2cg	1081.90	325.97	n2cgbrk
773.19	325.58	r2cg	1091.01	325.98	r2cgbrk
778.56	325.43	r2cg	1105.55	325.96	r2cgbrk
785.37	325.44	r2cg	1110.62	325.98	r2cgbrk
792.24	325.55	r2cg	1117.37	326.05	r2cgbrk
801.42	325.79	r2cg	1123.27	326.07	gcgbrk
809.16	325.68	r2cg	1127.96	326.12	gcg
821.04	325.63	r2cg	1131.45	326.07	gcg xs1
830.86	325.91	r2cg	1139.16	325.87	gcg xs1 real
843.21	325.79	r2cg	1147.27	325.93	gcg xs1 real
847.86	325.61	r2cg	1149.83	326.03	gcg
854.36	325.63	r2cg			
866.08	325.54	r2cg			
878.07	325.92	r2cg			
890.39	325.69	r2cg			
902.87	325.87	r2cg			
919.82	325.93	r2cg			
926.04	325.72	r2cg			
927.95	325.45	ncgcobbles			
933.77	325.44	ncgcobbles			
942.18	325.53	ncgcobbles			
947.16	325.56	ncgcobbles			
955.54	325.63	ncgcobbles			
963.86	325.75	ncgcobbles			
970.56	325.65	ncgcobbles			
983.10	325.58	ncgcobbles			
987.31	325.76	r2cgcobbles			
990.91	325.59	r2cgcobbles			
999.25	325.72	r2cgcobbles			
1008.90	325.62	n2cgcobbles			

Appendix C Continued. Longitudinal Profile Data

Site 12 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	324.06	pbrkcobble	257.02	325.06	gbrk
5.00	324.06	pbrkcobble	264.39	325.31	gbrk
14.19	324.15	pbrkcobble	275.60	325.18	pbrk
20.76	324.17	nbrkcobble	285.13	325.21	pbrk
27.40	324.18	nbrkcobble	295.37	325.11	pbrk
33.66	324.20	nbrkcobble	304.81	325.20	pbrk
41.93	324.21	nbrkcobble	317.85	325.11	pbrk
50.35	324.55	nbrkcobble	327.11	325.12	nbrk
62.19	324.58	nbrkcobble	334.62	325.11	nbrk
71.33	324.61	nbrkcobble	343.79	325.06	nbrk
79.92	324.62	nbrkcobble	357.01	325.17	nbrk
85.63	324.49	nbrkcobble	367.26	325.15	nbrk
92.52	324.76	nbrkcobble	379.55	325.16	nbrk
93.85	324.88	nbrkcobble	392.69	325.23	nbrk
102.26	324.98	nbrkcobble	405.66	325.19	nbrk
108.56	324.68	nbrkcobble	418.28	325.21	nbrk
114.98	324.95	nbrkcobble	430.86	325.23	nbrk
123.68	324.72	nbrkcobble	440.28	325.23	nbrk
130.20	324.71	nbrkcobble	449.35	325.18	nbrk
137.84	324.57	nbrkcobble	459.05	325.24	nbrk
143.38	324.74	rbrkcobble	471.45	325.18	nbrk
150.52	324.76	rbrkcobble	483.79	325.18	nbrk
151.71	325.09	rbrkcobble	493.53	325.08	nbrk
155.24	325.03	rbrkcobble	498.63	325.07	nbrk
155.40	325.17	rbrkcobble	507.88	325.19	nbrk
159.77	324.97	rbrkcobble	515.29	325.11	nbrk
166.28	324.86	rbrkcobble	521.21	324.87	nbrk
175.78	324.89	rcobble	527.02	324.79	rbrk
182.87	324.90	rcobble	534.46	324.89	rbrk
190.14	325.01	rcobble	540.19	324.91	rbrk
196.23	325.01	rcobble	544.91	324.90	rbrk
204.66	324.89	rcobble	549.47	324.92	rbrk
213.24	324.88	gcobble	553.06	325.03	rbrk
218.82	324.60	gcobble	559.63	325.16	rbrk
225.75	324.62	gcobble xs3	564.86	325.19	rbrk
235.18	324.71	gcobble	572.75	325.28	rbrk
242.27	324.95	gcobble	581.88	325.24	rbrk
249.74	325.05	gbrk	589.39	325.28	rbrk

Appendix C Continued. Longitudinal Profile Data

Site 12 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
594.34	325.21	rbrk	842.31	324.61	gbrk
598.61	325.18	rbrk	849.49	324.63	gbrk
604.19	325.17	rbrk	861.46	324.68	gbrk
609.80	325.35	gbrk	861.56	324.51	gbrk
615.39	325.35	gbrk	868.83	324.62	gcg cob
620.52	325.27	gbrk	876.11	324.67	gcg cob
626.25	325.15	gbrk	879.64	324.67	gcg cob
630.82	324.99	gbrk xs2	883.40	324.73	gcg cob
636.82	325.26	gbrk	893.15	324.66	gcg cob
643.92	325.46	gbrk	898.11	324.67	gcg
649.54	325.47	gbrk	901.78	324.60	gcg
652.58	325.29	gbrk	906.34	324.45	gcg
655.86	325.20	gbrk	910.43	324.46	gcg
659.94	325.01	gbrk	915.46	324.47	gcg
663.24	325.13	gbrk	920.68	324.49	gcg
669.05	325.18	gbrk	926.79	324.22	gcg
676.57	325.25	gcobble	929.56	324.38	gcg
683.04	325.12	gbrk	933.06	324.48	gcg
685.55	325.25	gbrk	939.46	324.64	gcg
690.12	325.29	gbrk	944.72	324.87	gcg
696.59	325.45	gbrk	950.45	324.82	p1cg
706.26	325.37	gbrk	958.01	324.81	p1cg
716.83	325.35	gbrk	962.72	324.76	p1cg
727.62	325.27	gbrk	967.57	324.81	p1cg
735.32	325.20	gbrk	972.49	324.86	p1cg
751.76	325.11	gbrk	976.49	324.73	p1cg
763.91	325.11	gbrk	982.32	324.64	p1cg
770.61	325.11	gbrk	991.54	324.67	p1cg
776.23	324.98	gbrk	995.91	324.49	p1cg
782.40	325.06	gbrk	1004.92	324.36	p1cg
786.45	324.91	gcg	1012.09	324.33	p1cg
792.67	324.89	gcg	1016.07	324.17	p1cg
796.91	324.78	gcg	1022.61	323.99	p1cg
805.18	324.52	gcg	1030.74	323.86	p1cg
812.75	324.59	gcg	1038.34	323.79	p1cg
818.90	324.55	gcg	1045.15	323.81	p1cg
824.28	324.61	gcg	1054.90	324.26	p1cg
832.88	324.61	gcg	1056.89	324.15	p1r

