CHANNEL PLANFORM ANALYSIS OF THE LEAF RIVER AND TRIBUTARIES IN MISSISSIPPI: A DECADE AFTER AN IN-STREAM MINING MORATORIUM

By

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To my family for their unquestioning
support on this journey.

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In-stream mining of alluvial rivers is a readily available source of construction material. River managers of the years did not consider the ecological and physical effects that removal of alluvial material has caused. Our study examines the impact of in-stream and floodplain mining on the Leaf River, Mississippi and tributaries and determines if a decade after a mining moratorium is a sufficient amount of time to stop degradation. The Leaf River is a large tributary of the Pascagoula River with no in-stream mining but some floodplain mining. The Leaf River has five major tributaries of these three rivers were analyzed. The Bowie River has large in-stream mining pits and adjacent floodplain mining, the Bogue Homo River has no history of in-stream or floodplain mining and Thompson Creek has in-stream and flood plain mining.

Lateral migration rates and point bar areas have decreased in the intensively mined rivers suggesting some recovery in the channel system. An increase in vegetative cover on point bars are contributing to a level of stability in the mined reaches.

Stream power is a driving force of channel change in streams and rivers. The higher the stream power the more change likely to be found in the system. The Leaf River and two tributaries were analyzed. It was found that sinuosity, point bar area, erosion change indices and

average lateral migration rates of the stream channels had a correlation to specific stream power, but not all change characteristic variables were consistent for all rivers. The more disturbed streams showed a correlation to lateral migration and point bar area but not erosion change indices.

The planform change response in disturbed river systems is difficult to predict. Channel response and recovery is dependent upon the extent of human disturbance such as mining and resistance factors such as geology and vegetation.

CHAPTER 1
INTRODUCTION

River managers have been neglected the effects of in-stream mining due to poor documentation (Rinaldi et al. 2005). In-stream mining has a profound morphological impact on river systems. Sand and gravel extracted are used in construction and road building trades. Avulsions into floodplain mining pits during large floods may cause increased incision upstream and downstream of the mined areas. Lateral channel instability may cause undermining of structures such as bridges (Rinaldi et al. 2005) and are a concern to landowners and road managers. Channel migration can compromise the integrity of structures built in floodplains. In some instances large riprap structures must be built to prevent channel migration (Figure 2-20). The impacts of actively changing rivers increase susceptibility due to flooding do to a lack of natural levee formation (Charlton 2008).

Stream power is a geomorphic driving force of channel change in alluvial rivers. Streams are classified into low, medium and high energy by their characteristics (Nanson and Croke 1992). Stream power is dependent upon the slope and width of the reach being analyzed (Reinfelds et al. 2003). According to Brookes (1988), a river system maintains stability with a stream power at a particular threshold therefore minimizing lateral migration and downstream migration (Knighton 1998) and seeking equilibrium or a state of balance within a system (Charlton 2008).

Stream characteristics analyzed include channel sinuosity, point bar area, channel change over two time periods, average lateral migration and average width. Sinuosity ratio gives an indication of how much bend is in a channel planform. Channels with a sinuosity ration between of less than 1.1 are defined as straight, 1.1 and 1.5 are sinuous and channels with a ratio over 1.5 are meandering (Charlton 2008). Point bars are sand bars usually located at the inside curve of a channel bendway. Change indices indicate the percent a channel has changed or stayed the same when comparing two time periods. Average lateral migration is defined as the amount the channel centerline moved per year. Average channel width describes the mean width of a channel.

These characteristics are important because they are in indication of the health of a stream system physically and ecologically. According to Simon and Downs (1995) increasing stresses being placed on alluvial channel systems through continued encroachment of urban areas and transportation systems, identifies a need for assessment of channel conditions and the relative sensitivity of channels to disturbance or altered environmental conditions. Stream with excessive sediment can produce large sandbars in low stream power areas causing the sediment load to settle filling channels and resulting in an increase in stream bed elevation. The change in bed elevation makes the floodplain more susceptible to flooding and catastrophic land cover change. If the centerline of a channel changes abruptly, this is an indication of lateral migration of the channel may cause loss of adjacent land to landowners.

Excessive sediment is also a cause of imperilment of spawning areas in streams. Large increases in sediment loads in streams can create substrate composition detrimental to fish spawning and rearing habitats (Platts et al. 1989). Mitigation of suspended sediments is an important management action for the conservation of fishes that spawn in benthic habitats (Burkhead and Jelks 2001).

Gravel mining is a major industry in Mississippi. The Pascagoula River, MS and tributaries is one of a few basins in southeast United States with no major flow control devices such as dams and diversions (Dynesius and Nilsson 1994), but anthropogenic activity such as mining, has had a diverse impact on the basin. The Leaf River combines with the Chickasawhay River to form the Pascagoula River at Merrill, MS (Figure 2-1). The Leaf River has five major tributaries that contribute to the drainage area. Mining has occurred in the Leaf River basin since the early 1900s but was expanded greatly in the 1980s (Mossa et al. 2007).

In 1995, the State of Mississippi changed the law concerning in-stream mining. The law prevented further in-stream mining, but still allowed floodplain mining (Mississippi State Legislature 1995).

Previous studies in the basin examined channel changes from the mid-1950s to the mid-1990s (Mossa et al. 2007). Our study examined the impact of mining on the planform on a major river system within the Pascagoula River basin after a decade of mining moratorium, analyzing channel characteristics and specific stream power to determine if the streams have become stabilized into equilibrium after ten years of no in-stream mining in the basin or are the rivers continuing to change.

Of the five tributaries of the Leaf River, our study examined changes that occurred from the mid-1990s to 2005 within the Leaf River, Bowie River, Bogue Homo River and Thompson Creek. All rivers were compared to historic channel characteristics and the Leaf River and two tributaries were examined to determine if stream power played a role in observed channel characteristics. Chapter 2 analyzes stream characteristics such as channel sinuosity, point bar area, channel change indices, average lateral migration rate and average channel width between the mid-1990s and 2005. Chapter 3 examines if there is a correlation between specific stream power and the defined channel characteristics. The goal was to determine if sufficient time has elapsed to facilitate stream recovery after a ten-year moratorium on in-stream mining.

CHAPTER 2
ANALYSIS OF CHANNEL PLANFORM CHANGE ON THE LEAF RIVER, MISSISSIPPI AND THREE TRIBUTARIES

Introduction

In a previous study concerning channel changes in the Pascagoula River basin, one of the findings was that major channel planform changes occurred in reaches affected by floodplain and in-stream mining (Mossa et al. 2007) from the mid 1950s to mid 1990s. In 1995, a Mississippi law (Mississippi State Legislature) prohibited in-stream mining, but continued to allow floodplain mining. The rationale for studying human induced impacts on river system include concern over future environmental changes, institutional needs and a desire to restore natural functionality to stream along with defining the destructive role of humans on nature (James and Marcus 2006).

Planform changes in the river system examined are sinuosity change, point bar area change, change indices, average lateral migration rate and average channel width change. Sinuosity of a river is defined as the ratio of channel to valley length (Schumm 1977). Point bar area is the size of the dry point bars and is variable by the water level in the river. Change indices are scale-independent ratios that compare channel planform changes along and between rivers (Mossa 2006). Average lateral migration is the migration rate of the stream centerline per year. Average channel width was determined by centerline length of the stream and the wetted area of the stream. Each of the planform changes was plotted by an average reach block length of 2km for the Leaf River and a 1km reach block for the Bowie River, Bogue Homo River and Thompson Creek.

Reach blocks were created every 1km or 2km extending across the floodplain encapsulating the probable width that the channel may migrate over the period being evaluated. The reach blocks used in our study were the same as the previous study by Mossa et al. (2007).

Geographic Information Systems (GIS) allows for remote analysis of the stream system which in the past would have required much field work to evaluate the study area and a large amount of time and money to complete the task of analyzing an entire drainage basin. The use of aerial imagery that has been remotely sensed over multiple time periods is an invaluable tool in assessing channel planform.

This chapter will examine the stream characteristics for the Leaf River, a major tributary of the Pascagoula River, and three of the Leaf River's tributaries from 2005 imagery and compare them to data from the previous study by Mossa et al. (2007). The purpose of our study is to determine if rivers examined have become less unstable seeking equilibrium where the amount of sediment eroded and deposited are equal after a ten year moratorium on in-stream mining.

Study Area

The Pascagoula River basin is located in southeast United States in the state of Mississippi (Figure 2-1). The Leaf River combines with the Chickasawhay River to form the Pascagoula River. The Leaf River has a drainage area of 9280 km^2 (3580 mi^2) and is free of in-stream mining with some floodplain mining occurring adjacent to the river channel south of the City of Petal, MS. Three tributaries analyzed are as follows: the Bogue Homo River, a natural flowing river with no record of mining; the Bowie River, an extensively mined river with large in-stream and floodplain pits; and Thompson Creek, a small tributary with a history of in-stream and floodplain mining.

Literature Review

Geographic Information Systems (GIS) in river channel change analysis has been used since the early advent of the software, allowing for the creation of temporal and spatial data in river floodplain studies (Oetter et al. 2004). The current technology allows for the use of varied methodologies in detecting change in river systems utilizing oblique digital imagery (Chander et al. 2002; Gilvear et al. 2000), multi-spectral imagery (Winterbottom and Gilvear 1997; Gilvear et al. 2004), aerial photography (Gurnell 1997) digital color aerial photography (Gilvear et al. 2004) and scanned historic maps (Winterbottom 2000; Marston et al. 2003; Oetter et al. 2004, Mossa et al., 2007) over multiple years. Some techniques utilized classified and unclassified remotely sensed raster data (Gilvear et al. 2004), and vector data (Mossa and McLean 1997; Wellmeyer et al. 2005) to detect planform change (Gurnell 1997; Mossa 2006; Winterbottom 2000) and lateral migration rates (Wellmeyer et al. 2005).

In addition to GIS, channel change has also been detected using topographic surveys and channel profiles from the 19th century to present day (Rinaldi and Simon 1998; VanLooy and Martin 2005). Other methods used to identify channel change over the last 100 years include sedimentation analysis, botanical, historical sources, planimetric resurvey, cross-profiling and erosion pins (Lawer 1993).

Channel change in rivers is defined by various authors as either caused by hydrology or sedimentation (Gregory 2006). Lateral migration of some channels is defined as expected channel change where the channel is translated downstream (Winterbottom 2000). Channel width is dependent upon if the river system is aggrading or degrading and incising (Winterbottom 2000). Sediment derived from incision is stored in point bars, terraces, deltas and floodplains playing a role in creating downstream features and physical and aquatic impacts (Simon and Rinaldi 2006).

Alluvial rivers are an attractive source of readily available sand and gravel for road building and construction in many areas of the United States. Mining in the rivers or on the floodplain can cause considerable disturbance in the channel morphology (Kondolf 1997) and biology (Meador and Layher 1998; Brown et al. 1998) caused by excess sedimentation upstream and downstream (Simon and Rinaldi 2006). In-stream mining has also caused lowering of the stream bed resulting in ecological consequences to the alluvial plain downstream (Petit et al. 1996), movement of mining pits (Lee et al. 1993), movement in sand gravel transition zones (Knighton 1999) and migration of nick points upstream (Marston et al. 2003). With the regrowth of vegetation on the stream banks (Knox 2004) and sedimentation rates decreasing due to re-forestation, channel stability may occur after several decades with no stream restrictions such as bridges therefore controlling force levels in disturbed streams (Graf 1979).

Methods

The imagery used in this research was the United States Department of Agriculture - Farm Services Agency (USDA-FSA) NAIP 2005 county mosaic image files of Pascagoula River basin and its tributaries. The imagery was downloaded from the Mississippi Automated Resource Information System (MARIS) website. The NAIP imagery product has a ground sampling distance of 2 meters and was ortho rectified to digital ortho quarter quads (DOQQ) with an accuracy of +/- 10 meters. The data and imagery were projected using the Mississippi Transverse Mercator (MSTM) Projection which is a customized Transverse Mercator projection created by MARIS Technical Center (MTC) and the Mississippi Department of Transportation (MDOT) and based on the North American Datum of 1983 (NAD83) (MARIS 2007).

Fly dates for the imagery varied from July 7, 2005 to November 11, 2005 (Figure 2-2). Depending upon the basin, the imagery mosaic was digitized with generally low flows or slightly above measured at Hattiesburg, MS (Figure 2-3) and McLain, MS (Figure 2-4) or if the imagery overlapped, the low flow images were used.

The imagery was then put into a Geographic Information System (GIS) using ESRI ArcGIS Editor Version 9.2 using the MSTM projection and NAD83 datum. The imagery was then digitized at 1:2000 scale. For each feature type, a separate shapefile was created (Table 2-1) and attributes for each shapefile were standardized (Table 2-2). A new polygon or polyline was created at each new quadrangle or river junction, creating multiple features for each river in the shapefile. After the main channel, channel bars and vegetated channel bars were digitized; the channel bars and vegetated channel bars were cut out from the main channels creating holes in the original polygon where the channel bar features were located. The whole basin was checked for topology using the topology feature in ArcGIS and any errors were corrected. The topology rules utilized are detailed in Table 2-3.

Our study builds on a previous geomorphic assessment of the Pascagoula River basin. Imagery and GIS data from the previous project (Mossa et al. 2007) was utilized for the earlier years of the 1950s and 1990s. Imagery fly dates varied for 1950s data from May 2, 1955 to October 23, 1960 and the 1990s data from February 8, 1992 to January 11, 1997 for the rivers analyzed (Figures 2-2 & 2-3). The majority of the imagery in the study area was from 1996 except for the lower 2 km of the Leaf River at the Chicksawhay River confluence which was from 1992.

The same methodology was followed for this research as was previous done (Mossa et al. 2007). Dr. Joann Mossa provided the geodatabase of the 1950s and 1990s data used for our analysis, University of Florida Department of Geography dated March 27, 2006. Table 2-4 details the data utilized from the previous project. The shapefile database files (.dbf) were saved as Microsoft Excel (.xls) files before manipulation, otherwise the shapefiles would have become corrupt and unusable.

Sinuosity

To determine the river sinuosity, the valley length from the previous study dataset and 2005 center line shapefiles were overlaid with the river reach polygons using the intersect function in ArcGIS to create valley length by reach and 2005 centerline by reach. The line lengths for both intersected files were then calculated using the software Data East LLC Xtools Pro 4.2.0 (Novosibirsk, Russia). The two shapefile databases were then opened in Microsoft Excel to create the sinuosity index by river reach.

$$P = Lc / Lv$$

Where P is the sinuosity index by reach, Lc is the river centerline length and Lv is the valley length by reach. The file was then sorted by reach number and the sinuosity indices were graphed in Microsoft Excel for past and present time periods.

Point Bar Area

To calculate the point bar area, Xtools Pro was used to calculate the area of the point bars in ArcGIS. The shapefile was then intersected with the river reach shapefile to create a point bar by reach shapefile. The database was then opened in Excel and the areas of the polygons were summed by reach block and graphed.

Change Indices

The change indices were created in ArcGIS using the union function by overlaying the main channel polygon shapefiles for 2005 (T2) and 1990s (T1); and for the second union 2005 (T2) and 1950s (T0) for each river analyzed (Figure 2-5) (Mossa and McLean 1997). When the union is completed topology is run again using the “must not have gaps (area)” rule to create the polygons between the other polygons. The resulting polygons were then attributed (Table 2-5). The data were opened in Microsoft Excel sorted by reach and the areas were summed by reach. Ratios were created for each reach with the initial area being defined as I = D + U (Table 2-6). The data were sorted again by indices and graphed.

Average Lateral Migration

Average lateral migration was measured and graphed for each river by time periods using the centerline shapefiles for 2005 (T2), 1990s (T1) and 1950s (T0). To calculate lateral migration, ArcGIS Spatial Analyst tools were used. For specific instructions see Appendix A.

Average Channel Width

The mean width channel is calculated by using the area of the river polygon and dividing by the centerline length. $Wa = Ar / Lr$ where Wa is average width of the channel by reach Ar is the area of the channel by reach and Lr is the centerline length of the channel by reach. In ArcGIS, the river of interest is selected in the main channel polygon shapefile and exported to a new shapefile. The intersect tool is used with the reach polygon shapefile to create a new shapefile (i.e.: BHmainchnl2005RID) and Xtools Pro is run to calculate the polygon area. Using the centerline by river reach shapefile (i.e.: BHcntlineRID) created in the sinuosity measurement and Xtools Pro is used to calculate the line length. Both files are opened in Excel, sorting each file by reach and summing the polygons area and centerline length. Then the centerline area field is divided by the centerline length field to get the average width by reach, repeating for each river and time step and graphing the results.

Statistical Analysis

Statistical analysis was performed on the stream characteristic sinuosity, point bar area, channel change indices, average lateral migration and average width using SPSS software to determine if first the characteristics are distributed normally and second to determine if the two temporal samples are the same. The non-parametric Kolmogorov-Smirnov test for normality was used because it makes no assumption of normality. Shapiro-Wilk test of normality was also used to assess how well the observed frequency distribution fits the expected cumulative frequency curve and if the data is normally distributed. The non-parametric Wilcoxon Signed Rank test was used to compare the stream planform characteristics for the two time periods because the samples tested are related.

Results

Sinuosity

Sinuosity for the four rivers was analyzed for the decade from mid-1990s to 2005. Data from the previous study was utilized for this analysis for the mid-1950s to mid-1990s (Tables 2-6 to 2-9) (Mossa et al. 2007). Examination of the plotted graph showed river sinuosity for 2005 deferred very little from the 1990s data.

The upper Leaf (Figure 2-6) at kilometer 22 did show reduced sinuosity from 1996 due to a recent meander cutoff identified in the aerial photographs. The middle Leaf River (Reach 41 to 57) and lower Leaf River (Reach 58 to 82) showed no notable changes from the mid-1990s.

The Bowie River (Figure 2-7) at kilometer reach 1 to 2 also shows a decrease in sinuosity from 2.5 to 1.8 and was caused by a change in the confluence of Bouie Creek, Okatoma Creek which forms the Bowie River. The large pit areas of the Bowie River did not show notable changes when compared to the 1990s graph.

The Bogue Homo River (Figure 2-9) sinuosity analysis indicated no changes when compared to 1996 and very little when compared to 1950s.

Thompson Creek (Figure 2-8) at reach 6 of within a mining pond sinuosity increased slightly from 2.0 to 2.1 and a slight decrease at reach 10 from 1.9 in 1990s to 1.75 in 2005. The lower reach of Thompson Creek (Reach 12 to16) showed a slight increase in the intensively mined areas when compared to 1996.

Point Bar Area

Since point bar area is affected by discharge level a similar stream gauge level would be necessary for the basin. The 2005 fly dates for the analyzed rivers were two days apart and the discharges (Table 2-18) were generally similar throughout the basin for the available imagery except for the upper reaches of the Bogue Homo River. Point bar area by reach and cumulative point bar area for all four rivers was plotted.

Leaf River point bars area (Figure 2-13) appear to be stable upstream of the confluence of the Bowie River (km 94), but downstream of the confluence (km 98 to 112) point bar area has increased by 88% between the years 1996 and 2005. The Leaf River showed an increasing area trend downstream of the Bowie River confluence starting at km 106 in comparison to previous time periods (Figure 2-14).

Point bar area was reduced in the mined reaches (km 11 to 15) of the Bowie River by 50% (Figure 2-10) due to infilling and vegetation of the mining pit banks, but increased 41% upstream of the mining reach (km 7 to 11). The Bowie River (Figure 2-16) showed a decreasing trend in point bar area at km 12 and an increase at km 9 to 11.

The Bogue Homo River point bar area (Figure 2-11) increased by an average of 47% from km 10 to 29 and may be due to exposure of the 1996 submerged point bars. A large increase of point bar area (km 7 to 10) may be a result of very recent deforestation of land adjacent to the Snake Creek tributary. The Bogue Homo River point bar (Figure 2-15) area was higher for the entire river but had a similar trend when compared to 1996 and 1958.

Thompson Creek point bar area (Figure 2-12) has decreased by 67% in the mined area due to infilling and vegetation of the mined pits (km 12 to 16). Thompson Creek (Figure 2-17) charts showed a decreasing trend in point bar area at km 13 although the values were considerably higher than in the 1950s.

Change Ratios

Scale independent change ratios have been used to determine stability of a river (Mossa and McLean 1997; Mossa et al. 2007). When short time periods are examined, the B/I ratio is typically zero, unless there are meander cutoffs, avulsions or very rapid lateral migration. U/I shows the proportion of the river unchanged or in its initial boundary, D/I shows what proportion is deposited from earlier time period, and E/I show the proportion of the initial channel that was eroded (Figure 2-5) (Mossa and McLean 1997).

The Leaf River change indices graph comparing 1996 to 2005 (Figure 2-18) indicates the area upstream of the Bowie River confluence has a steady and similar ratio of E/I and D/I with an average around 20% of the channel undergoing change with 80% in the same position. At kilometer 93 just upstream of the confluence (Figure 2-19), the percentage of change is about 50% of the unchanged, erosion and deposition indices that are unseen in the rest of the river. Downstream of the Bowie River confluence U/I index rises to 0.85 and then dips to 0.45 at kilometer 98 that is near the man-made sewage treatment pond (Figure 2-20) and then continues to rise to an average of 0.75. The sewage treatment plant has a manmade rock rip rap revetment to prevent capture by the Leaf River and to reduce lateral migration in that area. Concurrently D/I lowers to 0.35 to 0.20 and E/I lowers to an average of 0.10. At the confluence of the Chickasawhay and Pascagoula rivers the indices spike again. B/I for the entire river stayed between 0 and 0.10, with large values associated mostly with zones of rapid migration.

Bowie River (Figure 2-23) indices comparing 1996 to 2005 generally are level with U/I starting at 0.70 and rising to over 0.90, D/I reducing from 0.30 to 0.15, E/I lowering from 0.30 to near 0 and B/I at 0 except for the mined reach at kilometer 13 rising to 0.10. This is much lower than the values of cited in Mossa et al. (2007) over the time period of active in-stream mining but indicate little change in the in-stream pit areas from the mid-1990s to 2005.

When comparing change indices between the years 1996 to 2005, the Bogue Homo River (Figure 2-21) B/I ratio is at or close to 0, U/I indices had an average of 0.60, D/I averages 0.40 and E/I goes from 0.0 to 0.40. The highest erosion ratios occur near the confluence of Tiger Creek (Figure 2-22) and may be caused by land cover changes due to clearing of a forested area. Just upstream of the confluence of the Leaf River at reach 29 U/I rises to 0.85, D/I dips to 0.15, B/I is 0.0 and E/I becomes 0.10.

Thompson Creek change indices graph comparing 1996 to 2005 (Figure 2-24) starting at kilometer 4, U/I averages only 0.45 with D/I averaging 0.55. This suggests only 45% of the channel is where it was before, with some reduction due to lower water levels and migration and re-vegetation of point bars. E/I is near 0.20 and then rises to over 0.50 just upstream of second mining reach and lowers to below 0.10 and again rises near the confluence of the Leaf River.

Average Lateral Migration

Leaf River lateral migration rates (Figure 2-28) for the upper Leaf is on average 0.50 m/yr for 1996 to 2005, generally the same or slightly higher than previous through reach block 40. The area just upstream of the Bowie River confluence changes from 0.5 to 2.25 m/yr which is lower than the previous time period (up to 3.1 m/yr), but downstream of the juncture migration rates increase to 2 to 3.5 m/yr and are higher than the previous time period, which has maxima of about 2 m/yr. After the Thompson Creek confluence, the migration rates are the same as the previous time period. Just upstream of the Pascagoula River confluence, the rate rises dramatically to 7 m/yr for 1996 to 2005 from just less than 2 m/yr for 1982 to 1996, indicating a shift in the juncture with the Chickasawhay River.

Average lateral migration rates per year for the Bowie River (Figure 2.25) are generally the same for 1996 to 2005 as the previous time period (1982 to 1996) averaging 1.5 meters per year. For the upper 11 km examined near km 12 which is before the Glendale Bridge the rate jumps to

3.5 m/yr compared to the previous time period and then slowly returns to 1 meter at the confluence of the Leaf River.

The Bogue Homo River lateral migration rates (Figure 2-26) have increased from an average of 0.5 m/yr in 1982-1996 to an average of 1.25 m/yr for 1996-2005.

Thompson Creek lateral migration (Figure 2-27) is only slightly higher in the mined area (around 1 m/yr) than the previous time period (0.5 m/yr) for the upper 13 km, it stabilizes to an average of 0.75 m/yr. This reach has become more stable, such that migration rates have dropped from 3 meters per year to 1.2 m/yr.

Average Channel Width

Leaf River average channel width (Figure 2-32) upstream of the Bowie River confluence stayed the same as in 1996. The lower Leaf River average width has decreased from 100 to approximately 60 meters due to incision, lower water levels or a combination.

Average channel widths for the Bowie River (Figure 2-29) and Bogue Homo River (Figure 2-30) have not generally changed from 1996 to 2005. Thompson Creek average channel width (Figure 2-31) has decreased overall but especially in the mined reach of km 13 to 18.

Statistical Analysis

Characteristics of the Leaf River, Bowie River, Bogue Homo River, and Thompson Creek were analyzed to determine if there was statistical evidence of change. Sinuosity, point bar area, channel change indices, average lateral migration and average channel width were first tested for normality using SPSS version 15 and then tested for significance at the 95th percentile. The tests performed were Kolmogorov-Smirnov and Shapiro-Wilk for normality and Wilcoxon Signed Rank for significance. The results of the normality test and significance can be found in Tables 2-7 to 2-16. Because the test for significance determined some of the characteristics that were to be compared were not normal and the size of the population was small, a t-test could not be performed. A Wilcoxon Signed Rank test was chosen for all characteristics.

The hypothesis is as follows:
H0: two samples are the same
HA: two samples not the same

Sinuosity for the Bowie River and Thompson Creek failed to reject the null hypothesis while the Bogue Homo and Leaf Rivers were statistically different (Table 2-14). The Bowie River and Thompson Creek point bar areas were not statistically different and failed to reject the null hypothesis. The Bogue Homo River and all reaches of the Leaf River show statistically different point bar areas. (Table 2-12).

The change indices analysis (Table 2-16) for the Leaf River was broken up into three areas to see if they were significantly different from previous years; upper reaches (7 to 40), middle reaches (41 to 57) and lower reaches (58 to 82). These reaches were chosen because initial analysis indicated all of reaches were significantly different (Table 2-17) when the point bar area was analyzed. When the reaches were analyzed, the upper reaches failed to reject the null hypothesis for erosion, but was rejected for the between, unchanged and deposition change indices; middle reaches rejected the between and erosion change indices and failed to reject the unchanged and deposition change indices; lower reaches failed to reject the between change indices and rejected for unchanged, erosion and deposition change indices. Bowie River and Bogue Homo River (Table 2-16) showed statistically significant differences for all of the change indices. The null hypothesis was rejected for between and erosive change indices and failed to reject for unchanged and deposition change indices on Thompson Creek.

Average lateral migration only showed that the Bowie River as not statistically different from the previous time period. In comparison the Leaf River, Bogue Homo River and Thompson Creek were statistically different and rejects the null hypothesis (Table 2-10).

Average channel width and point bar area are also stage dependent so water levels in the rivers could account for some of the changes detected. Average channel width statistical analysis identified all of the rivers as being statistically different sizes between the years 1996 to 2005 (Table 2.8).

Discussion

The use of GIS technologies and aerial photography is invaluable in the research of channel change. The use of high resolution imagery is preferable when compared to maps and low resolution imagery. The detection of small channel features such as point bars and in-stream bars is easily accomplished.

Leaf River

The Leaf River continues to indicate change upstream and downstream of the confluence of the Bowie River. The change indices indicate straightening of the channel upstream of the confluence (Figure 2-19) and continued lateral migration downstream even though measures are in place to prevent migration through the use of rip-rap along the banks of the Hattiesburg sewage plant (Figure 2-20). The channel also appears to be narrowing downstream when compared to upstream of the confluence from the previous study (Mossa et al. 2007). Point bar area is also increasing downstream of the confluence compared to the previous study (Mossa et al. 2007).

Wilcoxon signed-rank test is a non-parametric test for two related samples compares the differences between measurements measured at an interval level. Utilizing this test the statistical analysis of the Leaf River indicates the point bar area and change indices indicate that the Leaf River for the lower reaches (58 to 82) show statistically significant change is still occurring, while the middle reaches (41 to 57) indicates erosion is still occurring and the between area is also significantly different supporting the conclusion of straightening in the middle reaches.

Bowie River

The Bowie River is an extensively mined tributary (Figure 2-33) of the Leaf River. Sediment from upstream is filling in portions of the mined pits and vegetation is stabilizing the visible point bars as indicated by the decrease in point bar area in the mined reaches and increase in channel bars. During flood conditions, the floodplain mining areas are very susceptible to capture (Kondolf 1997) causing diversion of the river. The change indices for the Bowie River also indicate stability in the mined areas but decreased stability directly upstream of the mined areas at 8 kilometers (Kondolf 1993). The lateral migration characteristic indicates continued stability upstream of the mined reaches and shifting of the main channel in the mined reaches as compared to the previous study (Mossa et al. 2007). Average width is decreasing indicating some incision occurring upstream of the mined areas or decreased flows. The mined areas of the river could also be susceptible to pit migration (Lee et al. 1993).

Wilcoxon signed-rank statistical analysis of the Bowie River indicates lateral migration was not statistically significantly different for the two change periods analyzed, but this may be due to geologic controls caused by the size of the mined area and exposed bedrock. Point bars area shows the area not significantly different from the 1990's but the change indices showed a significant difference for all change indices.

Observations in the field show the in-stream mining pits may be acting as a reservoir upstream of the Glendale bridge area (Figure 2-33) allowing for the settling of sediment in the water column and resulting in infilling and vegetative encroachment on the spoil piles.

Bogue Homo River

The Bogue Homo River is a natural flowing tributary of the Leaf River with no history of mining. According to Rosson (2001), 81-100% of the land area in Perry County occupied by the Bogue Homo River is in timberland, of which about 40% of land is owned by timber companies.

However land use records of the early 1900s to 1930s indicated intensive timber harvesting activity (Mossa et al. 2007). The Bogue Homo River change indices with deposition highs of 0.45 and erosion low below 0.10 and lateral migration at a higher rate than the previous study appears to be straightening in place when compared to the previous study (Mossa et al. 2007). But with the historical background of major landuse change, the river could still be considered a disturbed river due to excess sediment caused by clear cutting of forest for timber harvest (Simon and Downs, 1995) and continued use of the surrounding landscape for forest products (Howe 2001). Point bar areas has generally stayed the same or decreased slightly except at the confluence of Tiger Creek, where point bar area has changed from 10,000 m^2 to 25,000 m^2 (Figure 2-11). This may indicate a disturbance on Tiger Creek due to land cover changes (Figure 2-22).

Wilcoxon signed-rank statistical analysis of the Bogue Homo River showed statistically significant changes in point bar area sinuosity and change indices. A further visual analysis of aerial photographs from 2005 indicates land cover changes from forest to cleared and replanted forest occurring in the area of Tiger Creek (Figure 2-22) which may be causing the indicated changes.

Thompson Creek

Thompson Creek is a small mined tributary of the Leaf River. As with the Bowie River, Thompson Creek shows increased stability in the mined reach areas with decreases in point bar area caused by increased vegetation but also indicates shifting of the channel due to sediment deposition (Kondolf 1993) which is confirmed by only 40% of the channel being in the same location and 60% of the 1990’s channel changed to land in 2005. Lateral migration has also decreased in the mined reaches but increased directly upstream (Figure 2-34) and downstream (Figure 2-35) of the mined areas as compared to previous studies (Mossa et al. 2007). Channel width has decreased overall in the basin, due to lower water levels and possible incision. The mining pits in the floodplain are highly susceptible to capture or avulsion in a flood event (Kondolf 1997) due to their proximity to the main channel and the inter-pit channels that exist on the floodplain (Figure 2-34).

Statistical analysis of Thompson Creek shows point bar area and sinuosity as being not significantly different from the previous year analyzed indicating some stability, while the change indices show no significance in the deposition and unchanged indices. Lateral migration is still occurring which may be due to avulsions into the mining ponds to some degree.

Summary and Conclusions

The use of GIS allowed for analysis of large areas of a stream basin that would not have been possible with the time money constraints allotted in our study. The use of the previous studies data was invaluable in determining how much change occurred in the studied streams from time period to time period.

As identified in a previous study (Mossa et al. 2007) the Leaf River channel continues to change and may be affected by changes occurring on its tributaries. The addition of rip-rap is stabilizing migration of the Leaf River channel downstream of the Bowie River confluence but is only a temporary measure to prevent migration. Areas of the Leaf River above the confluence of the Bowie appear to be straightening.

Infilling of mining ponds on the Bowie River appears to be continuing and causing the flow of upstream sediment not to be passed into the Leaf River. Vegetation is encroaching on the spoil piles adjacent to the in-stream pits aiding with the stabilization of piles.

As determined by the average lateral migration rate, the Bogue Homo River is migrating downstream but is within normal range of changes (Winterbottom 2000). Changes associated with disturbance are indicated in the area of Tiger Creek due to possible land cover changes.

Thompson Creek in-stream mining pits are infilling causing shifts in channel location. Adjacent floodplain pits are susceptible to capture with large flood events.

Stream recovery from human disturbance such as in-stream mining is unpredictable. Dependent upon the extent of disturbance the possibility of stability is not realistic for a large disturbed basin within a short time frame. Further studies in the future may be able to determine the length of recovery from human impacts of in-stream mining. These changes identified indicate a river system that is continuing to adjust to disturbance during the last century, including in-stream and floodplain mining.

Table 2-1. Shapefile names

Shapefile name	Type
Channel_bars2005	polygon
Channel_bars_veg2005	polygon
Cntlines2005	polyline
Main_channels05	polygon
Meander_islands2005	polygon
Point_bars2005	polygon
Secondary_channels2005	polygon

Table 2-2. Shapefile attributes

Attribute	Type/length
RIVER	Text/25
UPDATED	date
TECH	Text/2
FEATURE	Text/25
QUAD_NUM	Text/25
QUAD	Text/25
YEAR_	Short integer

Table 2-3. Topology rules

Feature	Rule	Feature Class
Mainchannels_05	Must Not Overlap	
Secondary_channels2005	Must Not Overlap with	Mainchannels_05
Point_bars2005	Must Not Overlap with	Mainchannels_05
Point_bars2005	Must Not Overlap with	Secondary_channels2005
Mainchannels_05	Must Not Overlap with	Secondary_channels2005
Mainchannels_05	Must Not Overlap with	Point_bars2005
Meander_islands2005	Must Not Overlap with	Mainchannels_05
Meander_islands2005	Must Not Overlap with	Secondary_channels2005

Table 2-4. Pascagoula project geodatabase data utilized

Feature Dataset	Feature Class	Year	Type	Notes
ValleyLength	ValleyLengths		polyline	Digitized from 1980's DRGs
Strms90s	Main_channels90s	1990s	polygon	
Strms90s	Secondary_channels90s	1990s	polygon	
Strms90s	Point_bars90s	1990s	polygon	
Strms90s	Channel_bars90s	1990s	polygon	
Strms90s	Channel_bars_veg90s	1990s	polygon	
Strms90s	Meander_islands90's	1990s	polygon	
Strms90s	Cntlines90s	1990s	polyline	
ReachPolygons	LeafRiverRIDs		polygon	Digitized from 1980's DRGs
ReachPolygons	BogueHomaRIDs		polygon	Digitized from 1980's DRGs
ReachPolygons	BowieRiverRIDs		polygon	Digitized from 1980's DRGs
ReachPolygons	ThompsonCrRIDs		polygon	Digitized from 1980's DRGs
Strms50s	Main_channels50s	1950s	polygon	
Strms50s	Secondary_channels50s	1950s	polygon	
Strms50s	Point_bars50s	1950s	polygon	
Strms50s	Channel_bars50s	1950s	polygon	
Strms50s	Channel_bars_veg50s	1950s	polygon	
Strms50s	Meander_islands50's	1950s	polygon	
Strms50s	Cntlines50s	1950s	polyline	

Table 2-5. Attributes for main channel unions

Index	T0	T1
E	1996	0
D	0	2005
B	0	0
U	1996	2005

Table 2-6. Proportional area change ratios (Mossa and McLean 1997)

Indices	Description	Comment
U/I	Ratio of U to I	Shows proportion of initial channel area in same position
D/I	Ratio of D to I	Shows proportion of initial channel area abandoned
E/I	Ratio of E to I	Shows proportion of initial channel area eroded or created
B/I	Ratio of B to I	Shows proportion of initial channel area between channels
I	D + U	Initial area

Table 2-7. Average channel width test of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Leaf Avg Width 2005	0.150	10	0.200*	0.973	10	0.918
Leaf Avg Width1996	0.206	10	0.200*	0.858	10	0.073
Bowie Avg Width 2005	0.256	10	0.061	0.827	10	0.030
Bowie Avg Width 1996	0.278	10	0.028	0.810	10	0.019
Thompson Avg Width 2005	0.235	10	0.126	0.877	10	0.120
Thompson Avg Width 1996	0.214	10	0.200*	0.936	10	0.507
Bogue Homo Avg Width 2005	0.167	10	0.200*	0.897	10	0.202
Bogue Homo Avg Width 1996	0.204	10	0.200*	0.891	10	0.176

*This is a lower bound if the true significance
[a]Lilliefors Significance Correction

Table 2-8. Average channel width Wilcoxon Signed Rank Test statistics

	Leaf Avg Width 1996 & 2005	Bowie Avg Width 1996 & 2005	Thompson Avg Width 1996 & 2005	Bogue Homo Avg Width 1996 & 2005
Z	-6.146[a]	-3.464[a]	-3.823[a]	-2.685[a]
Asymp. Sig. (2-tailed)	0.000	0.001	0.000	0.007

[a]Based on negative ranks.

Table 2-9. Average lateral migration tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Leaf Avg Lat Mig 96-05	0.246	15	0.015	0.777	15	0.002
Leaf Avg Lat Mig 82-96	0.193	15	0.137	0.837	15	0.011
Bowie Avg Lat Mig 96-05	0.343	15	0.000	0.669	15	0.000
Bowie Avg Lat Mig 82-96	0.254	15	0.010	0.672	15	0.000
Thompson Avg Lat Mig 96-05	0.253	15	0.011	0.742	15	0.001
Thompson Avg Lat Mig 82-96	0.265	15	0.006	0.630	15	0.000
Bogue Homo Avg Lat Mig 96-05	0.124	15	0.200*	0.963	15	0.738
Bogue Homo Avg Lat Mig 82-96	0.158	15	0.200*	0.943	15	0.416

*This is a lower bound if the true significance
[a]Lilliefors Significance Correction

Table 2-10. Average lateral migration Wilcoxon Signed Rank Test statistics

	Leaf Avg Lat Mig 82-96 & Leaf Avg Lat Mig 96-05	Bowie Avg Lat Mig 82-96 & Bowie Avg Lat Mig 96-05	Thompson Avg Lat Mig 82-96 & Thompson Avg Lat Mig 96-05	Bogue Homo Avg Lat Mig 82-96 & Bogue Homo Avg Lat Mig 96-05
Z	-4.634_a	-0.155_a	-2.495_a	-4.268_a
Asymp. Sig. (2-tailed)	0.000	0.877	0.013	0.000

$_a$ Based on negative ranks.

Table 2-11. Point bar area Tests of normality

	Kolmogorov-Smirnov$_a$			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Leaf Pt Bars 96 Reach 1-40	0.246	16	0.011	0.845	16	0.011
Leaf Pt Bars 05 Reach 1-40	0.171	16	0.200*	0.869	16	0.026
Leaf Pt Bars 96 Reach 41-57	0.190	16	0.127	0.906	16	0.100
Leaf Pt Bars 05 Reach 41-57	0.181	16	0.169	0.942	16	0.375
Leaf Pt Bars 96 Reach 58-82	0.122	16	0.200*	0.925	16	0.203
Leaf Pt Bars 05 Reach 58-82	0.194	16	0.109	0.961	16	0.680
Bowie Point Bars 1996	0.219	16	0.038	0.776	16	0.001
Bowie Point Bars 2005	0.155	16	0.200*	0.936	16	0.302
Thompson Point Bars 1996	0.299	16	0.000	0.636	16	0.000
Thompson Point Bars 2005	0.218	16	0.040	0.833	16	0.008
Bogue Homo Point Bars 1996	0.347	16	0.000	0.599	16	0.000
Bogue Homo Point Bars 2005	0.266	16	0.004	0.691	16	0.000

* This is a lower bound if the true significance

$_a$ Lilliefors Significance Correction

Table 2-12. Point bar area Wilcoxon Signed Rank Test statistics

	Leaf Pt Bars Reach 1-40 2005 &1996	Leaf Pt Bars Reach 41-57 2005 &1996	Leaf Pt Bars Reach 58-82 2005 & 1996	Bowie Point Bars 2005 & 1996	Thompson Point Bars 2005 & 1996	Bogue Homo Point Bars 2005 & 1996
Z	-4.100_b	-2.249_a	-4.345_a	-0.227_a	-1.036_a	-4.114_a
Asymp. Sig. (2-tailed)	0.000	0.025	0.000	0.820	0.300	0.000

$_a$Based on negative ranks.