Appendix C Continued. Longitudinal Profile Data

Site 12 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
1061.87	324.04	p1r	1339.52	324.67	ncg
1067.17	323.67	p1r	1347.04	324.73	ncg
1071.07	323.59	p1r	1356.06	325.13	ncg
1081.18	323.47	p1r	1364.09	325.28	rcg
1087.29	323.34	p1r	1372.94	325.37	rcg
1091.70	323.39	p1r	1381.55	325.36	rcg
1098.48	323.61	p1r	1391.26	325.32	rcg
1101.56	323.42	p1r	1399.55	325.38	rcg
1104.63	323.67	p1r	1408.06	325.35	rcg
1109.87	323.79	p1r	1414.19	325.39	rcg
1116.24	323.91	p1r	1423.24	325.44	rcg
1122.53	323.76	p1r	1434.01	325.52	rcg
1130.57	324.01	p1cg cob	1442.30	325.62	gcg
1140.29	323.97	p1cg cob	1450.49	325.34	gcg
1147.86	323.74	p1cg cob	1460.33	325.39	gcg cs1
1154.40	323.87	p1cg cob	1473.74	325.46	gcg
1161.66	323.78	p1cg	1481.52	325.41	gcg
1170.75	323.53	p1cg	1492.68	325.30	gcg
1175.70	323.40	p1cg	1500.28	325.33	gcg
1182.09	324.01	p1cg			
1190.66	323.97	p1cg			
1198.45	323.86	p1cg			
1205.58	323.92	p1cg			
1215.18	323.90	p1cg			
1221.43	323.77	p1cg			
1227.22	323.94	p1cg			
1235.78	324.11	p1cg			
1241.57	324.01	p1cg			
1254.25	324.67	p1cg			
1263.52	324.49	p1cg			
1273.85	324.24	p1cg cob			
1280.89	324.16	p1cg cob			
1293.86	324.11	p1cg cob			
1303.20	324.29	p1cg cob			
1313.01	324.23	p1cg cob			
1316.29	324.26	p1cg cob			
1323.87	324.69	ncg cob			
1332.46	324.84	ncg			

Appendix C Continued. Longitudinal Profile Data

Site 13 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	314.35	r1brk	285.33	314.05	r1cg
8.91	314.37	r1brk	301.88	314.31	r1brk cobb
16.21	314.18	r1brk	316.63	314.18	r1brk cobb
23.79	314.31	r1cg cobbles	330.54	314.36	r1brk cobb
27.16	314.28	r1cg cobbles	342.51	314.38	r1brk cobb
34.68	314.17	r1cg cobbles	348.44	314.17	r1brk cobb
43.95	314.10	r1cg cobbles	356.28	314.15	r1brk cobb
48.58	314.69	r1cg cobbles	366.94	314.17	g1brk
52.35	314.52	r1cg cobbles	378.98	314.02	g1brkxs3
55.05	314.13	r1cg cobbles	389.14	313.91	g1brk
57.86	314.13	r1brk	400.39	314.00	g1brk
67.43	314.31	g1brk	409.52	314.23	g1brk
71.60	314.22	g1brk	425.90	314.16	g1brk
82.31	313.97	g1brk	434.93	314.18	g1brk
83.67	313.97	p1brk	441.77	314.17	g1brk
85.27	313.75	p1brk	449.97	314.40	g1brk
85.30	313.75	p1brk	464.84	314.44	g1brk
93.24	313.74	p1brk	475.26	314.43	g1brk
101.59	313.94	p1brk	488.16	314.39	g1brk
113.03	313.86	p1brk	495.93	314.39	g1brk
127.12	313.75	p1brk	496.39	314.20	g1brk
136.03	313.76	p1brk	510.24	314.05	g1brk
149.67	313.95	p1brk	520.60	314.21	p1brk
158.91	313.71	p1cg cob	534.87	314.16	p1brk
177.57	313.85	n1cg cob	542.21	314.15	p1brk
186.74	314.17	n1cg cob	560.10	314.03	p1brk
199.41	314.03	n1cg cob	570.17	314.19	p1brk
203.67	314.00	n1cg cob	578.44	314.12	p1brk
208.08	314.48	r1cgbrk	588.98	313.93	p1brk
214.80	314.14	r1cgbrk	599.52	314.06	p1brk
217.74	314.19	r1cgbrk	610.27	314.19	p1brk
219.38	313.83	r1cgbrk	624.87	314.10	p1brk
219.95	313.97	r1cgbrk	635.12	314.28	p1brk
231.78	313.99	r1cgbrk	646.28	314.23	p1brk
240.92	313.74	r1cgbrk	655.37	314.02	n2brk
249.21	313.99	r1cgbrk	665.47	314.06	n2brk
260.29	314.10	r1cgbrk	674.95	314.04	n2brk
273.00	314.05	r1cg	683.67	314.19	n2brk

Appendix C Continued. Longitudinal Profile Data

Site 13 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
683.94	314.32	n2brk	916.75	313.63	p1brk
684.96	314.44	r2brk	919.46	313.71	p1brk
691.93	314.40	r2brk	921.14	313.57	p1brk
697.36	314.51	r2brk	921.19	313.58	p1brk
705.45	314.39	p1brk	921.30	313.58	p1brk
715.51	314.29	p1brk	927.08	313.39	p1brk
723.26	314.32	p1brk	933.72	313.31	p1brk
734.25	314.38	p1brk	944.78	313.35	p1brk
744.63	314.27	p1brk	949.90	313.28	p1brk
754.76	314.25	p1brk	953.93	313.29	p1brk
757.23	314.34	p1brk	957.17	313.38	p1cg cobble
759.77	314.30	p1brk	961.73	313.49	p1cg cobble
765.36	314.21	p1cgbrk	965.81	313.72	p1cg cobble
771.58	314.18	p1cgbrk	969.50	313.77	p1cg cobble
774.48	314.06	p1cgbrk	973.29	313.75	p1cg cobble
778.02	314.14	p1brk	976.63	313.82	p1cg cobble
781.30	314.14	p1brk	979.20	313.86	p1cg cobble
781.50	314.05	p1brk	983.75	314.04	p1cg cobble
786.96	314.27	p1brk	990.10	314.04	ncg cobble
795.88	314.08	p1brk	996.55	314.02	ncg cobble
804.58	314.09	p1brk	1001.76	314.08	ncg cobble
814.45	314.09	p1cg	1005.85	314.18	ncg cobble
819.19	314.09	p1cg	1016.55	314.17	ncg cobble
831.28	314.11	p1cg	1025.07	314.28	ncg cobble
836.93	313.94	p1cg	1031.53	314.38	ncg cobble
838.61	314.15	p1cg	1037.57	314.23	ncg cobble
843.72	314.23	p1cg	1044.06	314.35	ncg cobble
848.83	314.27	p1cg	1051.63	314.22	ncg cobble
855.99	314.03	p1cg	1067.36	314.31	ncg cobble
863.47	314.19	p1cg	1075.95	314.32	ncg cobble
871.70	314.31	p1cg	1088.13	314.46	ncg cobble
878.78	314.13	p1cg	1099.15	314.38	ncg cobble
887.07	314.14	p1cg	1109.69	314.29	ncg cobble
892.92	314.05	p1cg	1114.66	314.01	ncg cobble
900.42	313.91	p1brk	1119.58	313.94	ncg cobble
905.63	314.03	p1brk	1128.74	313.91	ncg cobble
911.73	314.03	p1brk	1136.23	313.89	ncg cobble
914.22	313.87	p1brk	1144.42	314.02	ncg cobble

Appendix C Continued. Longitudinal Profile Data

Site 13 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
1152.69	313.95	ncg cobble	1314.49	313.42	p1cg
1159.10	313.98	ncg cobble	1318.01	313.58	p1cg
1164.92	314.10	ncg cobble	1321.87	313.86	p1cg
1168.63	314.30	ncg cobble	1327.72	313.32	p1cg
1170.35	314.58	ncg cobble	1342.00	313.39	p1brk
1176.72	314.72	ncg cobble	1347.06	313.13	p1brk
1181.11	314.82	ncg cobble	1352.67	313.10	p1brk
1186.97	314.72	ncg cobble	1356.29	313.03	p1brk
1191.51	314.68	ncg bartail	1359.07	313.25	p1brk
1196.57	314.58	ncg bartail	1367.41	313.17	p1brk
1202.35	314.42	ncg	1373.00	312.84	p1brk
1206.60	314.34	ncg	1376.42	312.69	p1brk
1212.77	314.25	rcg lwdscour	1380.82	312.54	p1brk
1218.71	314.19	rcg lwdscour	1384.43	312.70	p1brk
1225.44	314.27	rcg lwdscour	1389.22	312.84	p1brk
1231.22	314.22	rcg lwdscour	1391.19	313.00	pcg cobble
1236.41	314.17	rcg lwdscour	1395.29	313.06	pcg cobble
1239.80	314.11	rcg lwdscour	1399.82	312.93	pcg cobble
1244.30	314.12	rcg lwdscour	1403.54	313.25	ncg cobble
1248.93	313.99	rcg lwdscour	1407.11	313.64	ncg cobble
1253.19	313.92	rcg lwdscour	1410.56	313.71	ncg cobble
1257.54	313.66	rcg lwdscour	1413.82	313.85	ncg cobble
1261.44	314.04	rcg lwdscour	1415.93	313.94	ncg cobble
1265.59	314.37	rcg	1418.48	313.97	ncg cobble
1267.75	314.58	rcg	1419.87	314.20	ncg cobble
1269.42	314.59	rcg	1421.80	314.36	ncg cobble
1272.06	314.78	rcg	1424.20	314.58	nbrk
1274.59	314.74	gcg xs2	1426.44	314.66	nbrk
1278.25	314.55	g1cg cobbles	1429.92	314.71	nbrk
1280.80	314.46	g1cg cobbles	1432.98	314.86	nbrk nickpt
1284.02	314.33	g1cg cobbles	1434.94	314.97	nbrk nickpt
1287.80	314.18	g1cg cobbles	1437.60	315.02	nbrk nickpt
1290.54	313.92	g1cg cobbles	1438.36	315.11	nbrk nickpt
1297.53	313.77	g1cg cobbles	1438.91	315.18	nbrk nickpt
1300.87	313.85	g1cg cobbles	1439.90	315.31	nbrk nickpt
1302.74	313.88	g1cg cobbles	1440.58	315.28	nbrk nickpt
1307.84	314.13	p1cg cobbles	1441.02	315.33	nbrk nickpt
1310.77	313.83	p1cg cobbles	1443.92	315.31	nbrk nickpt

Appendix C Continued. Longitudinal Profile Data

Site 13 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
1446.92	315.45	nbrk nickpt	1599.53	315.45	rbrk
1448.79	315.40	nbrk nickpt	1604.50	315.46	rbrk
1449.12	315.54	nbrk nickpt	1607.69	315.35	rbrk
1451.13	315.54	nbrk nickpt	1609.40	315.51	rbrk
1451.62	315.58	nbrk nickpt	1611.15	315.56	rbrk
1456.16	315.49	nbrk nickpt	1614.05	315.51	rbrk
1460.49	315.40	nbrk nickpt	1617.32	315.37	rbrk
1463.70	315.28	nbrk	1621.28	315.38	rbrk
1468.47	315.22	nbrk	1624.68	315.48	rbrk
1472.32	315.28	nbrk	1627.14	315.60	rbrk
1476.61	315.22	nbrk	1632.48	315.77	rbrk
1480.14	315.14	nbrk	1637.73	315.80	gbrk xs1
1484.52	315.26	nbrk	1641.98	315.64	gbrk xs1
1487.57	314.89	nbrk	1644.44	315.51	gbrk xs1
1490.31	315.00	nbrk	1646.22	315.53	gbrk xs1
1493.30	315.23	nbrk	1652.21	315.54	gbrk
1498.14	315.20	nbrk	1653.92	315.55	gbrk
1502.78	315.29	nbrk	1657.30	315.51	gbrk
1507.80	315.19	nbrk	1663.22	315.55	gbrk
1512.19	315.26	nbrk	1669.01	315.69	gbrk
1516.23	315.31	nbrk	1675.98	315.61	gbrk
1523.21	315.30	nbrk	1680.01	315.62	gbrk
1529.95	315.47	nbrk	1685.37	315.42	gbrk
1534.76	315.19	nbrk	1689.07	315.68	gbrk
1537.44	315.35	nbrk	1695.19	315.57	gbrk
1541.92	315.17	nbrk			
1546.31	315.35	nbrk			
1551.62	315.29	nbrk			
1554.21	315.12	nbrk			
1559.75	315.23	rbrk			
1564.47	315.36	rbrk			
1568.49	315.38	rbrk			
1575.04	315.39	rbrk			
1578.78	315.51	rbrk			
1583.19	315.38	rbrk			
1587.25	315.39	rbrk			
1591.04	315.47	rbrk			
1595.40	315.45	rbrk			