$_b$Based on positive ranks.

Table 2-13. Sinuosity tests of normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Sinuosity Leaf 2005	0.146	16	0.200*	0.943	16	0.386
Sinuosity Leaf 1996	0.236	16	0.018	0.810	16	0.004
Sinuosity Bowie 2005	0.208	16	0.061	0.910	16	0.117
Sinuosity Bowie 1996	0.186	16	0.142	0.897	16	0.071
Sinuosity Thompson 2005	0.167	16	0.200*	0.930	16	0.247
Sinuosity Thompson 1992	0.118	16	0.200*	0.967	16	0.794
Sinuosity BogueHomo 2005	0.108	16	0.200*	0.946	16	0.432
Sinuosity BogueHomo 1996	0.097	16	0.200*	0.951	16	0.498

* This is a lower bound of the true significance.
[a]Lilliefors Significance Correction

Table 2-14. Sinuosity Wilcoxon Signed Rank Test statistics

	Sinuosity Leaf 1996 & 2005	Sinuosity Bowie 1996 & 2005	Sinuosity Thompson 1992 & 2005	Sinuosity BogueHomo 1996 & 2005	Sinuosity Leaf 1996 & 2005
Z	-3.289[a]	-1.758[a]	-0.443[a]	-2.371[a]	-3.289[a]
Asymp. Sig. (2-tailed)	0.001	0.079	0.658	0.018	0.001

[a]Based on positive ranks.

Table 2-15. Change Indices tests of normality

	Kolmogorov-Smirnov$_a$			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
LFciB8296R7-40	0.316	15	0.000	0.534	15	0.000
LFciB9605R7-40	0.461	15	0.000	0.367	15	0.000
LFciB8296R41-57	0.252	15	0.011	0.782	15	0.002
LFciB9605R41-57	0.462	15	0.000	0.311	15	0.000
LFciB8296R58-82	0.432	15	0.000	0.523	15	0.000
LFciB9605R58-82	0.489	15	0.000	0.297	15	0.000
LFciD8296R7-40	0.181	15	0.199	0.942	15	0.413
LFciD9605R7-40	0.217	15	0.055	0.842	15	0.013
LFciD8296R41-57	0.181	15	0.200*	0.929	15	0.262
LFciD9605R41-57	0.216	15	0.058	0.929	15	0.263
LFciD8296R58-82	0.169	15	0.200*	0.931	15	0.282
LFciD9605R58-82	0.126	15	0.200*	0.954	15	0.585
LFciE8296R7-40	0.210	15	0.075	0.844	15	0.014
LFciE9605R7-40	0.275	15	0.003	0.860	15	0.024
LFciE8296R41-57	0.158	15	0.200*	0.970	15	0.852
LFciE9605R41-57	0.167	15	0.200*	0.874	15	0.039
LFciE8296R58-82	0.144	15	0.200*	0.963	15	0.751
LFciE9605R58-82	0.196	15	0.125	0.892	15	0.072
LFciU8296R7-40	0.181	15	0.199	0.942	15	0.413
LFciU9605R7-40	0.217	15	0.055	0.842	15	0.013
LFciU8296R41-57	0.181	15	0.200*	0.929	15	0.262
LFciU9605R41-57	0.216	15	0.058	0.929	15	0.263
LFciU8296R58-82	0.169	15	0.200*	0.931	15	0.282
LFciU9605R58-82	0.126	15	0.200*	0.954	15	0.585
BWciB8296	0.303	15	0.001	0.694	15	0.000
BWciB9605	0.477	15	0.000	0.320	15	0.000
BWciD8296	0.137	15	0.200*	0.935	15	0.321
BWciD9605	0.135	15	0.200*	0.974	15	0.916
BWciE8296	0.253	15	0.011	0.652	15	0.000
BWciE9605	0.239	15	0.021	0.808	15	0.005
BWciU8296	0.137	15	0.200*	0.935	15	0.321
BWciU9605	0.135	15	0.200*	0.974	15	0.916
THciB8296	0.288	15	0.002	0.573	15	0.000
THciB9605	0.310	15	0.000	0.750	15	0.001
THciD8296	0.146	15	0.200*	0.961	15	0.707
THciD9605	0.184	15	0.181	0.894	15	0.076
THciE8296	0.143	15	0.200*	0.916	15	0.169
THciE9605	0.150	15	0.200*	0.882	15	0.050
THciU8296	0.146	15	0.200*	0.961	15	0.707
THciU9605	0.184	15	0.181	0.894	15	0.076
BHciB8296	0.278	15	0.003	0.802	15	0.004
BHciB9605	0.327	15	0.000	0.700	15	0.000
BHciD8296	0.182	15	0.194	0.949	15	0.503
BHciD9605	0.104	15	0.200*	0.977	15	0.944
BHciE8296	0.125	15	0.200*	0.951	15	0.544
BHciE9605	0.257	15	0.009	0.846	15	0.015
BHciU8296	0.182	15	0.194	0.949	15	0.503
BHciU9605	0.104	15	0.200*	0.977	15	0.944

* This is the lower bound of the true significance

a Lilliefors Significance Correction

Table 2-16. Change indices Wilcoxon Signed Rank Test statistics

	LFciB9605 & LFciB8296 Reach 7-40	LFciD9605 & LFciD8296 Reach 7-40	LFciE9605 & LFciE8296 Reach 7-40	LFciU9605 & LFciU8296 Reach 7-40	LFciB9605 & LFciB8296 Reach 41-57	LFciD9605 & LFciD8296 Reach 41-57	LFciE9605 & LFciE8296 Reach 41-57	LFciU9605 & LFciU8296 Reach 41-57
Z	-2.875_a	-4.796_a	-0.846_a	-4.796b	-2.934_a	-0.639_a	-3.574_a	-0.639_b
Asymp. Sig. (2-tailed)	0.004	0.000	0.397	0.000	0.003	0.523	0.000	0.523

Table 2-16. Change indices Wilcoxon Signed Rank Test statistics (continued)

	LFciB9605 & LFciB8296 Reach 58-82	LFciD9605 & LFciD8296 Reach 58-82	LFciE9605 & LFciE8296 Reach 58-82	LFciU9605 & LFciU8296 Reach 58-82	BWciB9605 & BWciB8296	BWciD9605 &- BWciD8296	BWciE9605 & BWciE8296	BWciU9605 & BWciU8296
Z	-1.423_a	-2.516_b	-4.372_a	-2.516_a	-2.073_a	-2.172_a	-3.516_a	-2.172_b
Asymp. Sig. (2-tailed)	0.155	0.012	0.000	0.012	0.038	0.030	0.000	0.030

Table 2-16. Change indices Wilcoxon Signed Rank Test statistics (continued)

	THciB9605& THciB8296	THciD9605& THciD8296	THciE9605 & THciE8296	THciU9605 & THciU8296	BHciB9605 & BHciB8296	BHciD9605 & BHciD8296	BHciE9605 & BHciE8296	BHciU9605 &- BHciU8296
Z	-2.430_a	-1.913_b	-2.896_a	-1.913_a	-3.490_a	-2.685_b	-4.684_a	-2.685_a
Asymp. Sig. (2-tailed)	0.015	0.056	0.004	0.056	0.000	0.007	0.000	0.007

$_a$Based on positive ranks
$_b$Based on negative ranks

Table 2-17. Leaf River change indices Wilcoxon Signed Rank Test statistics

	D/I 1996-2005 - D/I 1982-1996	E/I 1996-2005 - E/I 1982-1996	U/I 1996-2005 - U/I 1982-1996	1996-2005 B/I - 1982-1996 B/I
Z	-2.402_a	-5.757_a	-2.402_b	-4.383_a
Asymp. Sig. (2-tailed)	0.016	0.000	0.016	0.000

$_a$Based on positive ranks
$_b$Based on negative ranks

Table 2-18. Leaf River, MS discharge data for imagery fly Dates

Date	USGS Gauge Station	Discharge (cfs)
7-7-2005	Hattiesburg, MS	1070
7-9-2005	Hattiesburg, MS	992
8-15-2005	Hattiesburg, MS	979
8-18-2005	Hattiesburg, MS	814
7-7-2005	McLain. MS	2380
9-8-2005	McLain. MS	5170

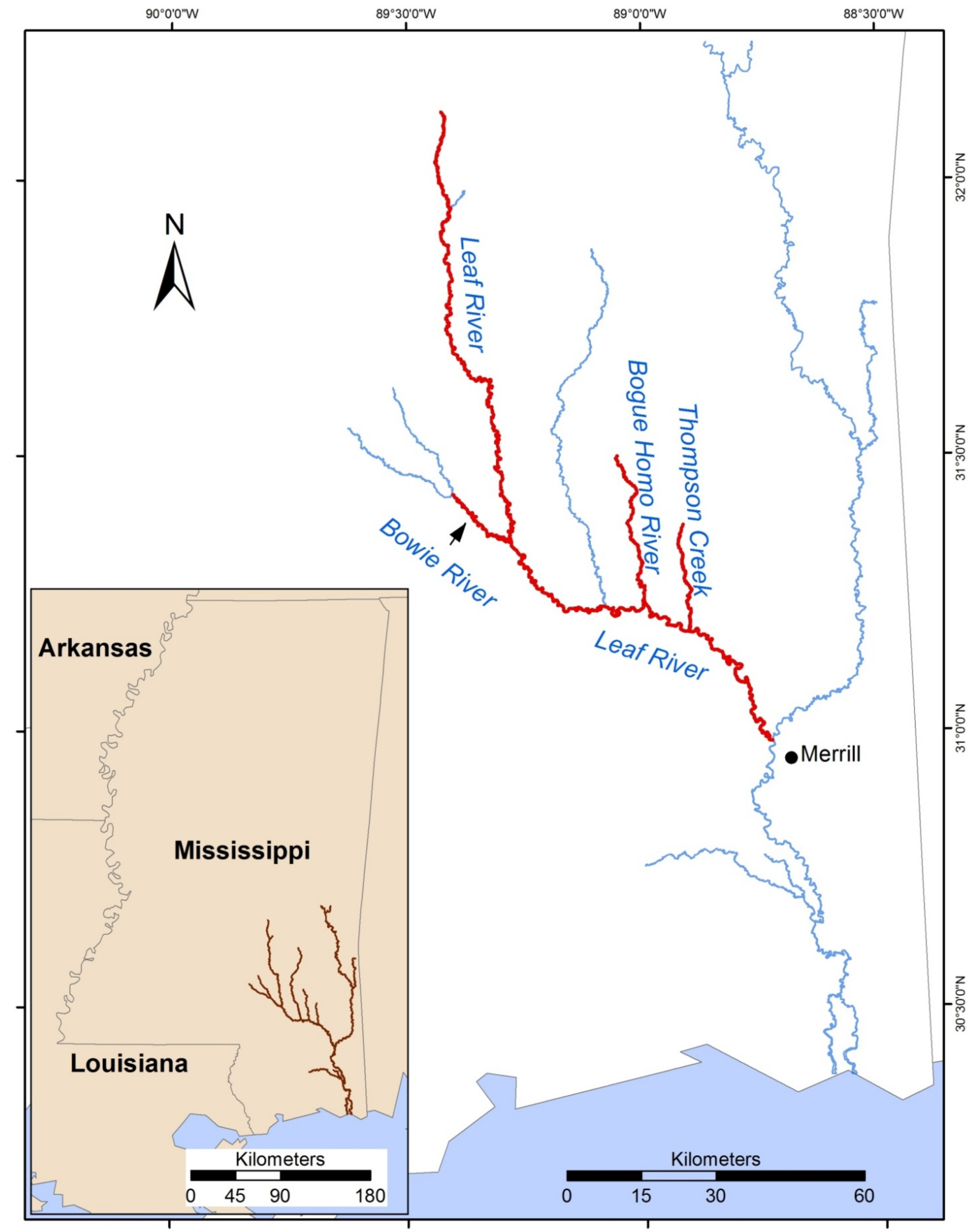

Figure 2-1. Pascagoula River basin and tributaries under study

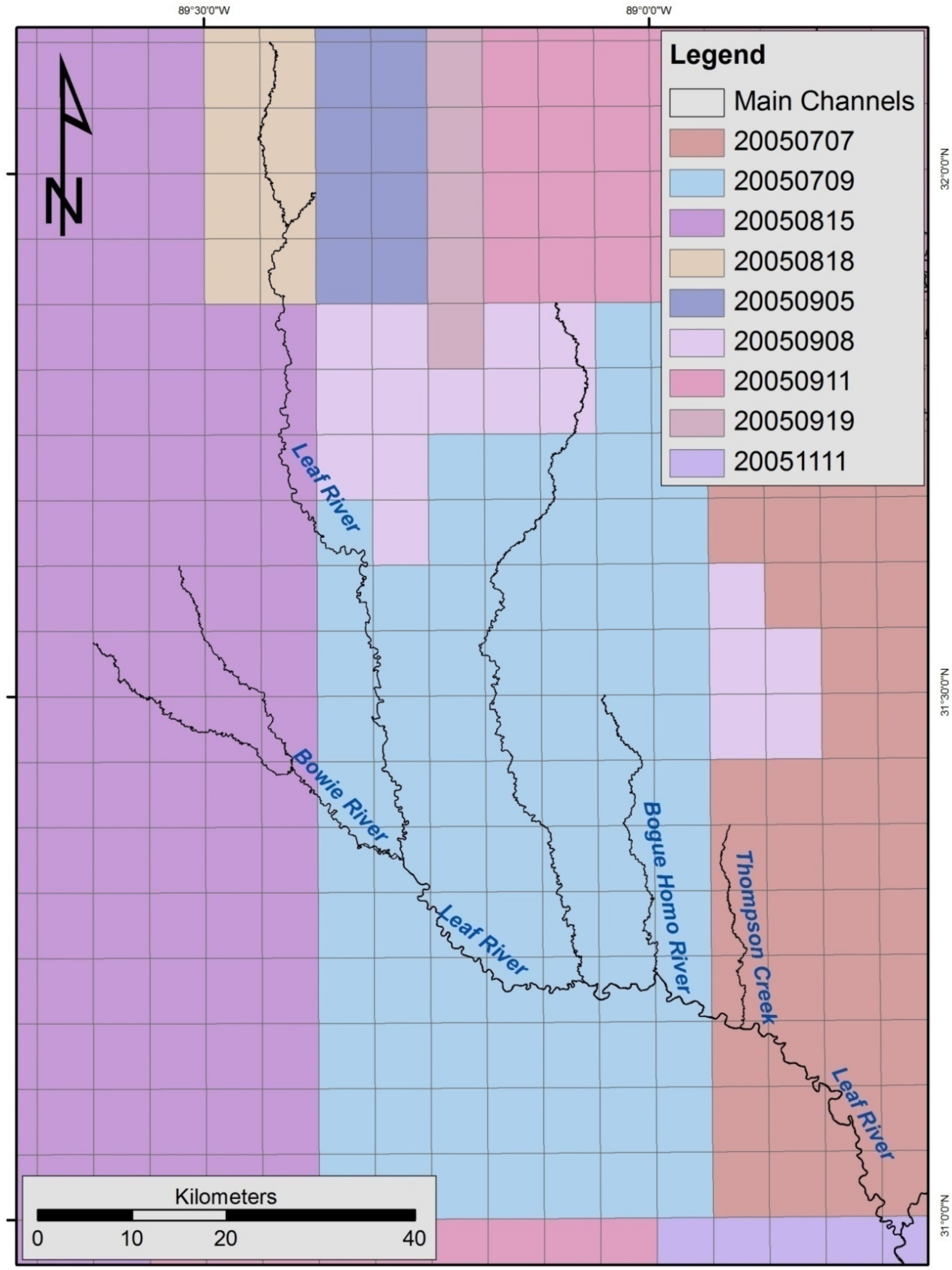

Figure 2-2. 2005 imagery fly dates

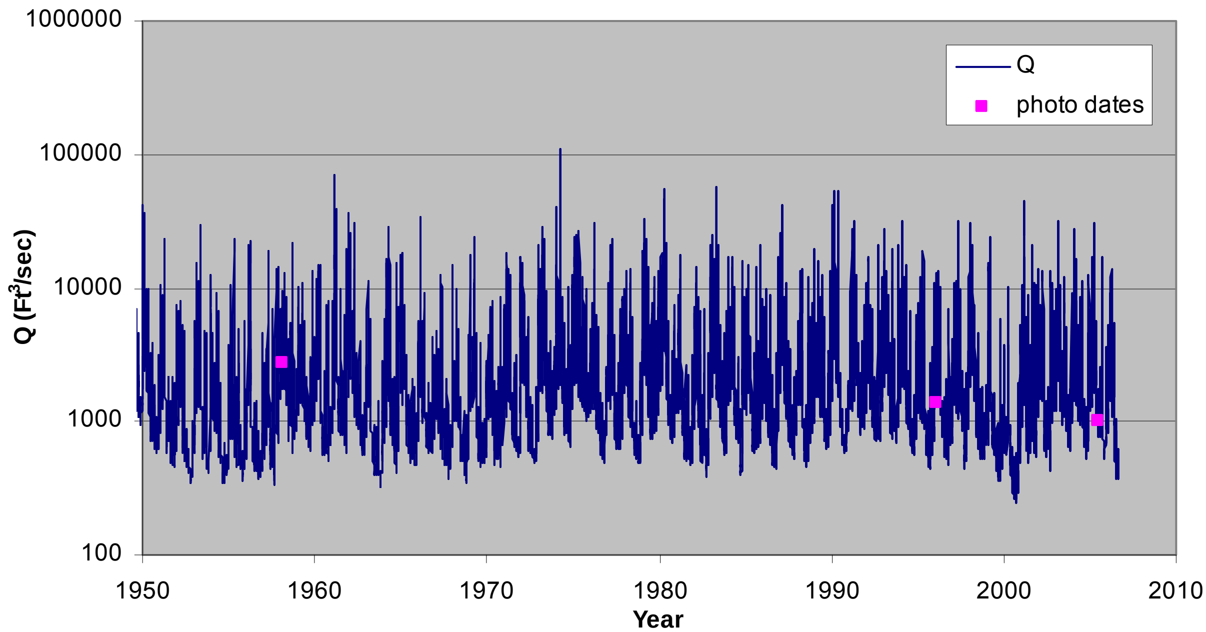

Figure 2-3. Imagery fly dates in comparison to discharge at Hattiesburg, MS

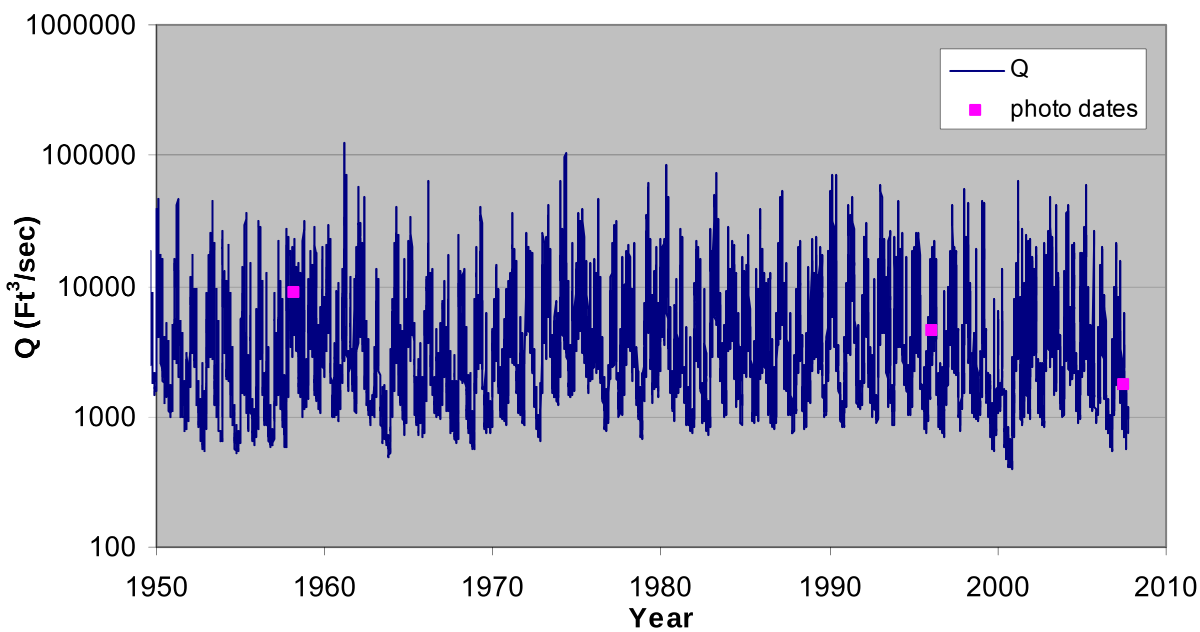

Figure 2-4. Imagery fly dates in comparison to discharge at McLain, MS

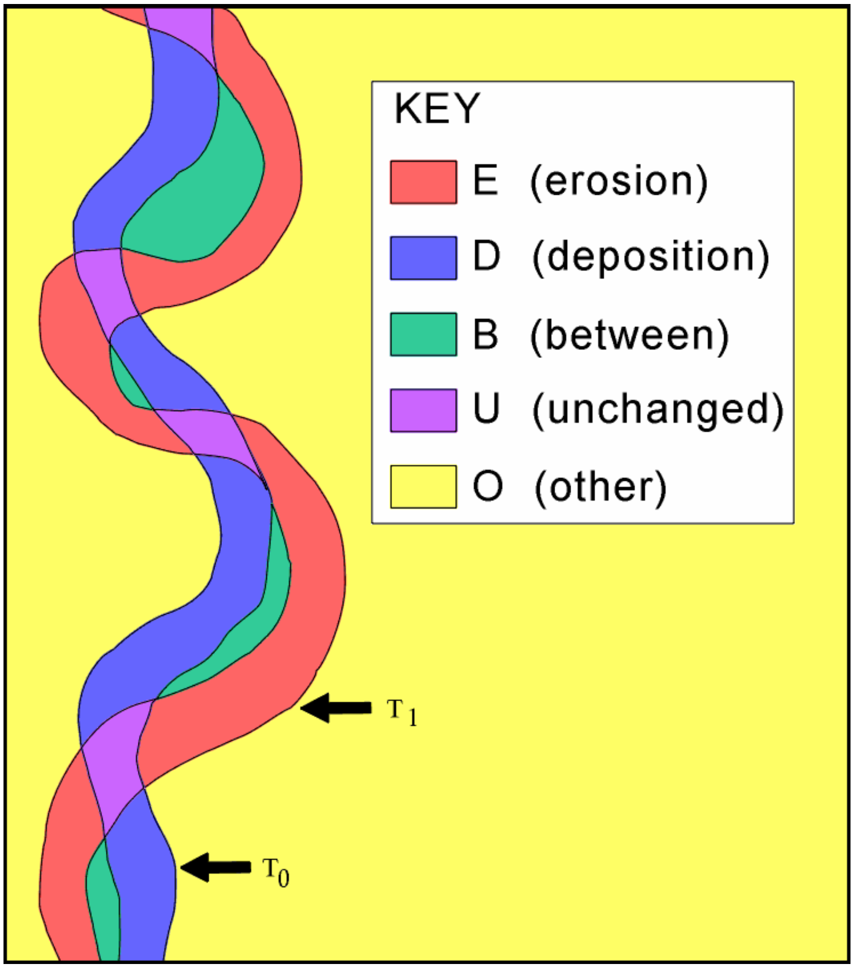

Figure 2-5. Change indices methods (Mossa and McLean 1997)