Appendix C Continued. Longitudinal Profile Data

Site 14 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	306.54	p1cg	296.12	306.41	p1cgbrk
5.93	306.20	p1cg	301.02	306.51	p1cgbrk
13.48	306.05	p1brk	308.68	306.40	p1cgbrk
23.28	306.18	p1brk	312.48	306.33	p1cgbrk
30.86	306.14	p1brk	317.07	306.39	p1cgbrk
36.25	306.16	p1cgcobbles	325.33	306.44	p1cgbrk
51.74	306.06	p1cgcobbles	331.59	306.33	p1cgbrk
61.15	306.02	ncgcobbles	336.42	306.26	p1cgbrk
70.89	306.15	ncgcobbles	343.39	306.31	p1cgbrk
80.65	305.96	ncgcobbles	358.94	306.19	p1cgbrk
93.71	306.17	r1cgcobbles	366.84	306.13	p1brk
100.54	306.23	r1cgcobbles	372.29	306.22	p1cg brk
107.80	306.48	r1cgcobbles	383.38	306.19	p1cg brk
114.39	307.01	r1cgcobbles	392.26	306.31	p1cg brk
121.92	306.97	r1cgcobbles	399.64	306.30	p1cg brk
133.64	307.06	r1cgcobbles	405.25	306.34	p1cg brk
141.02	307.17	r1cgcobbles	415.88	306.44	p1cg brk
151.77	307.10	r1cgcobbles	425.40	306.43	p1cg brk
160.40	307.04	g1cgcobbles	428.52	306.75	r2cg cobble
171.57	307.03	g1cgcobbles	438.65	306.87	r2cg cobble
182.64	307.03	g1cgcobbles	452.76	307.02	r2cg cobble
191.79	306.99	g1cgcobbles	468.37	307.08	r2cg cobble
201.19	307.01	g1cgcobbles	480.65	306.98	r2cg cobble
207.22	306.96	g1brkcobble	494.03	307.02	p1cg cobble
212.57	306.76	g1brkcobble	502.97	306.88	p1cg cobble
216.72	306.62	g1brk	511.34	306.74	p1cg cobble
221.45	306.85	g1 cobb xs3	521.71	306.62	p1cg cobble
227.76	307.01	g1brk cobb	534.28	306.57	p1cg cobble
234.11	307.18	g1brk	542.45	306.75	p1cg cobble
239.01	306.68	g1brk	554.34	307.00	n1cg cobble
242.31	306.58	g1brk	564.29	306.97	n1cg cobble
251.08	306.45	g1brk	573.51	307.04	n1cg cobble
263.21	306.91	g1cg cobble	585.64	307.18	n1cg cobble
269.88	306.86	g1cg cobble	597.38	307.27	n1cg
277.32	306.71	g1cg cobble	618.45	307.26	n1cg brk
283.32	306.69	g1cg cobble	634.95	307.28	n1cg brk
291.97	306.77	g1cg cobble	653.68	307.27	n1cg brk
293.75	306.54	p1cgbrk	669.94	307.37	n1cg brk

Appendix C Continued. Longitudinal Profile Data

Site 14 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
679.82	307.31	n1cg brk	944.43	307.68	p1cg cobble
691.84	307.26	n1cg brk	956.05	307.58	p1cg cobble
703.89	307.33	n1cg brk	964.73	307.59	p1cg cobble
717.95	307.32	n1cg brk	975.15	307.50	p1cg
727.20	307.37	n1brk cg	984.68	307.45	p1cg
735.39	307.34	n1 cg	1001.80	307.41	p1cg
744.78	307.31	r1brk cg	1011.74	307.41	p1cg
750.17	307.44	r1brk cg	1020.59	307.40	p1cg
757.46	307.28	r1brk cg	1031.31	307.33	p1cgbrk
763.79	307.31	r1brk cg	1041.19	307.32	p1cgbrk
769.15	307.15	r1brk	1051.35	307.33	p1cgbrk
777.05	307.28	r1brk	1059.01	307.24	p1cgbrk
785.55	307.24	r1brk	1068.44	307.19	p1cgbrk
790.82	307.26	r1brk	1075.71	307.39	p1fgcobble
795.89	307.20	r1brk	1084.50	307.38	p1fgcobble
799.78	307.21	r1brk	1094.39	307.47	nfgcobble
801.98	307.29	r1brk	1110.75	307.40	nfgcobble
804.50	307.67	r1cg cobble	1120.60	307.39	nfgcobble
809.00	307.69	r1cg cobble	1130.71	307.49	ncg
817.08	307.79	r1cg cobble	1141.79	307.41	ncg
822.23	307.59	r1cg cobble	1153.70	307.41	ncg
826.98	307.61	gcg cobble	1164.45	307.35	ncg
831.78	307.51	gcg cobble	1175.69	307.13	ncg
834.92	307.42	gcg cobble	1182.45	307.23	ncg
840.02	307.37	gcg cobb xs2	1195.28	307.64	rcg
844.26	307.35	gcg cobble	1206.03	307.74	rcg
851.55	307.16	g brk	1217.34	307.79	rcg
855.88	307.23	g brk	1229.02	307.89	rcg
863.29	307.17	gcg brk	1240.04	307.88	rcg
868.21	307.21	gcg brk	1253.92	307.80	rcg
872.47	307.28	gcg brk	1271.19	307.87	rfgcobble
879.73	307.26	gcg brk	1278.18	307.78	rfgcobble
886.22	307.35	gcg cobble	1289.75	307.75	rcg cobble
894.41	307.47	gcg cobble	1298.03	307.63	gcg cobble
902.86	307.88	gcg cobble	1309.93	307.68	gcg xs1
911.73	307.88	gcg cobble	1313.14	307.74	gcg
927.21	307.82	gcg cobble	1320.43	307.43	gcg
936.43	307.73	gcg cobble	1324.19	307.40	gcg

Appendix C Continued. Longitudinal Profile Data

Site 14 DUPLICATE Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	306.85	rcg	328.86	306.96	gcgfg
7.26	306.63	rcg	334.52	306.87	pcg
21.00	306.66	rcg	343.39	306.73	pcg
37.49	306.69	rcg	349.62	306.79	pcg
51.88	306.92	rcg	357.66	306.65	pcg
64.10	306.68	rcg	361.10	306.45	pcg
69.50	306.30	rcg	369.59	306.41	pbrk
77.33	306.32	rcg	377.27	306.45	pbrk
87.28	306.36	rbrk	385.00	306.40	pcg
95.98	306.40	rbrk	394.44	306.41	pcg
103.93	306.07	rbrk	402.30	306.41	pcg
113.56	305.99	rbrk	410.11	306.52	pbrk
122.12	306.03	rbrk	419.21	306.40	pcg
127.58	306.17	rbrk	426.20	306.40	pcg
133.63	305.93	rbrk	434.19	306.40	pcg
140.56	306.22	rcg scour	444.90	306.49	pbrk
144.17	306.19	rcg scour	452.73	306.57	pcg
149.40	306.21	rcg scour	464.82	306.68	pcg
153.35	306.39	rcg scour	471.86	306.99	pcg
159.89	306.38	rcg	486.13	307.15	pcg
165.76	306.43	rcg	509.93	307.31	pcg
172.73	307.09	rcg	533.02	307.24	pcg
181.51	307.25	rcg	547.30	307.06	pcg
193.44	307.25	rcg	561.07	306.83	pcg
202.59	307.26	rcg	573.05	306.48	pcg
216.81	307.27	rcg	585.11	306.64	ncg
227.39	307.32	rcg	596.25	306.91	ncg
240.52	307.32	rcg	610.90	307.05	ncg
250.34	307.27	rcg	629.23	307.34	ncg
259.35	307.18	gcobbcg	651.49	307.49	ncg
267.14	307.04	gcobbcg	673.49	307.60	ncg
277.28	307.01	gcobbcg xs3	691.92	307.53	ncg
286.80	307.19	gbrkfg	711.88	307.54	ncg
291.93	307.22	gbrkfg	729.67	307.48	nbrk
296.28	306.93	gbrkfg	743.18	307.28	rfg
305.07	306.69	gbrk	756.79	307.39	rfg
311.60	306.69	gbrk	773.94	307.39	rbrkfg
319.87	307.00	gcgfg	784.92	307.35	rbrkfg

Appendix C Continued. Longitudinal Profile Data

Site 14 DUPLICATE Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
794.57	307.42	rbrk	1381.30	307.17	gfg
801.44	307.41	rbrk	1392.08	307.13	gfg
806.38	307.46	rbrk			
816.16	307.19	rcg			
825.22	307.32	rcg			
833.92	307.36	rcg			
838.74	307.31	rcg			
844.41	307.23	rcgfg			
853.55	307.82	rcgfg			
864.22	307.89	rccgfg			
876.65	307.79	gcgfg			
896.24	307.65	gcg xs2			
915.05	307.66	gcg			
936.47	307.60	gcg			
950.83	307.61	gcg			
969.92	307.71	gcg			
989.10	307.69	pcg			
1000.89	307.77	pcg			
1013.42	307.67	pbrk			
1029.64	307.57	pcg cobb			
1046.17	307.48	pcg			
1062.25	307.47	pcg			
1077.80	307.47	pcg			
1096.52	307.47	pcobbfines			
1109.75	307.27	pcobbcg			
1128.81	307.44	pce			
1149.91	307.58	ncg			
1170.99	307.55	ncg			
1191.81	307.44	ncg			
1210.99	307.45	ncg			
1229.59	307.58	rcg			
1252.01	308.01	rcg			
1276.77	308.04	rcg			
1301.34	307.86	gcg			
1318.03	307.88	gcg			
1339.73	307.89	gcg xs1			
1358.58	307.48	gfg			
1367.97	307.21	gfg			

Appendix C Continued. Longitudinal Profile Data

Site 15 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	293.27	ncobb	389.92	293.63	ncob fg
9.20	293.23	ncobb	401.02	293.56	ncob fg
23.71	293.29	ncobb	412.25	293.58	ncob fg
38.69	293.18	ncobb	423.02	293.47	ncob fg
50.72	293.53	rcobb	433.22	293.56	ncob fg
63.94	293.38	rcobb	444.18	293.61	ncob fg
76.94	293.62	rcobb	451.51	293.57	ncob fg
88.41	293.61	rcobb	462.38	293.87	ncob fg
99.75	293.78	rcobb	468.71	293.59	nbrk
114.07	293.74	rcg	480.28	293.70	ncg
128.67	293.96	rcg	496.06	293.53	r1cg
136.19	294.01	rcg	511.30	293.58	r1brk
145.23	294.01	gcg	524.71	293.61	r1brk
149.89	293.92	gcg xs3	538.55	293.61	r1cg
159.54	293.50	gcg	551.11	293.61	r1brk
170.97	293.10	pbrk	568.49	293.52	r1brk
177.08	293.09	pbrk	578.04	293.83	r1cg
185.24	293.17	pbrk	590.08	293.58	r1cg
195.07	293.12	pbrk	602.65	293.82	r1brk
204.54	293.10	pbrk	621.17	293.80	r1cg
214.60	293.12	pbrk	632.09	294.06	r1cg
222.41	293.27	pbrk	648.03	294.07	r1cg
229.85	293.28	pbrk	664.89	294.07	r1cg
239.42	293.12	pbrk	682.20	294.07	r1cg
248.62	293.43	pbrk	692.70	294.20	r1cg cobb
259.36	293.44	p1cg	707.00	294.12	r1cg cobb
272.17	293.62	p1cg	721.52	294.45	r1cg cobb
283.84	293.82	p1cg	735.04	294.34	r1cg cobb
295.01	293.52	p1cg	748.09	294.07	r1cg cobb
305.04	293.29	p1brk	765.97	293.89	r1cg cobb
316.62	293.23	p1brk	781.50	294.29	r1cg cobb
327.73	293.18	p1brk	794.60	294.40	r1cg cobb
337.07	293.33	p1brk	805.57	294.66	r1cg cobb
347.41	293.28	p1brk	826.78	294.68	r1cg cobb
355.64	293.29	p1brk	836.86	294.36	g1cg xs2
365.65	293.42	p1cg	854.19	294.37	p1cg
375.63	293.50	ncob fg	869.26	293.79	p1cg
382.11	293.60	ncob fg	881.87	293.79	p1cobble

Appendix C Continued. Longitudinal Profile Data

Site 15 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
892.21	293.78	p1cobble			
901.62	293.76	p1brk			
913.28	293.74	p1brk			
924.57	293.72	nbrk			
935.96	293.84	nbrk			
951.24	294.14	ncobb			
969.67	294.20	ncobb			
978.22	294.29	ncobb			
989.17	294.31	ncobb			
995.77	294.27	r1 cobb			
1005.02	294.49	r1 cobb			
1012.82	294.50	r1 cobb			
1020.37	294.70	r1cg cobb			
1026.95	294.44	r1cg cobb			
1035.27	294.97	g1cg			
1038.93	294.33	g1cg			
1047.13	294.41	g1cg			
1055.07	294.41	g1cg xs1			
1080.57	294.30	g1cgcob xs1			
1093.15	293.62	p1brk			
1100.94	293.63	p1cg			
1105.76	293.78	p1cg			
1111.96	293.78	p1brk			
1116.49	293.77	p1brk			
1123.35	294.11	p1brk			
1130.30	293.78	p1brk			
1137.19	294.11	p1brk			
1145.54	294.12	p1cg			
1153.69	294.11	p1cg			