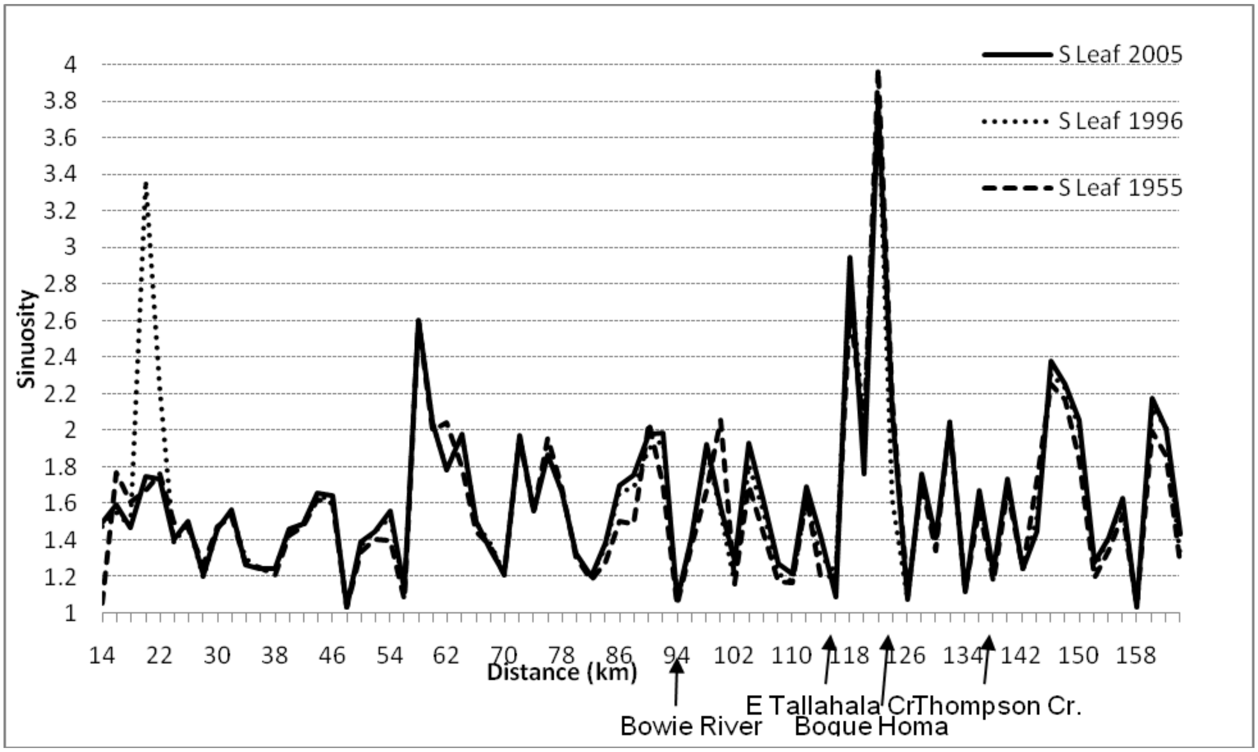

Figure 2-6. Leaf River sinuosity index 1955-2005

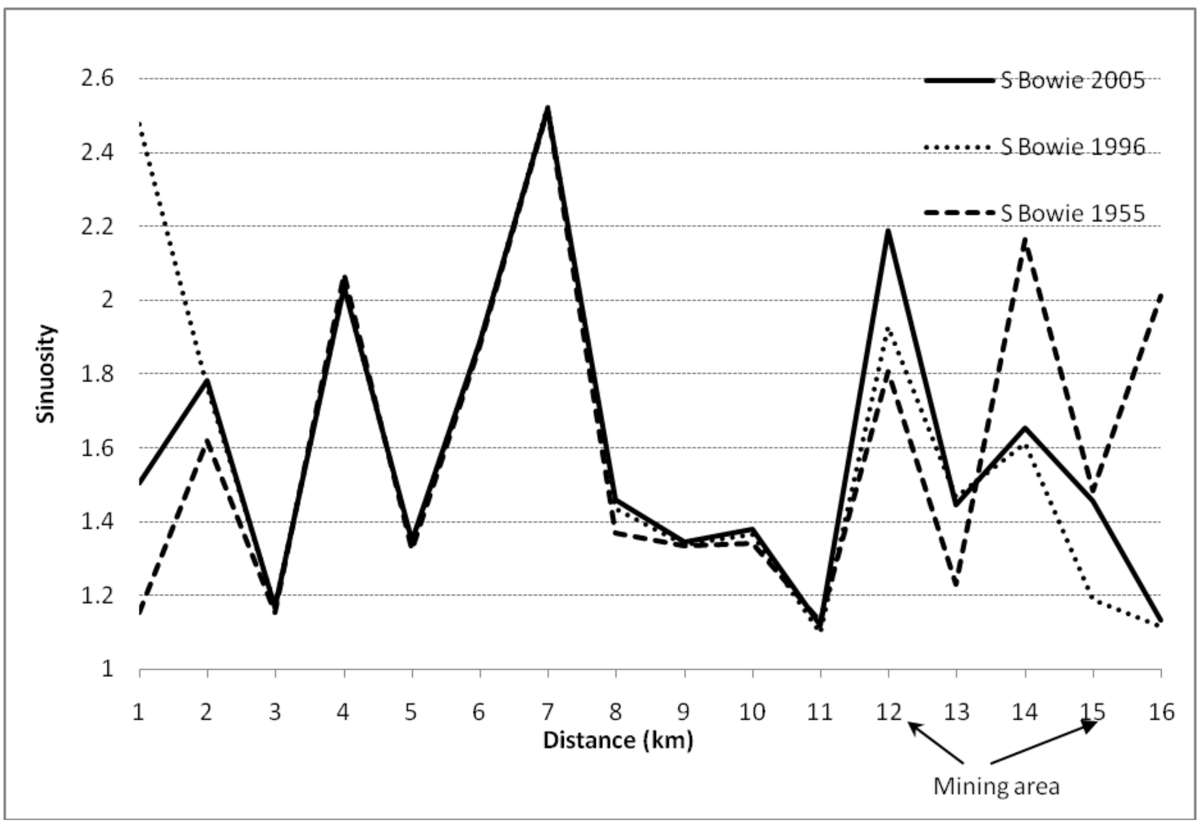

Figure 2-7. Bowie River sinuosity index 1955 - 2005

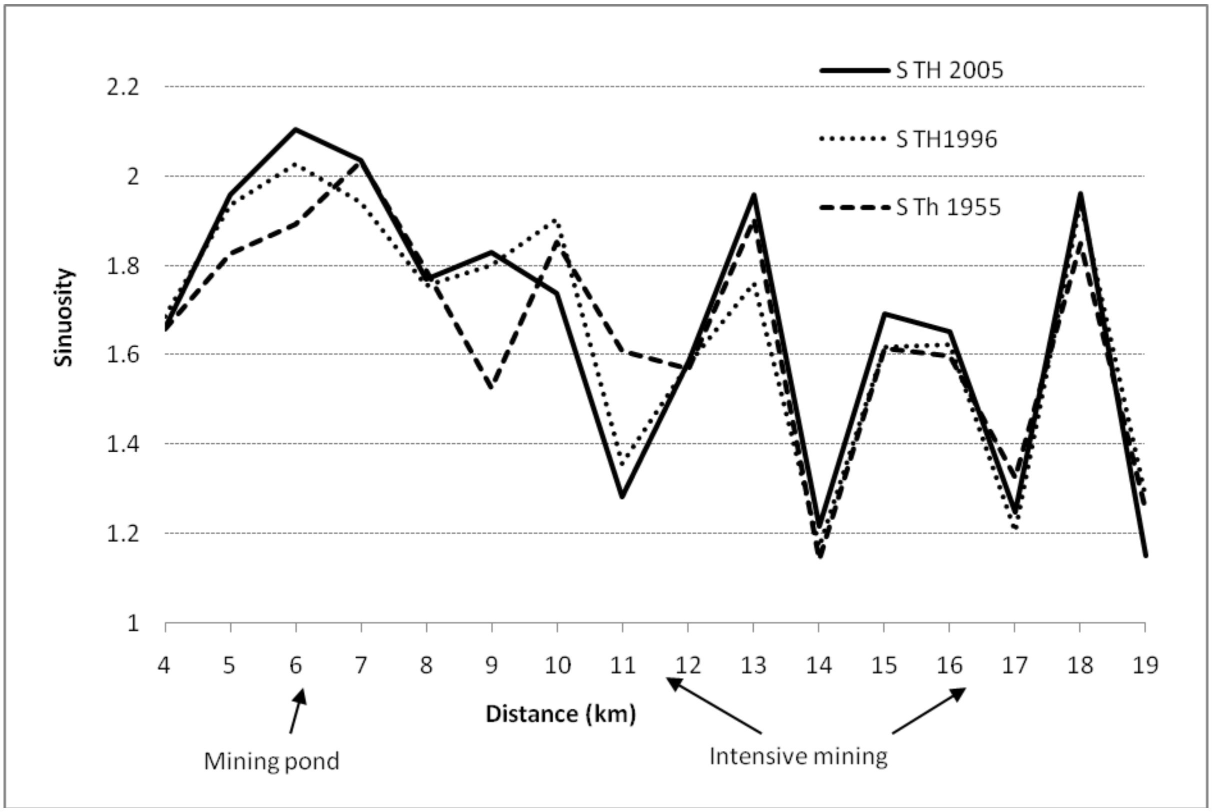

Figure 2-8. Thompson Creek sinuosity index 1955-2005

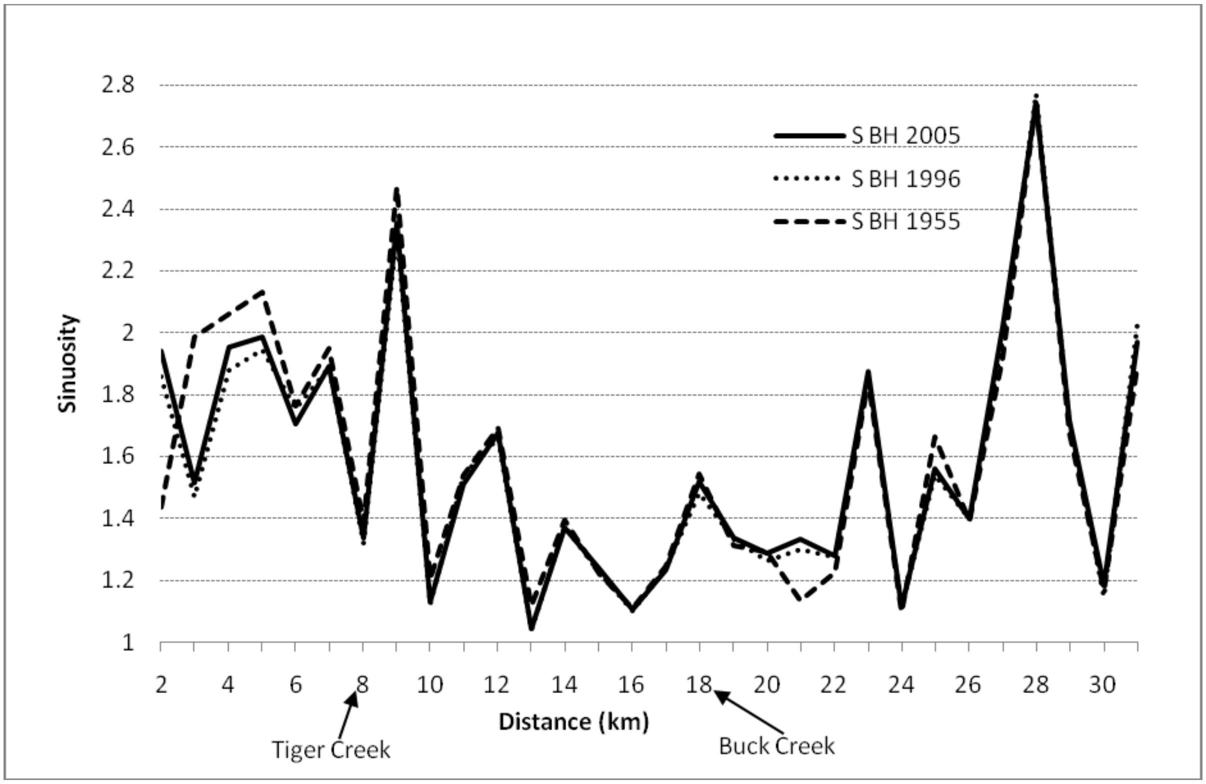

Figure 2-9. Bogue Homo River sinuosity index 1955-2005

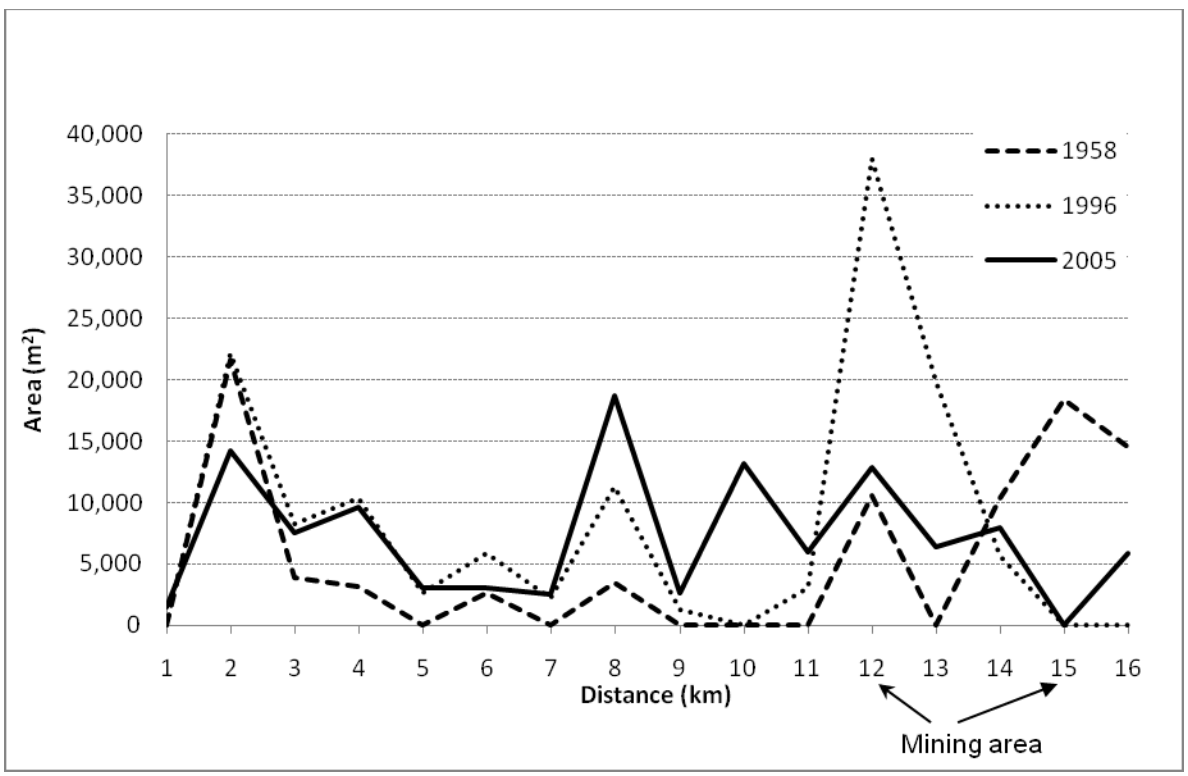

Figure 2-10. Bowie River point bar areas 1958 - 2005

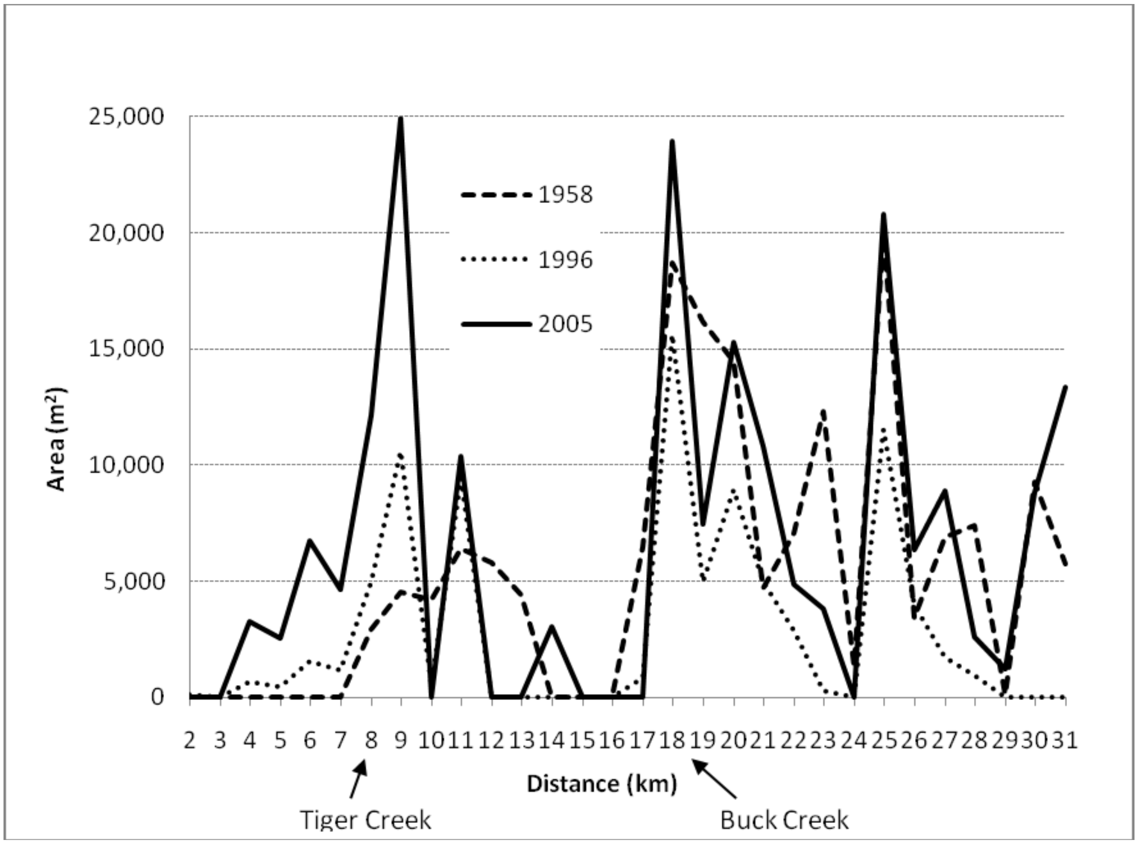

Figure 2-11. Bogue Homo River point bar areas 1958-2005

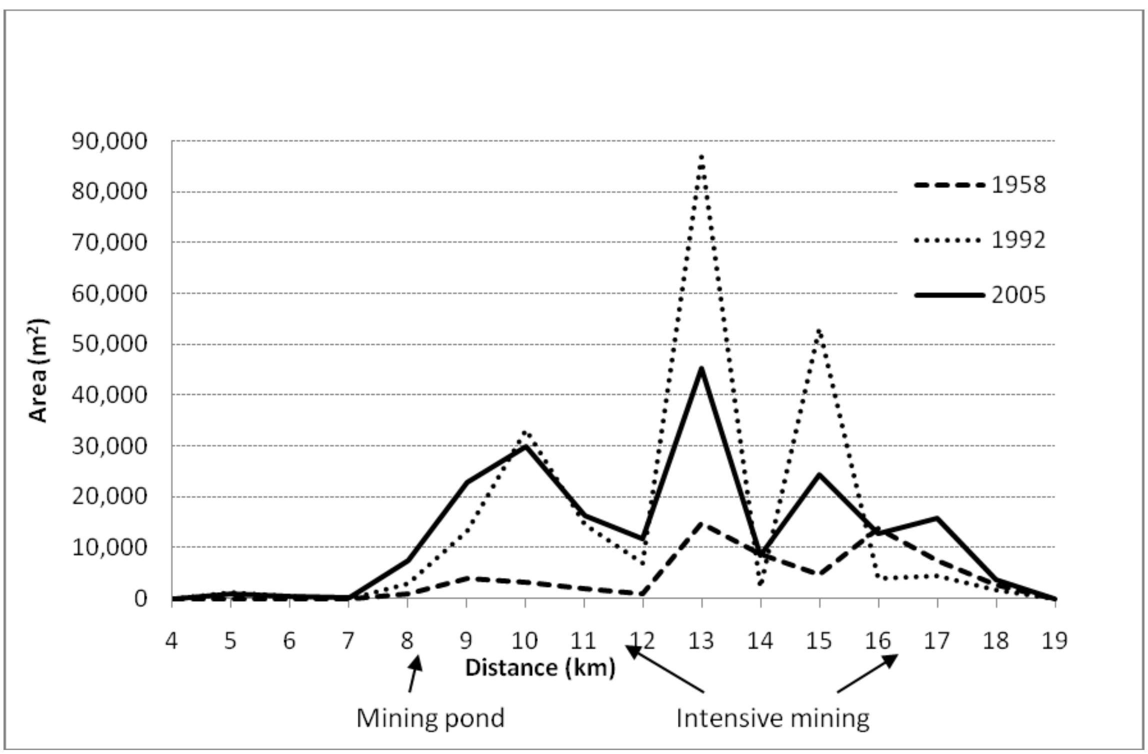

Figure 2-12. Thompson Creek point bar areas 1958-2005

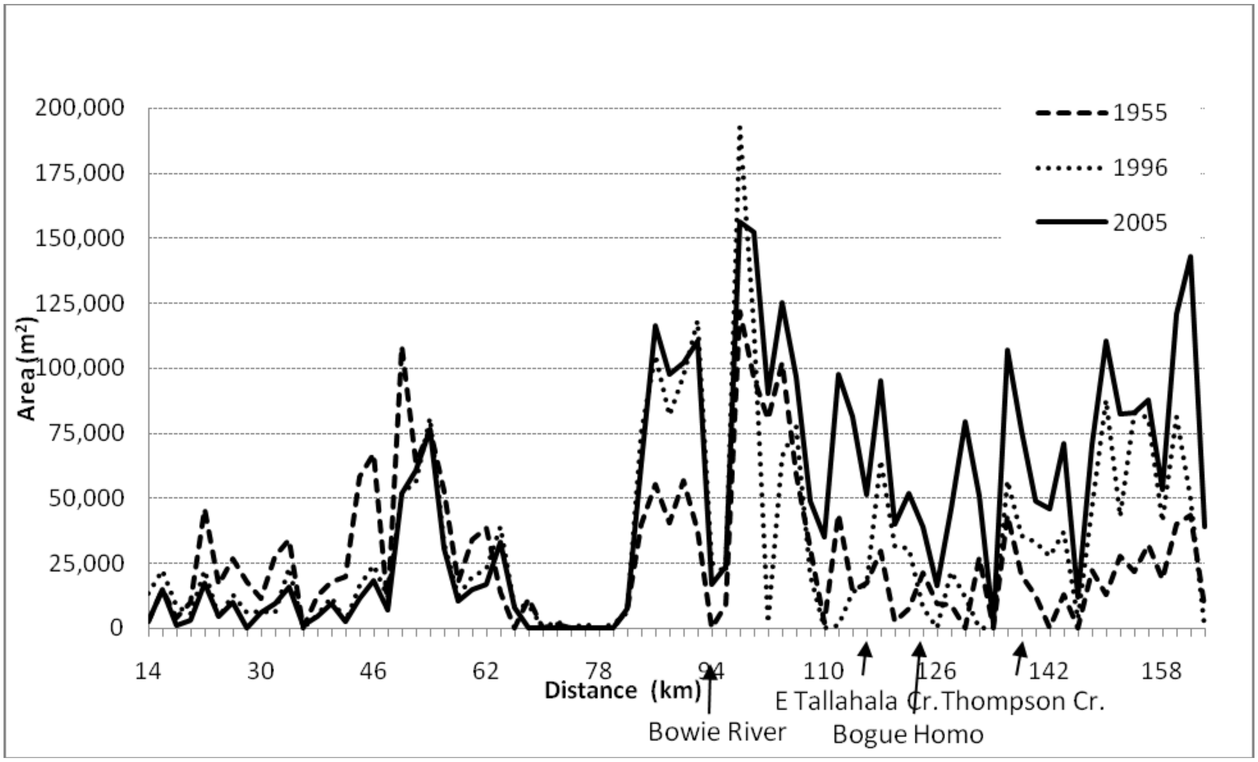

Figure 2-13. Leaf River point bar areas 1955-2005

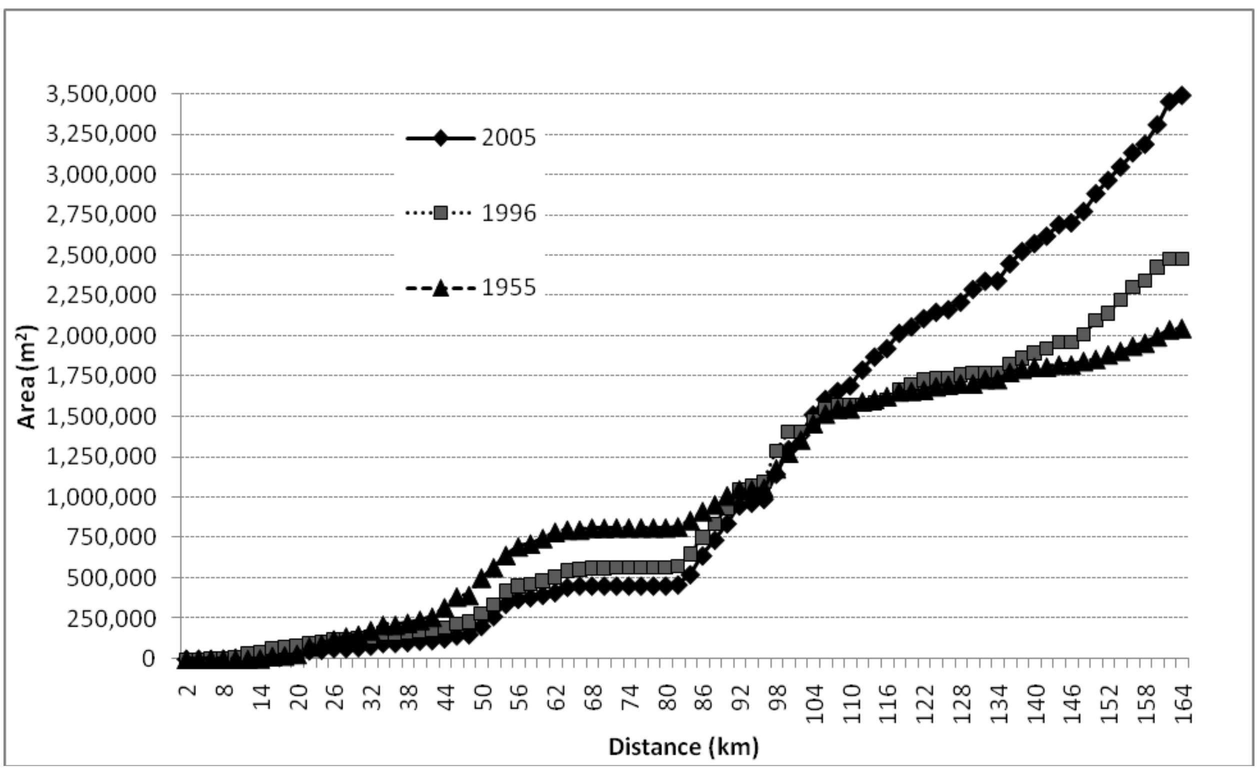

Figure 2-14. Leaf River cumulative point bar area

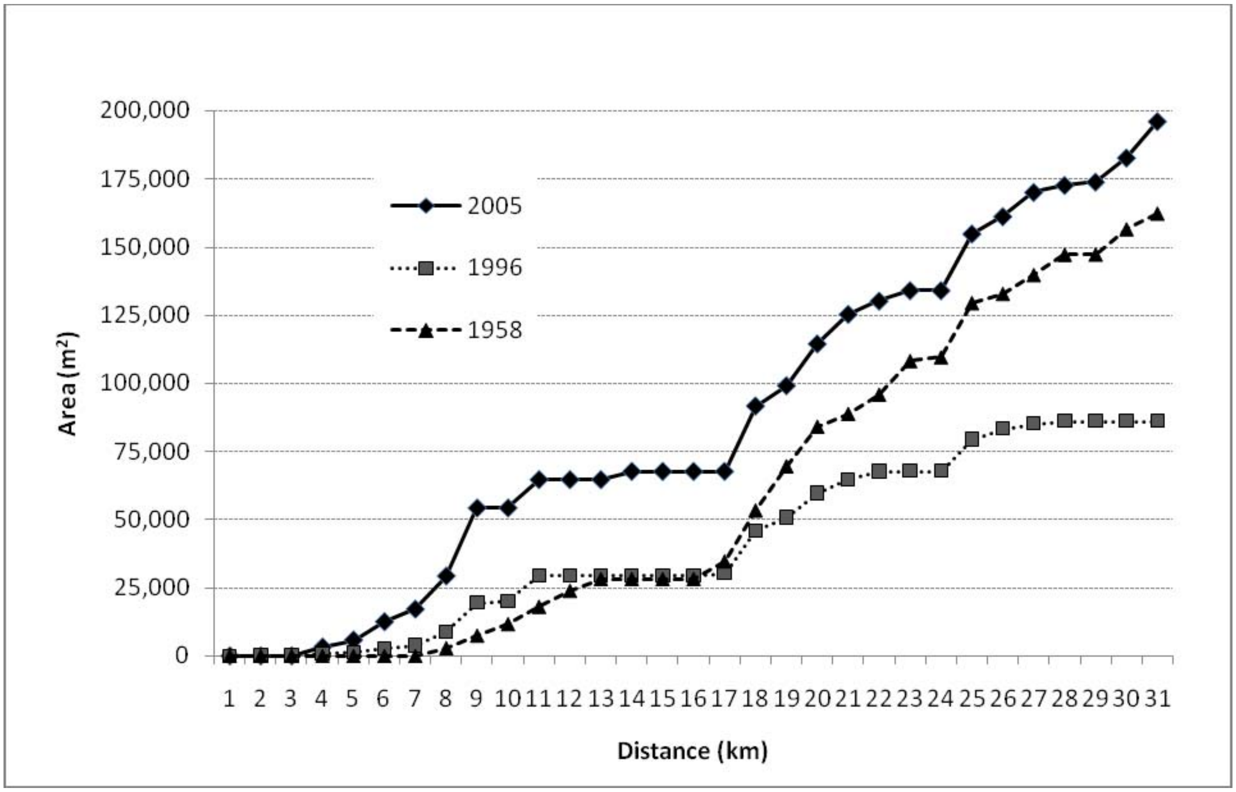

Figure 2-15. Bogue Homo River cumulative point bar area

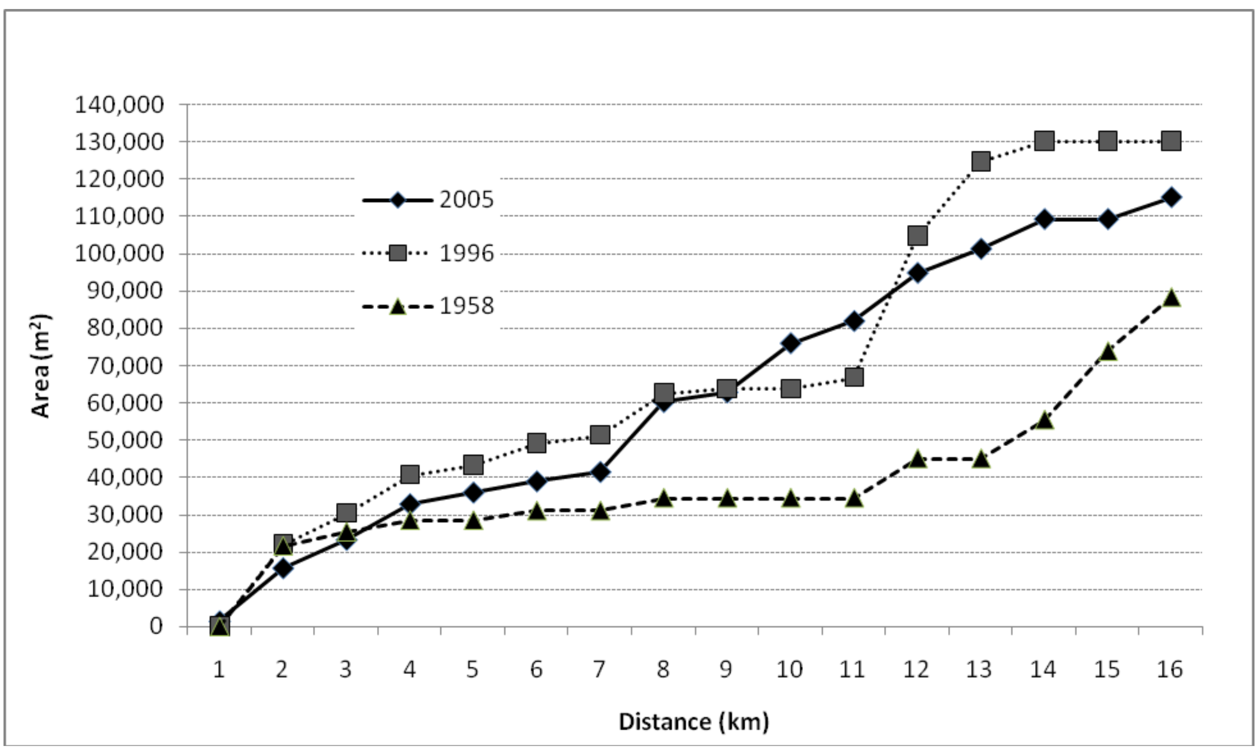

Figure 2-16. Bowie River cumulative point bar area

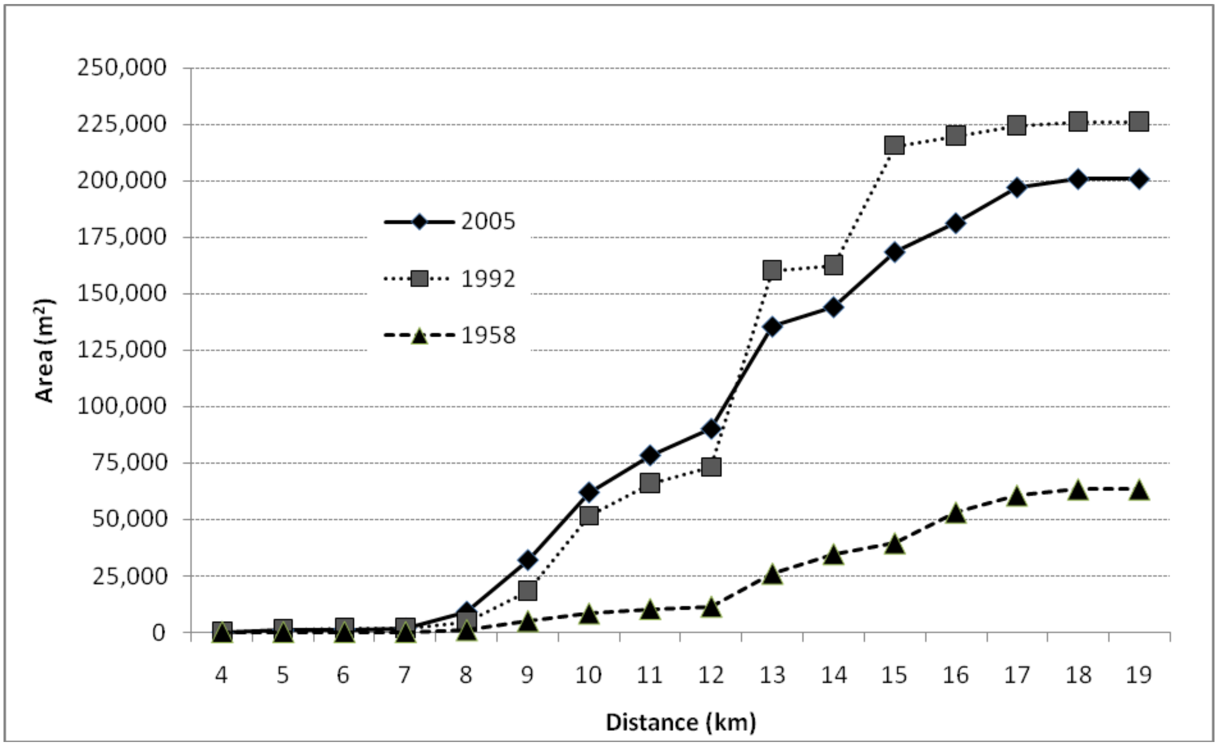

Figure 2-17. Thompson Creek cumulative point bar area

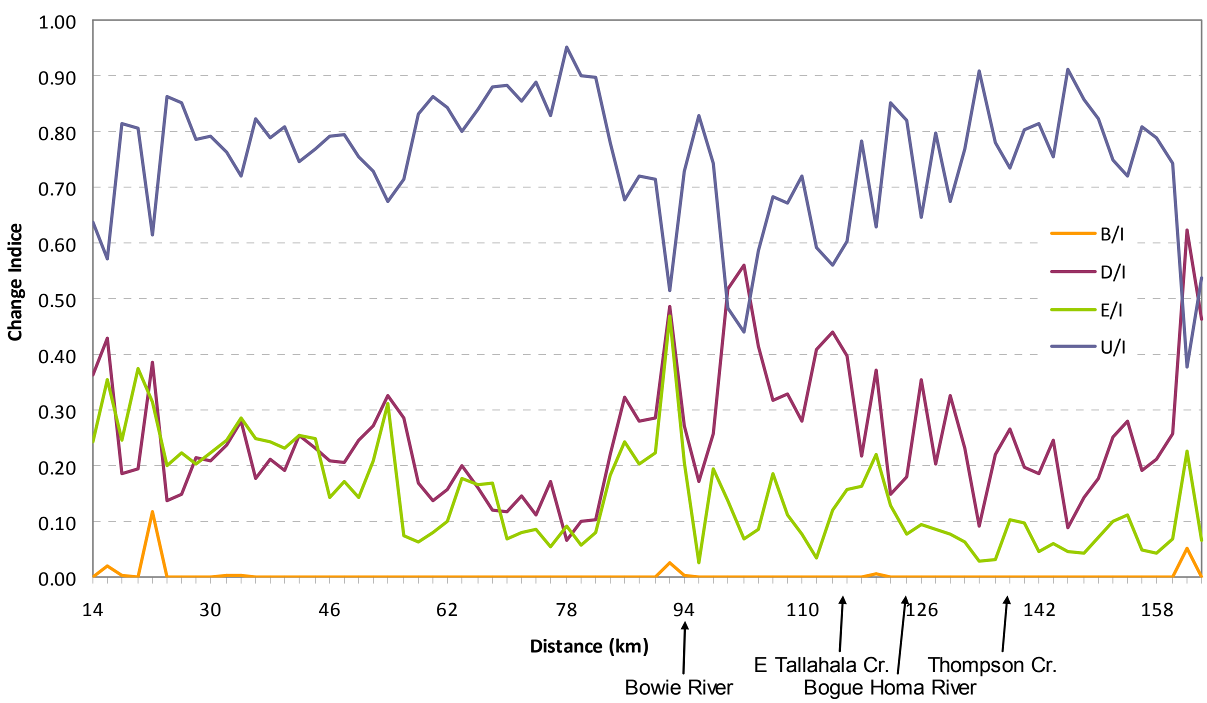

Figure 2-18. Leaf River change indices 1996-2005

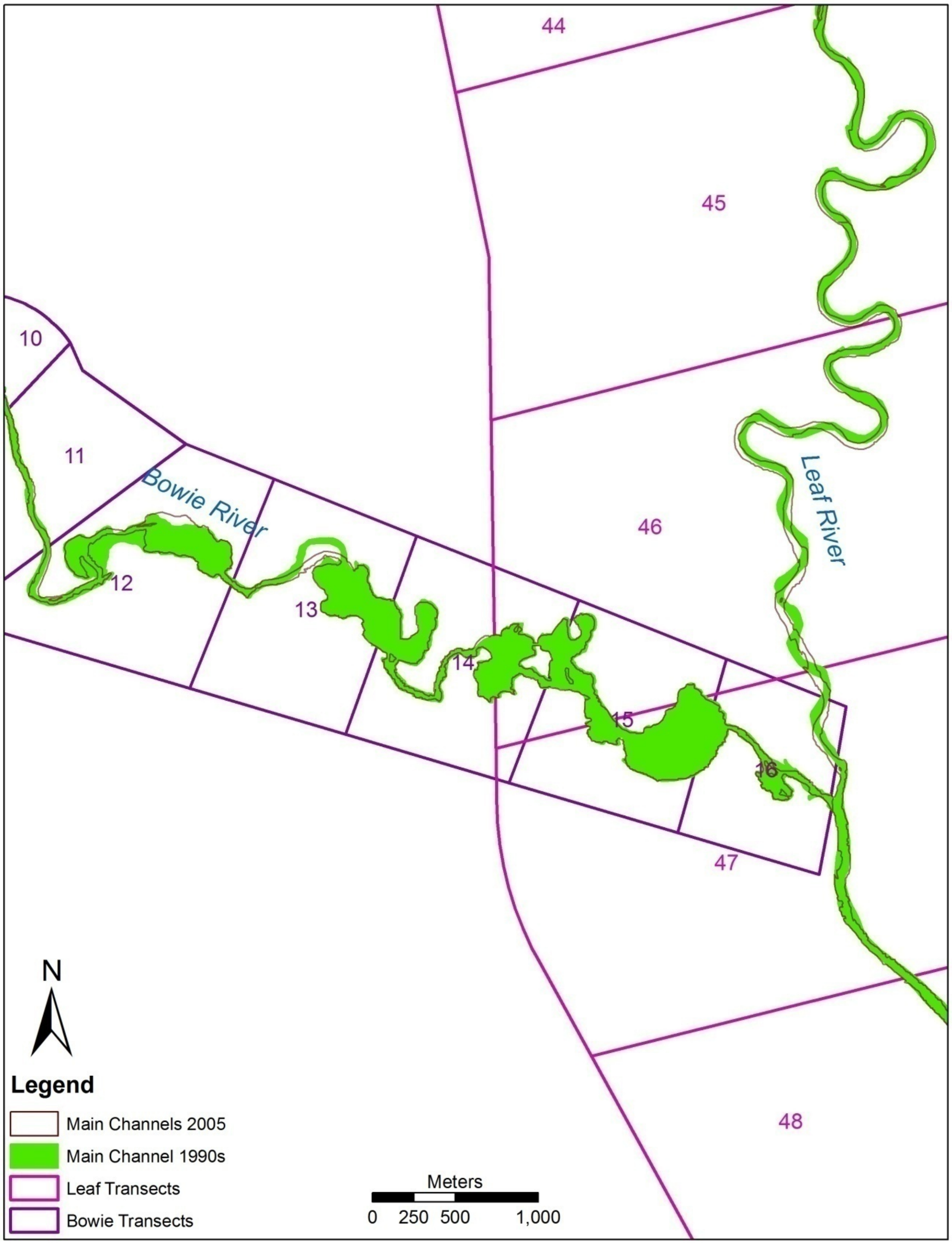

Figure 2-19. Bowie River in-stream mining pits