Appendix C Continued. Longitudinal Profile Data

Site 16 Longitudinal Profile

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	283.08	r1 cg cob	421.29	282.23	p1 cg
12.25	283.12	r1 cg cob	436.58	282.15	p1 cg
32.33	283.11	r1 cg cob	445.03	282.36	p1 cg
47.25	283.41	r1 cg cob	461.92	282.80	p1 cg
61.18	283.34	r1 cg cob	471.57	282.75	p1 cg
73.59	283.46	r1 cg	486.54	282.63	p1 cg
82.79	283.30	r1 cg	495.72	282.37	p1 cg
93.94	282.86	scourpool cg	507.90	282.51	p1 cg
101.23	282.72	scourpool cg	522.34	282.41	p1 cg
107.79	283.18	r1 cg cob	532.26	282.38	p1 cg
113.40	283.10	r1 cg cob	542.87	282.66	p1 cg
122.37	283.21	r1 cg cob	559.92	282.55	p1 blk
133.54	283.34	r1 cg cob	571.33	282.57	p1 cg
147.24	283.50	r1 cg cob	585.20	282.78	p1 blks
162.46	283.64	r1 cg cob	598.01	282.83	p1 blks
179.24	283.71	r1 cg cob	614.04	282.50	p1 blks
193.86	283.73	r1 cg cob	628.71	282.28	p1 blks
210.78	283.48	r1 cg cob	641.53	282.46	p1 blks
217.80	283.32	r1 cg cob	654.43	282.64	p1 blks
225.41	283.35	r1 cg cob	664.42	282.41	p1 blks
243.53	283.42	r1 cg	674.19	282.78	p1 blks
257.20	283.70	r1 cg	682.35	282.72	p1 blks
265.12	283.62	r1 cg	691.12	282.68	p1 blks
275.88	283.71	r1 cg	698.63	282.66	p1 blks
287.56	283.65	r1 cg	706.19	282.72	p1 blks
296.70	283.61	g1 cg	715.61	282.61	p1 blks
307.25	283.58	g1 cg	721.00	282.62	p1 blks
314.09	283.59	g1 cg	726.40	282.74	p1 blks
321.96	283.34	g1 cg	736.59	282.89	p1 blks
325.96	283.68	g1 cg	743.11	282.91	p1 blks
332.18	283.85	g1 cg	749.92	283.03	p1 blks
343.18	283.74	g1 cg	755.16	282.97	p1 blks
352.01	283.65	g1 cg xs3	758.39	283.35	p1 blks
360.28	283.56	g1 cg	762.34	283.45	p1 cg blks
368.96	283.60	g1 cg	772.36	283.45	p1 cg blks
384.06	283.14	g1 cg	781.86	283.36	p1 cg blks
397.29	283.12	p1 cg	788.52	283.20	p1 cg
408.01	282.92	p1 cg	793.85	283.20	p1 cg

Appendix C Continued. Longitudinal Profile Data

Site 16 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
794.71	283.27	p1 cg	1170.56	283.41	n1 cg
799.00	283.32	p1 cg	1182.22	283.45	n1 cg
806.07	283.20	p1 cg	1190.10	283.55	r1 cgcob
814.19	283.42	r cg	1195.71	283.62	r1 cgcob
824.91	283.48	r cg	1203.65	283.58	r1 cgcob lwd
835.45	283.57	p1 cg	1210.70	283.58	r1 cgcob lwd
849.45	283.43	p1 cg	1216.10	283.36	r1 cgcob lwd
863.78	283.42	p1 cg	1219.40	283.31	r1 cgcob lwd
876.19	283.15	p1 cg	1224.37	283.54	r1 cgcob
889.60	283.10	p1 cg	1231.63	283.82	r1 cgcob
901.79	283.15	p1 cg	1239.60	283.86	r1 cgcob
912.74	283.32	r2 cg	1247.55	283.86	r1 cgcob
926.77	283.55	r2 cg	1256.68	284.05	r1 cgcob
935.01	283.49	p1 cg	1265.43	284.04	r1 cgcob
943.01	283.20	p1 cg	1273.52	284.06	r1 cgcob
949.50	283.27	p1 brck	1282.14	283.99	r1 cgcob
959.68	283.07	p1 brck	1290.55	283.99	r1 cgcob
974.17	283.18	p1 brck	1295.93	283.90	g1 cgcob
983.75	283.36	p1 brck	1304.16	283.94	g1 cgcob
995.12	283.24	p1 brck	1313.86	283.94	g1 cgcob
1008.73	283.28	p1 brck	1325.96	283.77	g1 cgcob xs2
1021.06	283.15	p1 brck	1326.85	283.95	gcgcblecs2
1034.13	283.27	p1 brck	1335.58	283.90	gcgcblecs2
1044.40	283.11	p1 brck	1342.86	283.88	gcgcble
1050.66	282.99	p1 brck	1352.97	283.76	gcgcble
1059.77	283.13	p1 brck	1363.30	283.58	ncg
1073.38	283.07	p1 brck	1371.14	283.08	ncg
1084.55	283.10	p1 brck	1381.73	283.37	ncg
1093.45	283.05	p1 brck	1393.42	283.65	ncgcble
1101.37	283.35	p1 brck	1406.13	283.79	ncgcble
1109.98	283.31	p1 brck	1422.03	283.67	ncgcble
1117.50	283.03	p1 brck	1438.55	283.95	ncgcble
1124.41	283.07	n1 cgcob	1453.17	283.89	ncgcble
1133.52	283.17	n1 cgcob	1466.12	283.83	ncgcble
1139.58	283.26	n1 cgcob	1479.99	283.80	ncgcble
1146.24	283.13	n1 cg	1494.08	283.77	ncgcble
1155.38	283.14	n1 cg	1506.04	283.64	ncgcble
1163.63	283.25	n1 cg	1518.07	283.73	ncgcble

Appendix C Continued. Longitudinal Profile Data

Site 16 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
1527.83	283.56	ncgcble	2022.38	283.63	pcgblk
1535.18	283.40	ncgcble	2034.37	283.29	pcgblk
1539.07	283.42	ncgcble	2046.83	283.61	pcgblk
1542.41	283.59	ncgcble	2058.86	283.92	pcgblk
1549.86	283.85	ncgcble	2075.44	283.48	pcgblk
1559.89	284.00	ncgcble	2090.01	283.69	pcgblk
1570.13	284.09	ncgcble	2110.40	283.84	pcgblk
1578.71	284.30	ncgcble	2123.01	283.42	pcgblk
1585.98	284.17	ncgcble	2139.98	283.58	pcgblk
1599.08	284.05	ncgcble	2147.11	283.64	pcgblk
1612.73	284.05	rcgcble	2154.96	283.80	pcgblk
1629.76	284.34	rcgcble	2164.77	283.86	pcgblk
1646.61	284.34	rcble	2175.29	283.77	pcgblk
1661.56	284.30	rcble	2179.43	283.85	pcgblk
1668.62	284.40	rcble	2192.29	283.97	pcgblk
1678.76	284.27	rcble	2201.08	283.48	pcgblk
1692.13	284.33	rcble	2210.34	283.32	pcg blk
1707.99	284.28	gcgblk	2219.85	283.40	pcg
1720.62	284.22	gcgblk	2232.42	283.50	pcg
1720.69	284.23	gcgblk	2241.92	283.41	pcg blk
1734.48	284.09	gcgblkcs1	2247.68	283.66	pcg blk
1737.49	284.05	gcgblk	2263.86	283.51	pcg blk
1754.62	284.25	gcgblk	2273.72	283.85	pcg blk
1770.29	284.22	gcgblk	2282.59	283.66	pcg blk
1787.53	284.01	gcgblk	2290.24	283.76	pcg blk
1806.41	283.92	gcgblk	2297.78	283.76	pcg blk
1824.16	283.94	gcgblk	2304.17	283.73	ncg
1838.25	283.59	pfgblk	2312.10	283.86	ncg
1852.94	283.75	pfgblk	2320.65	283.92	ncg
1871.29	283.68	pfgblk	2330.45	284.10	ncg ramp
1887.77	283.72	pfgblk	2341.21	284.14	ncg ramp
1914.48	283.64	pfgblk	2353.79	284.25	ncg ramp
1935.12	283.56	blkk	2369.39	284.51	ncg
1950.85	283.43	blkk	2380.78	284.68	r2cg
1966.72	283.21	blkk	2388.76	284.78	r2cg
1977.55	283.45	blkk	2399.95	284.92	r2cg
1990.95	283.57	blkk	2411.46	284.84	r2cg
2004.14	283.44	blkk	2420.42	284.70	r2cg

Appendix C Continued. Longitudinal Profile Data

Site 16 Longitudinal Profile Continued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
2430.85	284.83	r2cg			
2444.19	284.99	r2cg			
2456.84	284.87	ncg			
2480.19	284.78	ncg			
2499.01	284.80	ncg			
2519.70	284.78	ncg			
2535.84	284.68	ncg			
2547.76	284.76	ncg			
2562.11	284.75	ncg			
2576.36	284.66	ncg			
2585.41	284.65	ncg			
2598.83	284.57	ncg			
2610.45	284.69	ncg			
2623.37	284.75	rcg			
2631.27	284.92	rcg			
2643.52	285.13	rcg			
2656.11	285.33	rcg			
2665.43	285.40	rcg			
2672.01	285.32	rcg			
2687.10	285.37	rcg			
2697.68	285.38	gcg			
2709.66	285.39	gcgcmpt0			
2713.45	285.39	gcg			
2719.03	285.44	gcgcs0			
2726.30	285.45	gcg			
2736.98	285.36	gcg			
2746.98	285.36	gcg			
2757.83	285.50	gcg			
2770.25	285.49	gcg			
2783.00	285.48	gcg			

Appendix C Continued. Longitudinal Profile Data

Site 16 Longitudinal Profile (Shortened Duplicate)

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes	Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
0.00	287.50	rcgcble	390.52	287.63	ncgcble
12.18	287.37	rcg	403.62	287.51	ncgcble
23.04	287.48	rcg	417.28	287.51	rcgcble
34.26	287.65	rcg	434.31	287.80	rcgcble
47.29	287.67	rcg	451.15	287.80	rcble
59.44	287.72	rcg	466.10	287.76	rcble
71.15	287.66	rcg	473.16	287.86	rcble
81.63	287.69	rcg	483.31	287.73	rcble
91.36	287.69	rcg	496.67	287.79	rcble
101.49	287.50	rcg	512.54	287.74	gcgblk
114.46	287.50	gcgcble	525.17	287.68	gcgblk
114.58	287.50	gcgcble	525.23	287.69	gcgblk
121.28	287.40	gcgcble	539.03	287.55	gcgblkcs1
131.40	287.41	gcgcblecscm	542.04	287.51	gcgblk
140.13	287.36	gcgcblecs1	559.17	287.71	gcgblk
147.41	287.34	gcgcble	574.83	287.68	gcgblk
157.52	287.22	gcgcble	592.08	287.47	gcgblk
167.85	287.04	ncg	610.95	287.38	gcgblk
175.68	286.54	ncg	628.71	287.40	gcgblk
186.27	286.83	ncg	642.79	287.05	pfgblk
197.96	287.11	ncgcble	657.49	287.21	pfgblk
210.67	287.25	ncgcble	675.84	287.14	pfgblk
226.57	287.13	ncgcble	692.31	287.18	pfgblk
243.10	287.41	ncgcble	719.02	287.10	pfgblk
257.71	287.35	ncgcble	739.66	287.02	blkk
270.67	287.29	ncgcble	755.39	286.89	blkk
284.53	287.26	ncgcble	771.27	286.67	blkk
298.62	287.23	ncgcble	782.10	286.91	blkk
310.58	287.10	ncgcble	795.49	287.03	blkk
322.62	287.19	ncgcble	808.69	286.90	blkk
332.38	287.02	ncgcble	826.92	287.09	pcgblk
339.72	286.86	ncgcble	838.92	286.75	pcgblk
343.61	286.88	ncgcble	851.37	287.07	pcgblk
346.95	287.05	ncgcble	863.40	287.38	pcgblk
354.40	287.31	ncgcble	879.98	286.94	pcgblk
364.43	287.46	ncgcble	894.55	287.15	pcgblk
374.67	287.55	ncgcble	914.94	287.30	pcgblk
383.25	287.76	ncgcble	927.55	286.88	pcgblk

Appendix C Continued. Longitudinal Profile Data

Site 16 Longitudinal Profile (Shortened Duplicate) Contuinued

Distance Upstream (m)	Approx. Elevation (m asl.)	Notes
944.52	287.04	pcgblk
951.65	287.10	pcgblk
959.51	287.26	pcgblk
969.32	287.32	pcgblk
979.83	287.23	pcgblk
983.97	287.31	pcgblk
996.84	287.43	pcgblk
1005.62	286.94	pcgblk
1014.89	286.78	pcg blk
1024.39	286.86	pcg
1036.96	286.96	pcg
1046.46	286.87	pcg blk
1052.23	287.12	pcg blk
1068.41	286.97	pcg blk
1078.26	287.31	pcg blk
1087.13	287.12	pcg blk
1094.78	287.22	pcg blk
1102.33	287.22	pcg blk
1108.72	287.19	ncg
1116.65	287.32	ncg
1125.19	287.38	ncg
1135.00	287.56	ncg ramp
1145.76	287.60	ncg ramp
1158.33	287.71	ncg ramp
1173.93	287.97	ncg
1185.32	288.14	r2cg
1193.30	288.24	r2cg
1204.50	288.38	r2cg
1216.00	288.30	r2cg
1224.97	288.16	r2cg
1235.39	288.29	r2cg
1248.73	288.45	r2cg
1261.38	288.33	ncg
1284.73	288.24	ncg
1303.55	288.26	ncg
1324.24	288.24	ncg
1340.38	288.14	ncg
1352.31	288.22	ncg
1366.66	288.21	ncg
1380.91	288.12	ncg
1389.96	288.11	ncg
1403.38	288.03	ncg
1415.00	288.15	ncg
1427.91	288.21	rcg
1435.81	288.38	rcg
1448.06	288.59	rcg
1460.65	288.79	rcg
1469.97	288.86	rcg
1476.56	288.78	rcg
1491.65	288.83	rcg
1502.22	288.84	gcg
1514.21	288.85	gcgcmpt0
1517.99	288.85	gcg
1523.57	288.90	gcgcs0
1530.84	288.91	gcg
1541.53	288.82	gcg
1551.52	288.82	gcg
1562.37	288.96	gcg
1574.80	288.95	gcg
1587.54	288.94	gcg

Appendix D. Channel Substrate Data

Glide, Riffle, and Bar Pebble Count Data (values in mm, D = duplicate)