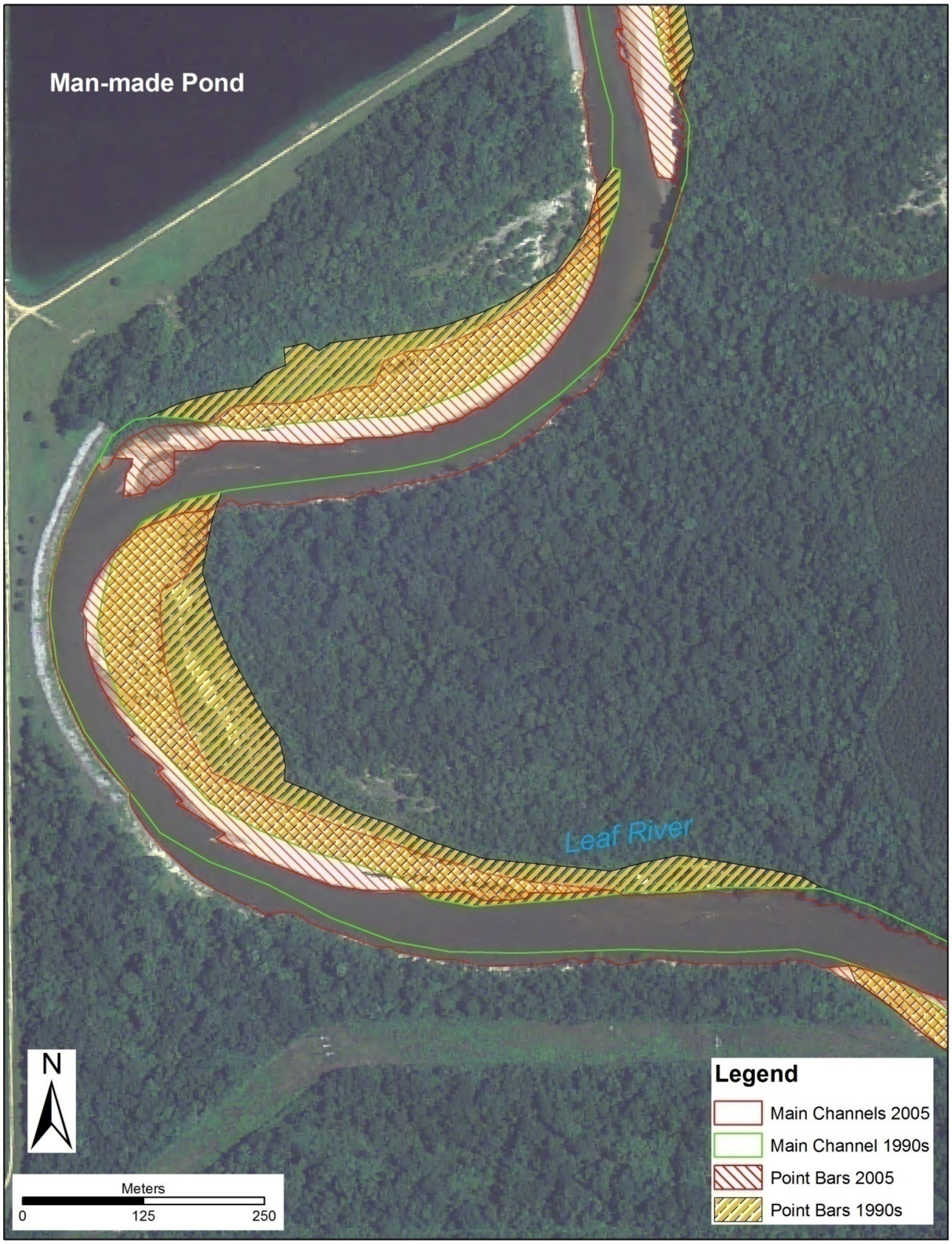

Figure 2-20. Leaf River instability at kilometer 98

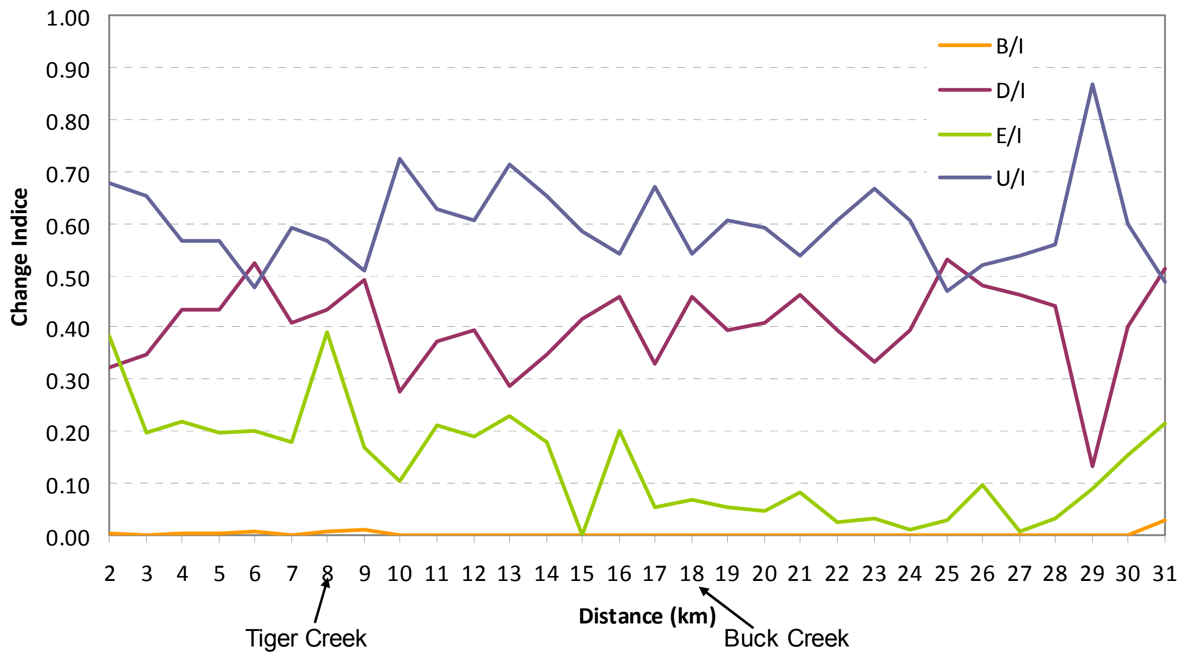

Figure 2-21. Bogue Homo River change indices 1996-2005

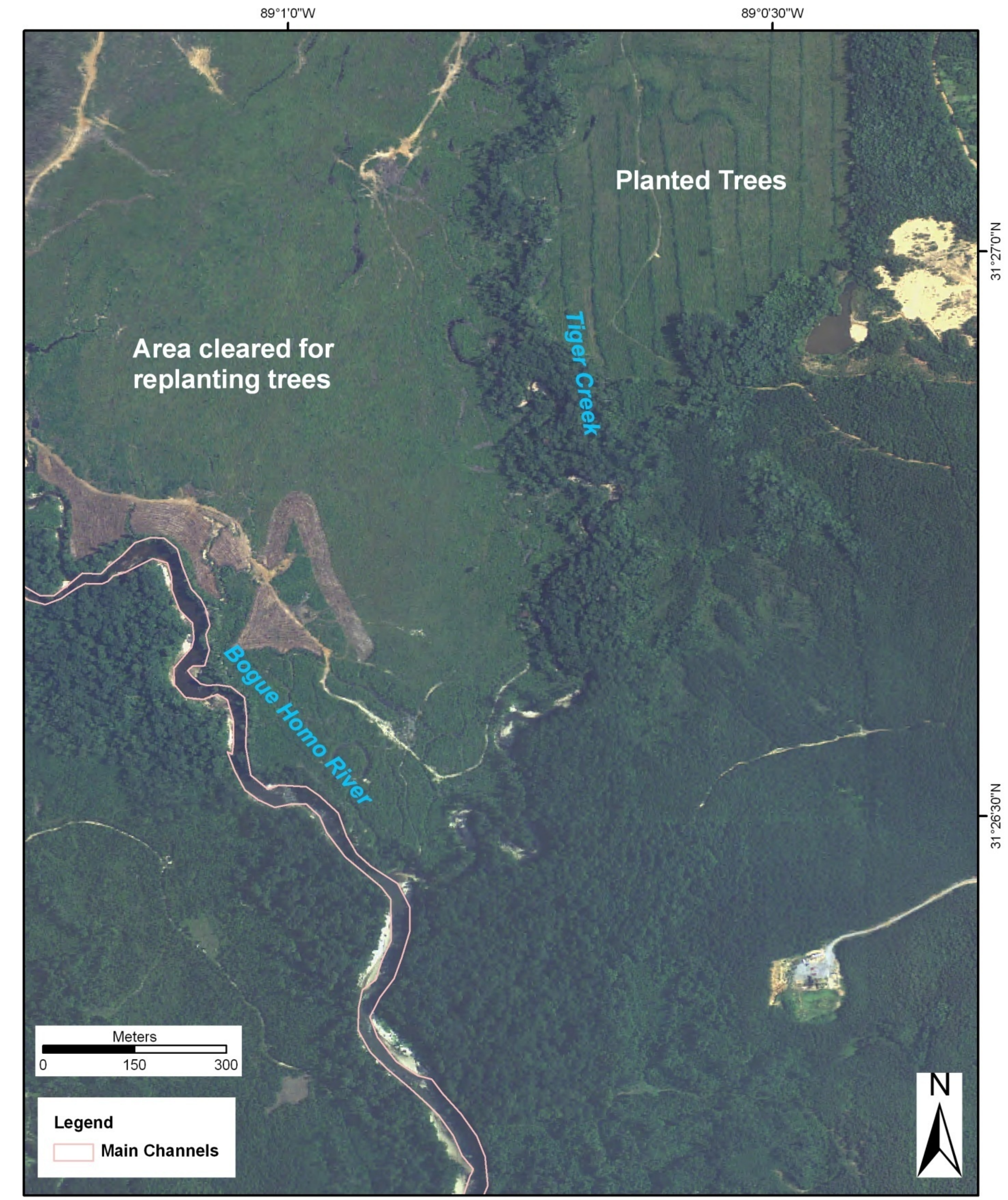

Figure 2-22. Confluences of the Bogue Homo River and Tiger Creek

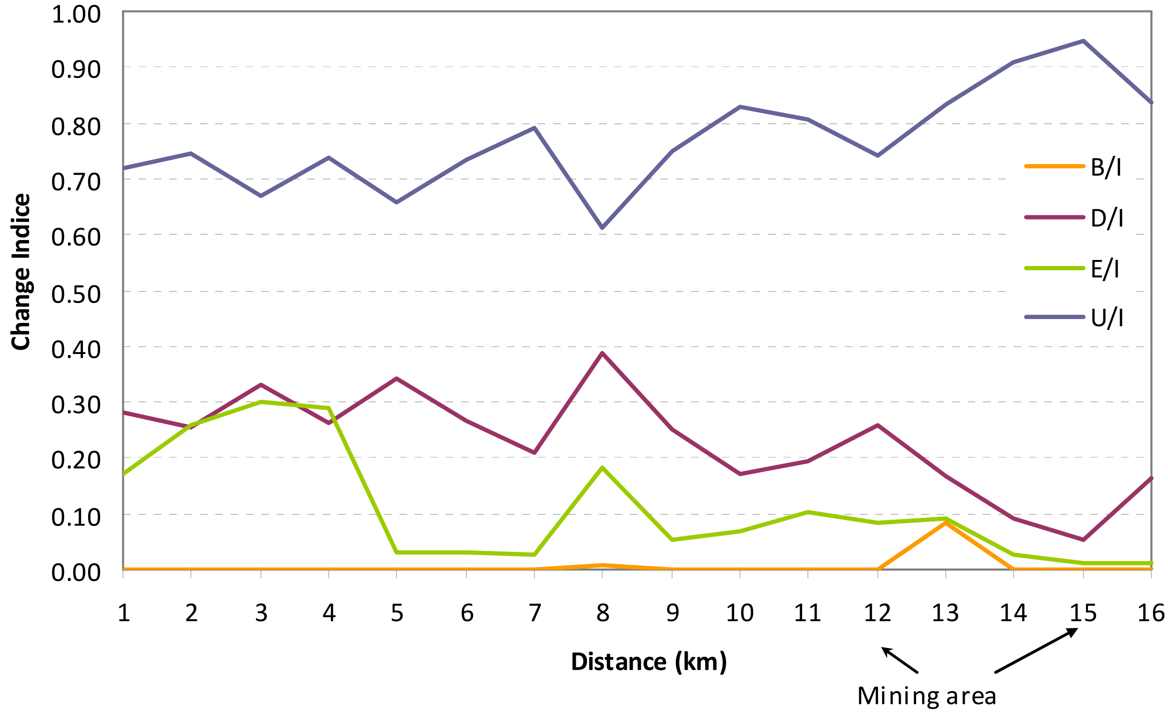

Figure 2-23. Bowie River change indices 1996-2005

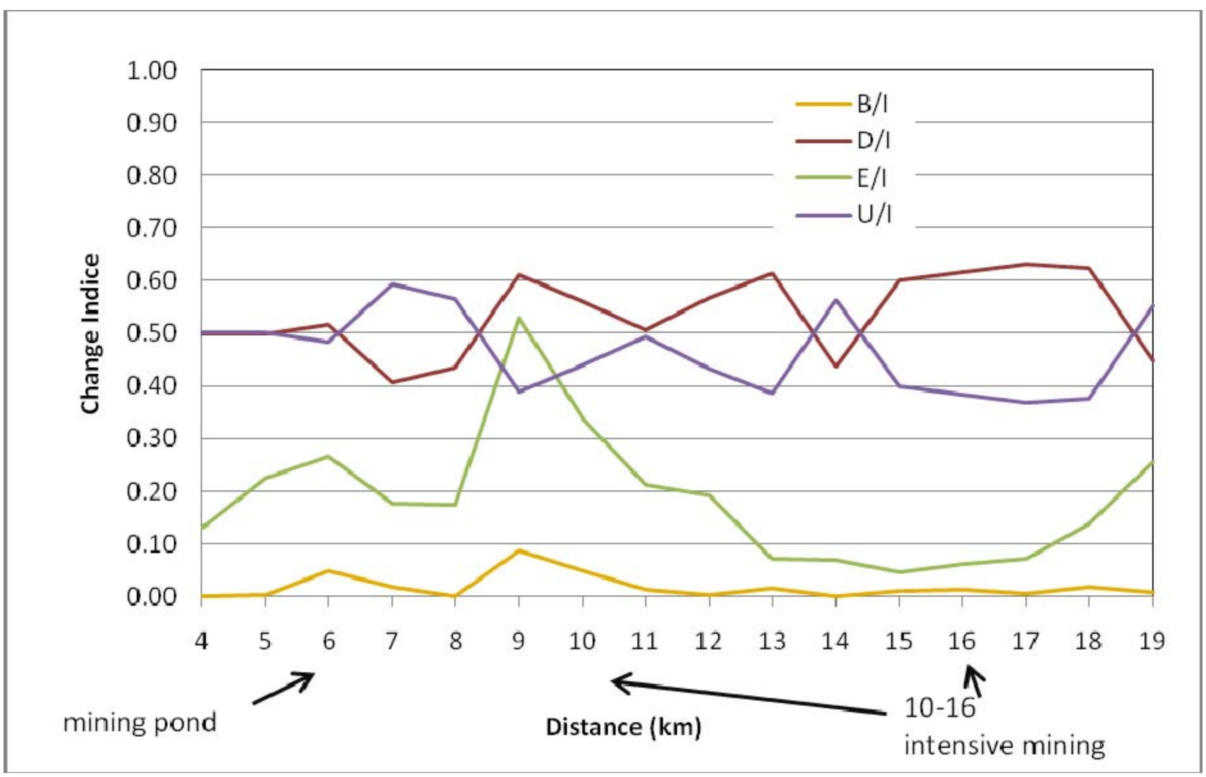

Figure 2-24. Thompson Creek change indices 1996-2005

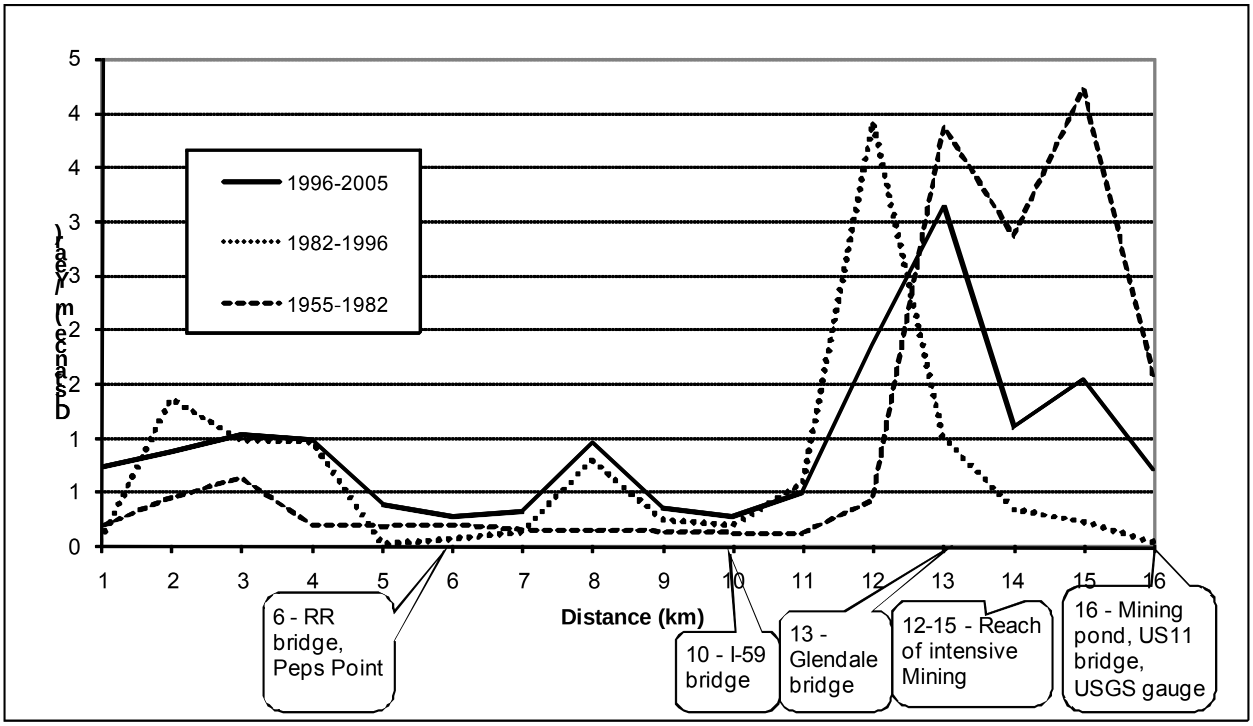

Figure 2-25. Bowie River average lateral migration per year

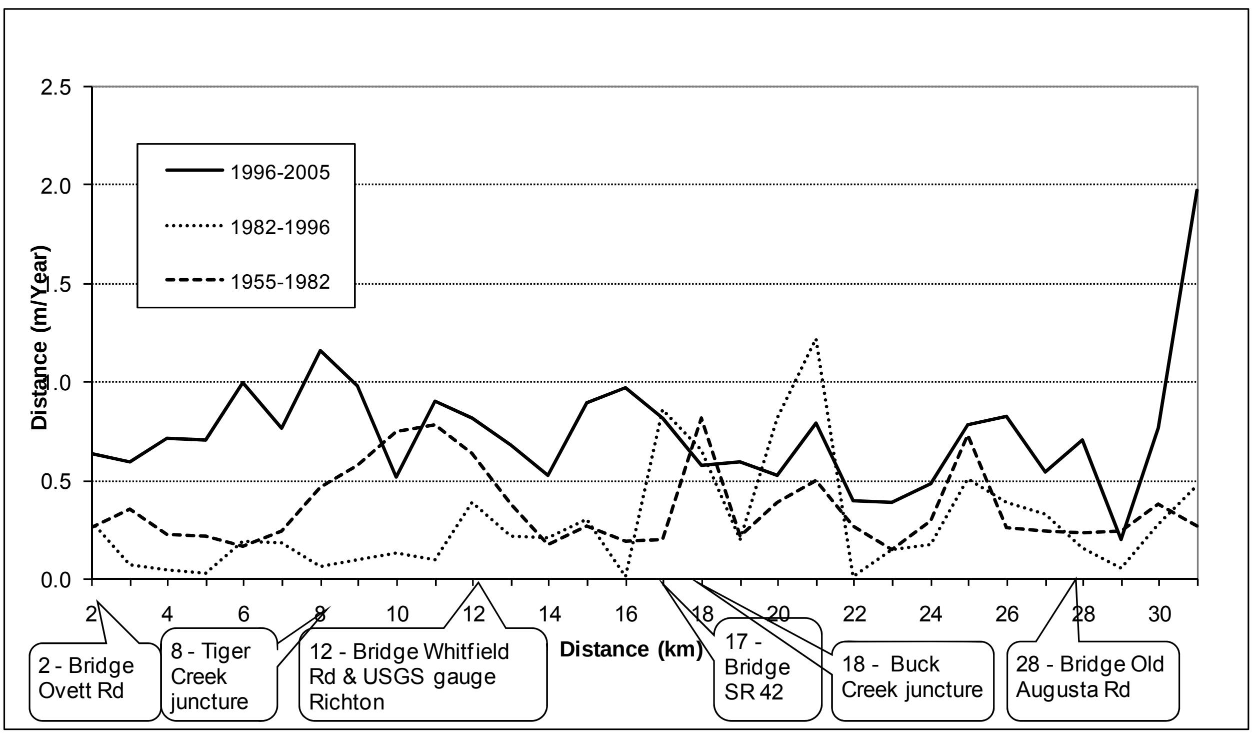

Figure 2-26. Bogue Homo River average lateral migration per year

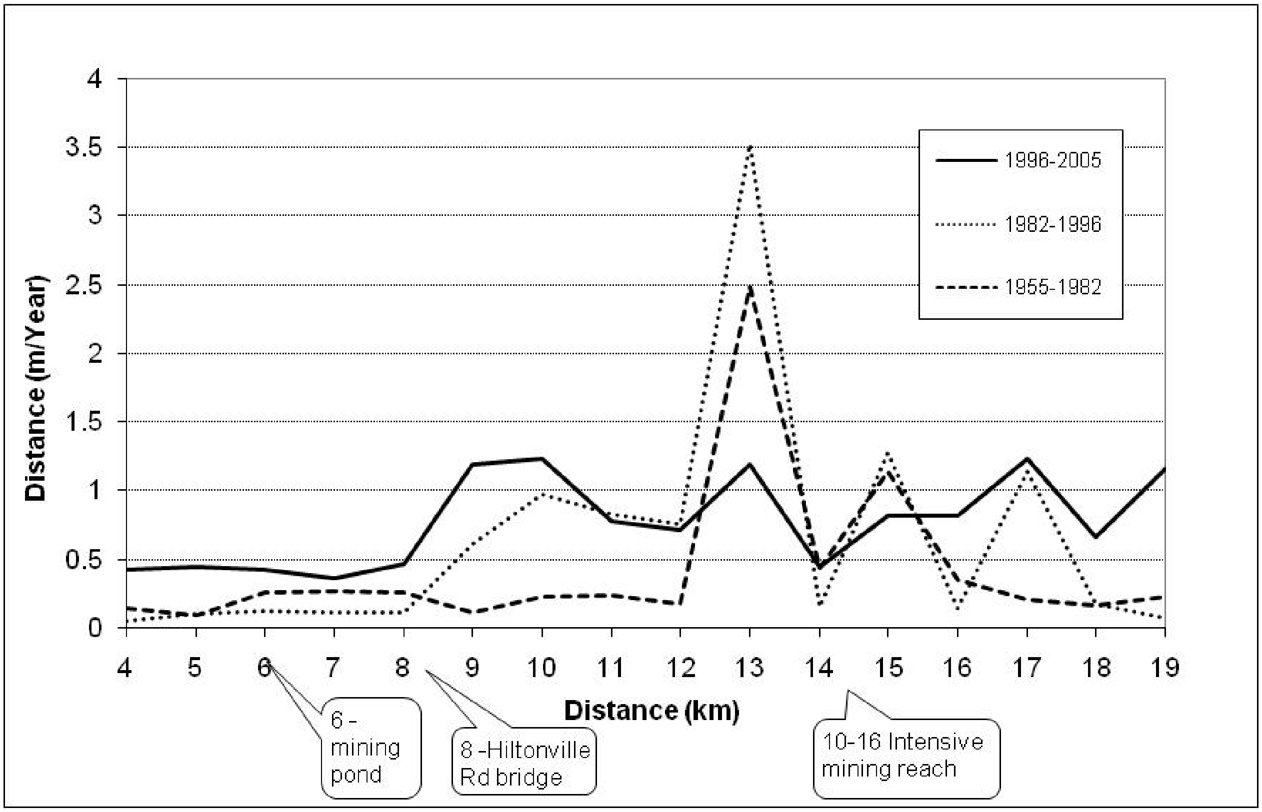

Figure 2-27. Thompson Creek average lateral migration per year

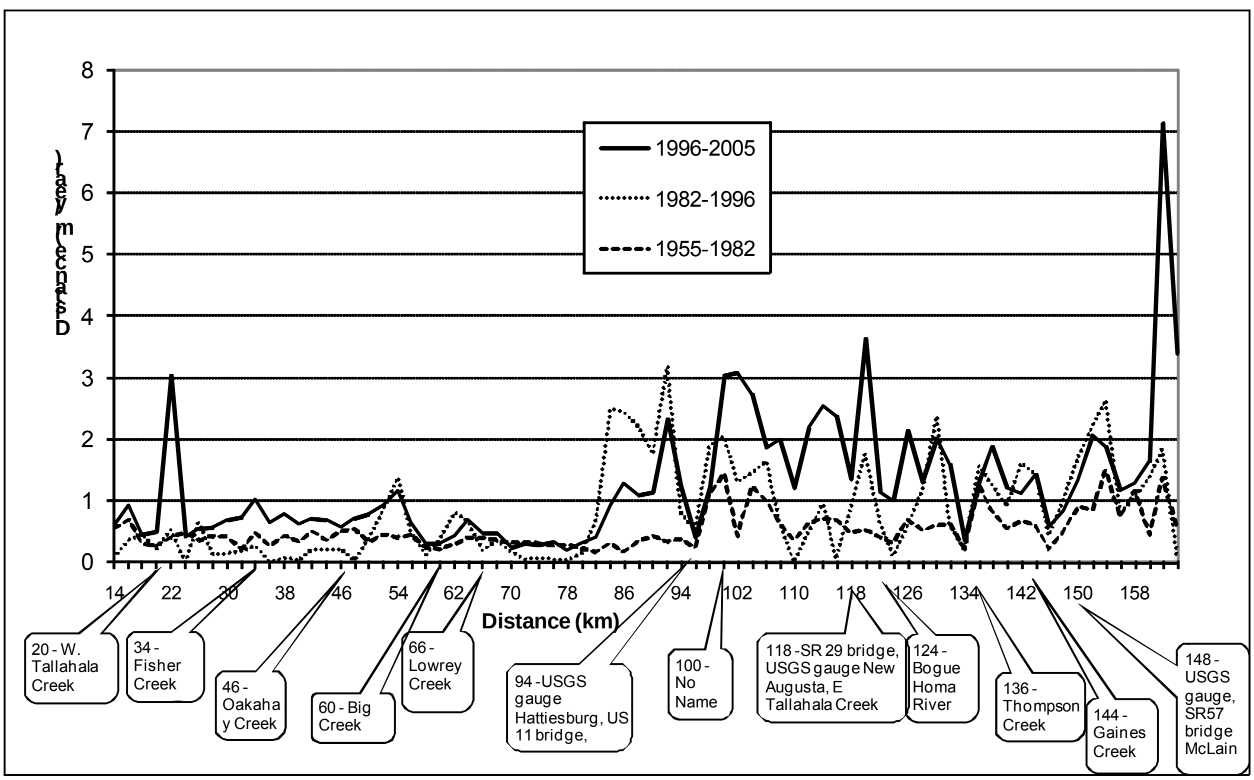

Figure 2-28. Leaf River average lateral migration per year

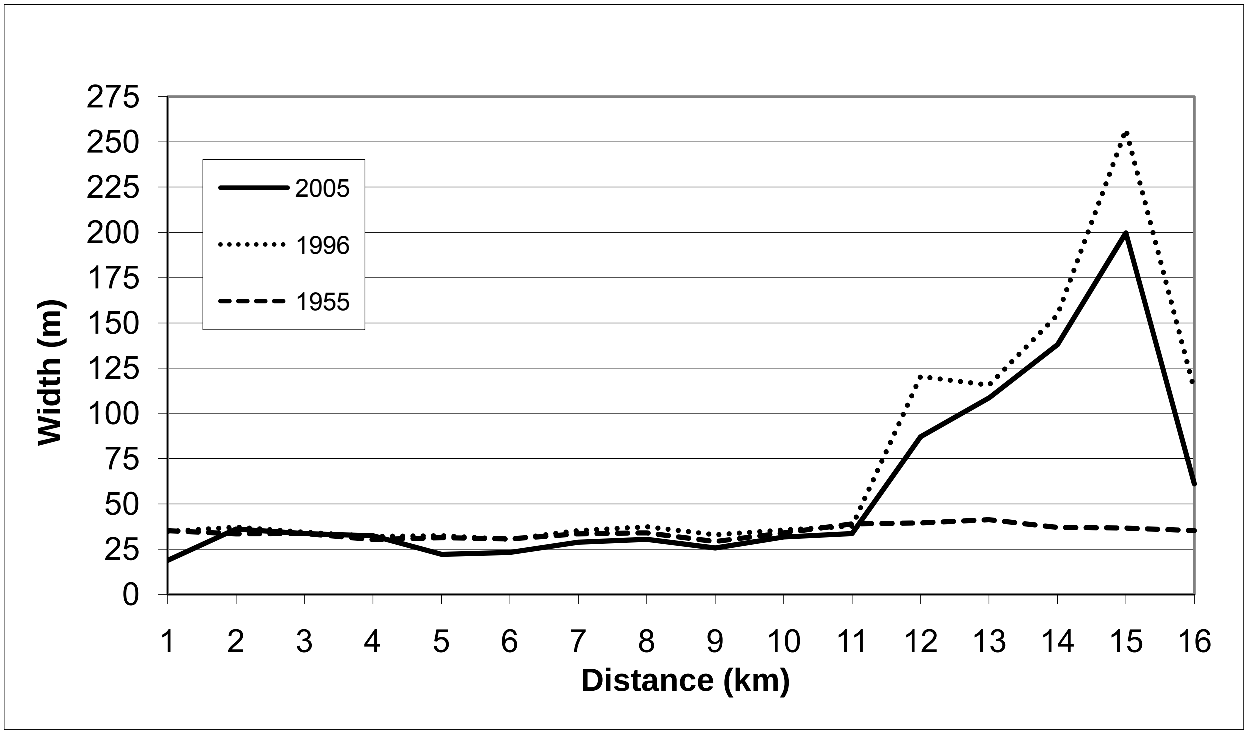

Figure 2-29. Bowie River average width

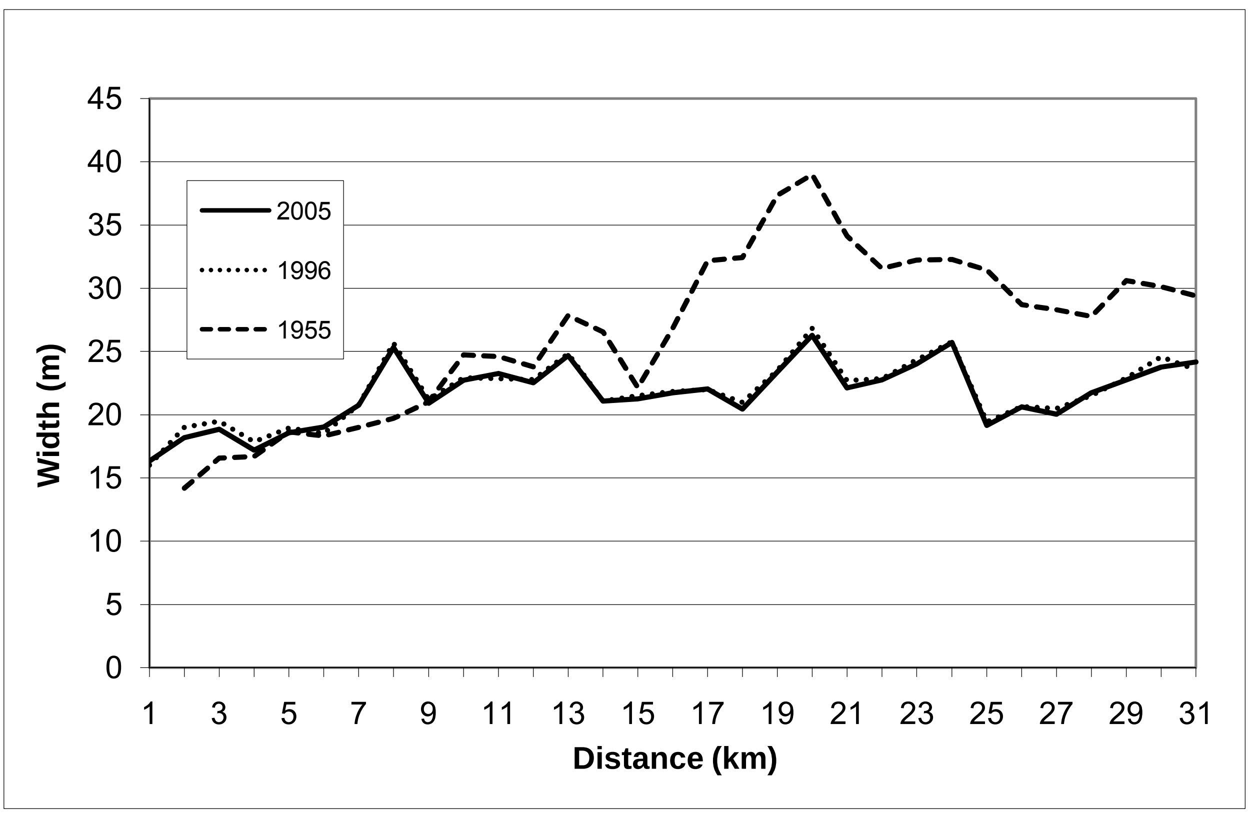

Figure 2-30. Bogue Homo River average width

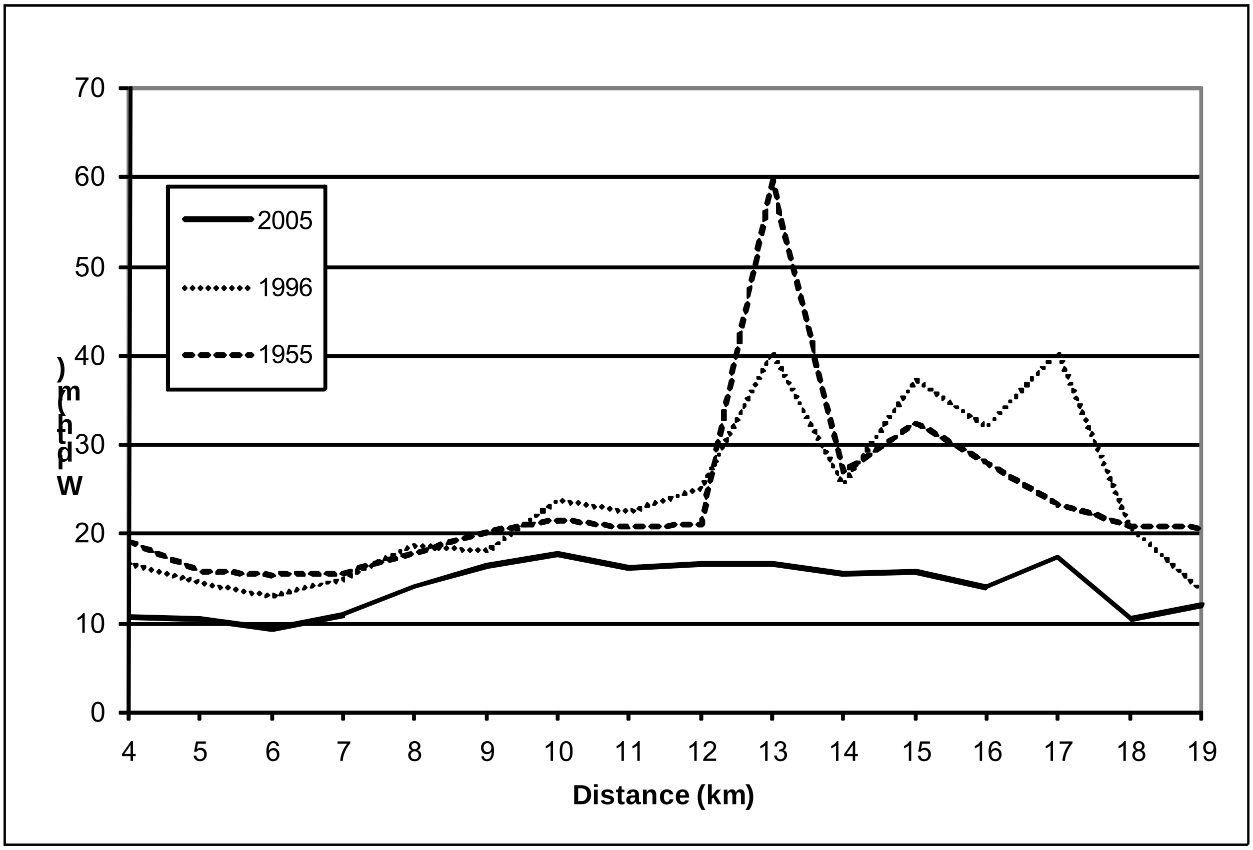

Figure 2-31. Thompson Creek average width

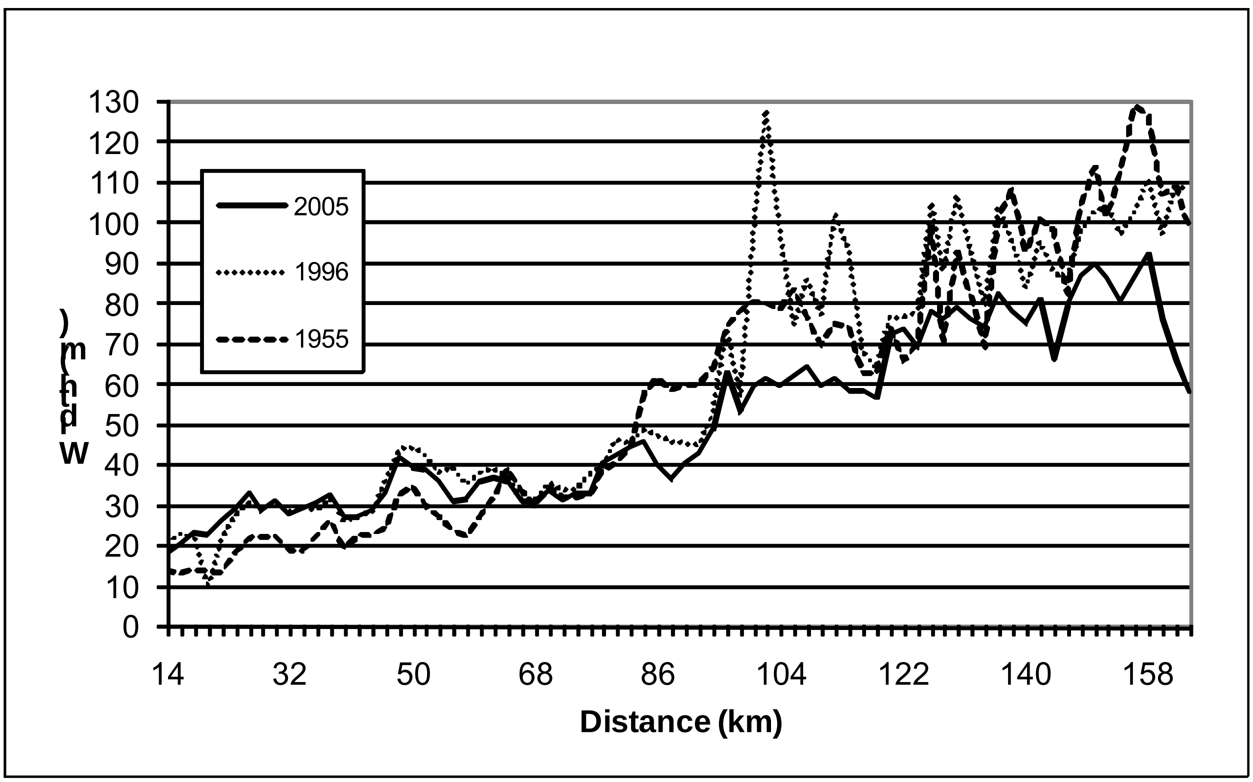

Figure 2-32. Leaf River average width

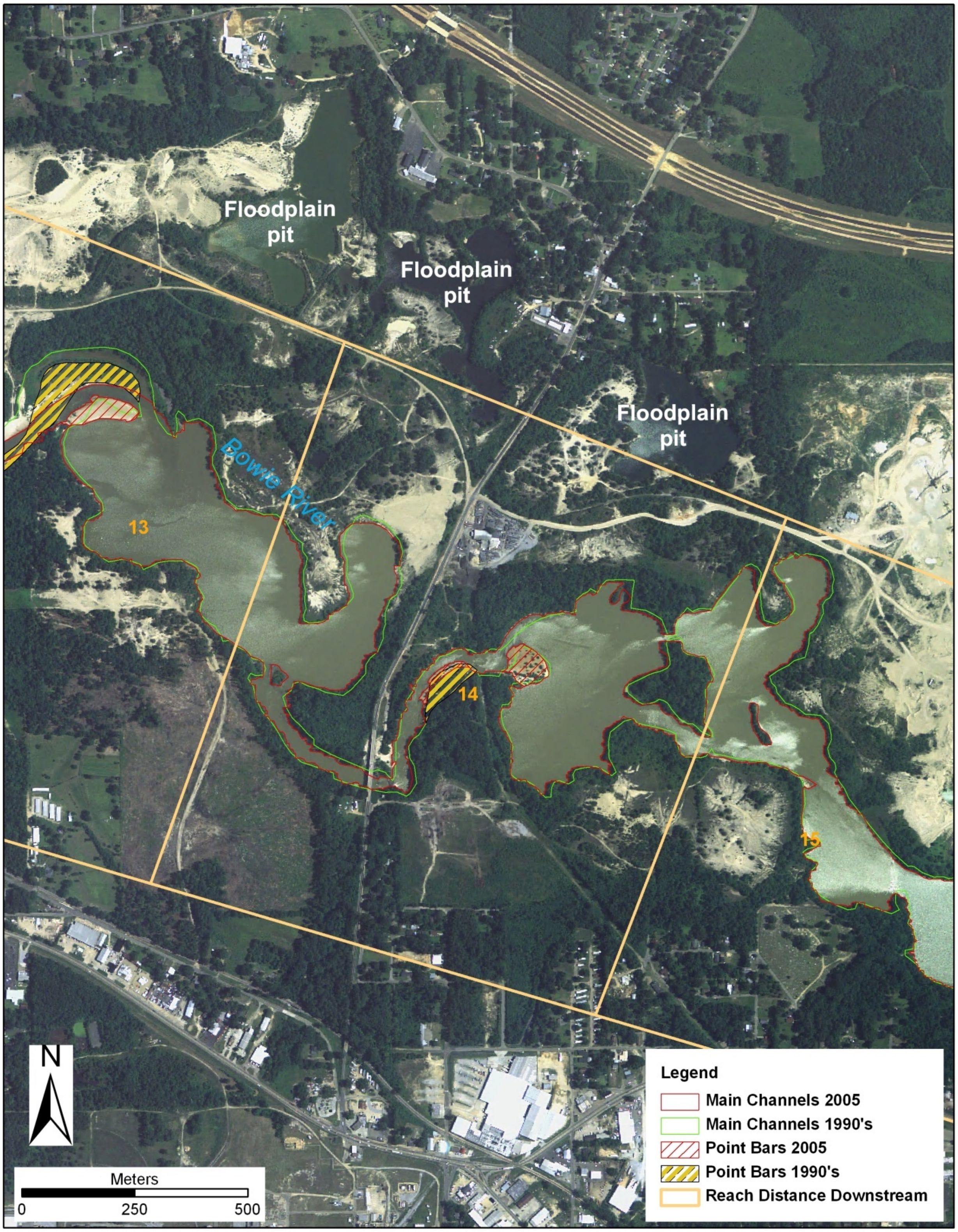