Site No.	Riffle			Glide			Riffle & Glide			Bar Head			Bar Mid			Bar Tail			Bar All		
	D16	D50	D84	D16	D50	D84	D16	D50	D84	D16	D50	D84	D16	D50	D84	D16	D50	D84	D16	D50	D84
0	11.0	32.0	45.0	8.7	22.6	45.0	11.0	22.6	45.0	7.1	16.0	32.0	8.0	16.0	59.4	na	na	na	5.6	19.3	45.0
1	8.0	32.0	90.0	5.6	11.0	45.0	5.6	22.6	64.0	22.6	45.0	64.0	11.0	22.6	45.0	5.0	13.5	32.0	11.0	22.6	45.0
2	16.0	22.6	45.0	8.0	22.6	32.0	11.0	22.6	45.0	na	na	na	8.0	16.0	32.0	na	na	na	8.0	16.0	32.0
3	16.0	32.0	45.0	16.0	32.0	45.0	16.0	32.0	45.0	8.0	22.6	45.0	22.6	32.0	45.0	11.0	22.6	32.0	11.0	32.0	45.0
4	5.6	11.0	32.0	4.0	16.0	32.0	5.6	11.0	32.0	na	na	na	5.6	11.0	22.6	na	na	na	5.6	11.0	22.6
5	16.0	32.0	45.0	16.0	32.0	45.0	16.0	32.0	45.0	11.0	16.0	45.0	11.0	32.0	64.0	11.0	22.6	45.0	11.0	22.6	45.0
6	8.0	16.0	32.0	11.0	32.0	45.0	8.0	22.6	45.0	4.7	22.6	45.0	11.0	22.6	45.0	16.0	32.0	45.0	8.0	22.6	45.0
7	8.0	16.0	32.0	8.0	22.6	32.0	8.0	16.0	32.0	8.0	16.0	32.0	9.9	22.6	32.0	11.0	16.0	32.0	8.0	16.0	32.0
8	11.0	32.0	64.0	11.0	32.0	77.5	11.0	32.0	64.0	8.0	16.0	32.0	8.0	16.0	32.0	8.0	16.0	22.6	8.0	16.0	32.0
9	11.0	22.6	45.0	11.0	22.6	45.0	11.0	22.6	45.0	na	na	na	22.6	32.0	45.0	na	na	na	22.6	32.0	45.0
10	16.0	32.0	90.0	11.0	32.0	64.0	16.0	32.0	64.0	na	na	na	14.2	27.3	45.0	na	na	na	14.2	27.3	45.0
11	22.6	45.0	90.0	11.0	32.0	64.0	16.0	32.0	64.0	16.0	32.0	64.0	16.0	32.0	45.0	11.0	22.6	59.4	11.0	32.0	63.2
12	16.0	22.6	45.0	11.0	22.6	32.0	11.0	22.6	45.0	11.0	16.0	32.0	16.0	22.6	32.0	11.0	22.6	32.0	11.0	22.6	32.0
13	16.0	32.0	83.8	11.0	22.6	90.0	16.0	32.0	90.0	16.0	45.0	90.0	16.0	32.0	64.0	16.0	32.0	64.0	16.0	32.0	64.0
14	22.6	32.0	61.6	8.0	22.6	64.0	16.0	32.0	64.0	11.0	22.6	45.0	17.6	32.0	64.0	11.0	22.6	32.0	11.0	22.6	41.9
15	16.0	45.0	128	16.0	32.0	64.0	16.0	45.0	128	11.0	22.6	32.0	11.0	22.6	45.0	11.0	22.6	39.3	11.0	22.6	45.0
16	16.0	32.0	64.0	12.2	22.6	45.0	16.0	32.0	64.0	16.0	22.6	32.0	5.6	16.0	32.0	11.0	22.6	32.0	8.0	22.6	32.0
1D	5.6	22.6	64.0	5.6	16.0	45.0	5.6	16.0	64.0	16.0	38.5	90.0	11.0	22.6	64.0	16.0	32.0	64.0	11.0	32.0	64.0
2D	8.0	22.6	45.0	11.0	22.6	45.0	11.0	22.6	45.0	na	na	na	4.4	11.0	29.7	na	na	na	4.4	11.0	29.7
5D	11.0	22.6	45.0	5.6	22.6	45.0	8.0	22.6	45.0	5.6	11.0	22.6	5.6	16.0	32.0	11.0	22.6	32.0	5.6	16.0	32.0
9D	16.0	32.0	45.0	11.0	32.0	45.0	16.0	32.0	45.0	na	na	na	16.0	32.0	45.0	na	na	na	16.0	32.0	45.0
14D	8.0	22.6	45.0	11.0	22.6	45.0	8.0	22.6	45.0	16.0	32.0	45.0	16.0	22.6	45.0	16.0	22.6	32.0	16.0	22.6	45.0
16D	12.2	27.3	41.9	11.0	22.6	32.0	11.0	22.6	32.0	11.0	22.6	32.0	11.0	16.0	32.0	8.0	16.0	32.0	8.0	16.0	32.0

Appendix D Continued. Channel Substrate Data

Maximum Sediment Size and Percent Bedrock (D = duplicate)

Site No.	Bar Max (mm)	Riffle Max (mm)	% Bedrock G+R Pebble Count	% Bedrock Rod Survey
0	151.7	165.3	0.0	9.9
1	159.0	220.7	14.4	42.6
2	142.0	184.0	0.0	1.6
3	188.5	260.0	0.0	0.0
4	100.0	149.0	36.1	56.5
5	114.9	154.2	0.0	0.0
6	122.0	111.5	17.2	36.4
7	112.0	130.0	0.0	3.6
8	107.0	248.7	36.1	33.3
9	117.5	136.7	0.0	0.0
10	89.0	275.6	12.2	3.0
11	155.3	262.7	16.7	14.2
12	152.5	274.0	41.7	53.1
13	479.2	672.0	16.1	58.1
14	125.2	193.0	0.0	17.4
15	118.3	313.7	4.4	30.5
16	98.2	297.0	0.0	6.6
1D	163.3	208.7	19.4	na
2D	153.5	136.6	0.0	8.2
5D	134.7	167.7	0.0	0.0
9D	100.0	144.7	0.0	0.0
14D	102.0	234.0	0.0	19.0
16D	91.2	147.7	0.0	0.0

Appendix E. Photo Log

Site 0 – Drainage Area = 6.4 km^2

Site 1 – Drainage Area = 16.4 km^2

Appendix E Continued. Photo Log

Site 2 – Drainage Area = 41.3 km^2

Site 3 – Drainage Area = 118.3 km^2

Appendix E Continued. Photo Log

Site 4 – Drainage Area = 242.5 km^2

Site 5 – Drainage Area = 296.4 km^2

Appendix E Continued. Photo Log

Site 6 – Drainage Area = 437.0 km^2

Site 7 – Drainage Area = 528.3 km^2

Appendix E Continued. Photo Log

Site 8 – Drainage Area = 631.8 km^2

Site 9 – Drainage Area = 666.8 km^2

Appendix E Continued. Photo Log

Site 10 – Drainage Area = 817.3 km^2
Site 11 – No photo

Site 12 – Drainage Area = 1,128.4 km^2

Appendix E Continued. Photo Log

Site 13 – Drainage Area = 1,194.8 km^2

Site 14 – Drainage Area = 1,919.3 km^2

Appendix E Continued. Photo Log

Site 15 – Drainage Area = 2081.2 km^2

Site 16 – Drainage Area = 2534.4 km^2