Figure 2-33. Bowie River floodplain pits in relation to river channel

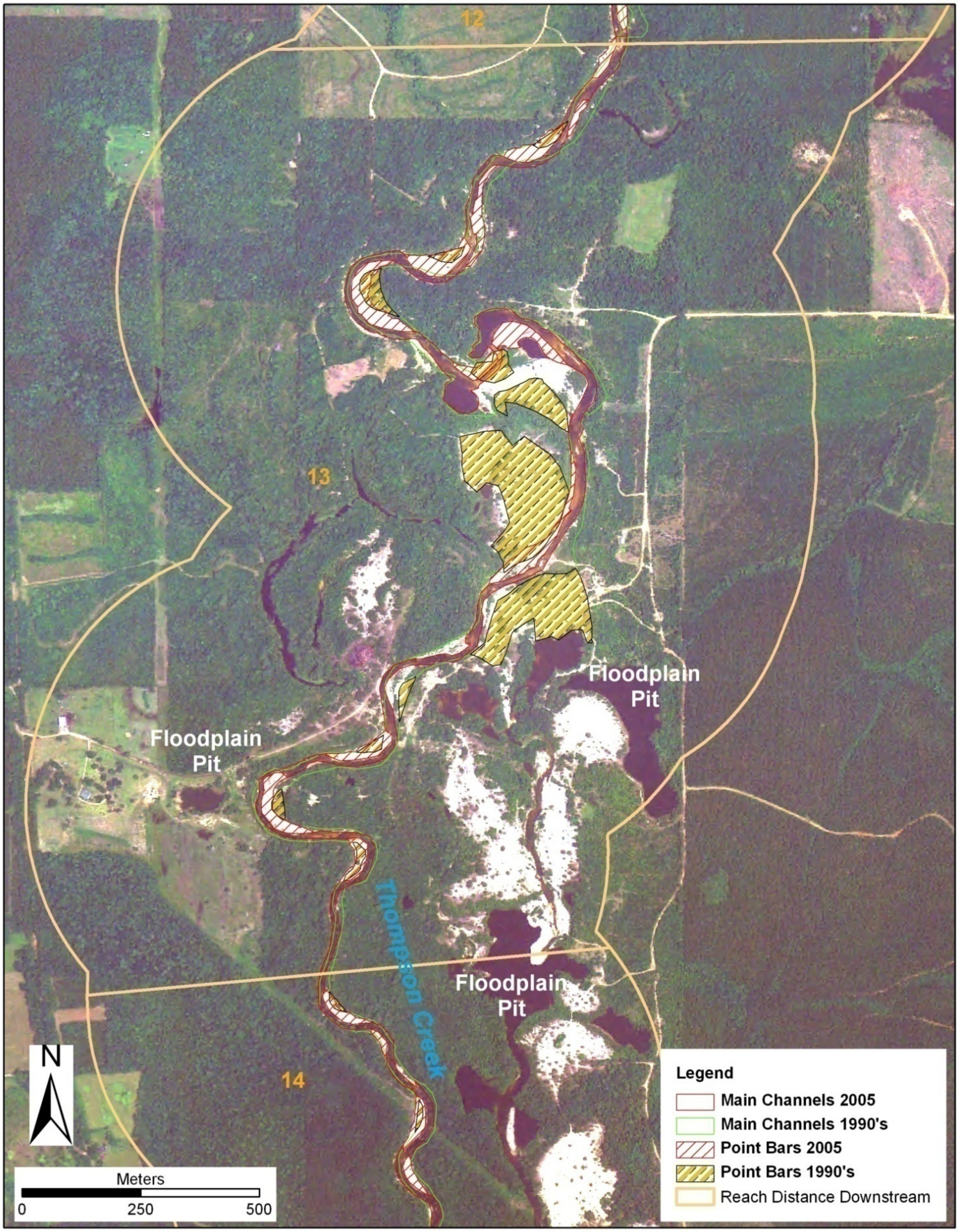

Figure 2-34. Thompson Creek floodplain pits

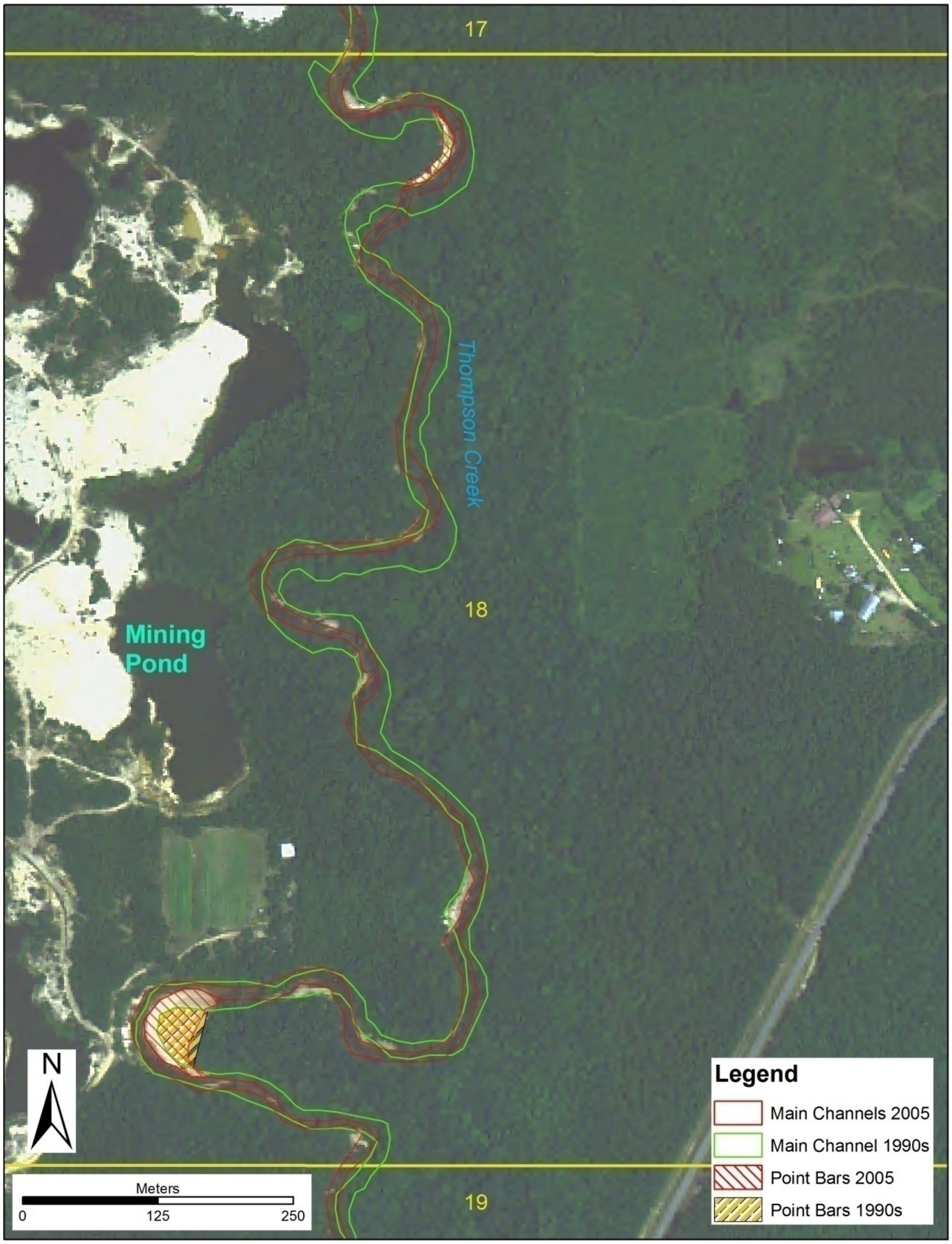

Figure 2-35. Thompson Creek mining areas

CHAPTER 3
STREAM POWER IN COMPARISON TO CHANNEL PLANFORM OCCURING ON THE LEAF RIVER, MISSISSIPPI AND TWO TRIBUTARIES

Introduction

Anthropogenic activities such as floodplain and in-stream mining leave rivers more vulnerable to various types of channel change. The purpose of this analysis was to determine if stream power had any effect on stream characteristics in river basins.

Rhodes (1987) identifies many definitions of stream power and identifies stream power as a factor in channel change. Stream power formulas generally utilize the weight of water, drainage area, slope and discharge in the calculation. As drainage area increases, discharge increases which directly affects stream power. Specific stream power adds width of the channel to the analysis and was therefore utilized in this analysis (Knighton 1999).

Brookes (1988: 172) identified streams that have specific stream power of greater than 35 ωm^{-2} as actively changing and seeking dynamic equilibrium while specific stream power in the range of 1 to 35 ωm^{-2} are stable (Brookes 1988: 98). Nanson and Croke (1992) also identified in their classification system, rivers with stream power ranges 10 to 60 ωm^{-2} as meandering streams. The Leaf River, Bogue Homo River and Thompson Creek are meandering rivers with lateral point bars. According to Nanson and Croke (1992) in their classification of rivers based on stream power and characteristics, categorizes these rivers as the medium-energy.

Because of the few gauging station located though out the research area, this analysis also considers varying methods of determining stream discharge and determine how stream powers varies downstream. The calculated stream discharge was used to calculate specific stream power for the Leaf River, Bogue Homo River and Thompson Creek, MS by 1km to 2km reaches. Changes analyzed from 1996 to 2005 on the Leaf River and two of its tributaries Bogue Homo River and Thompson Creek were used as indicators of stream change. Stream characteristics used in this analysis from the previous chapter were lateral migration, sinuosity, point bar area, and change indices. The purpose of the study is to determine if stream power is influencing any of the identified stream characteristics.

Literature Review

Studies of disturbed low stream power watersheds have identified a response to channelization as being induced by the disturbance (Urban and Rhoads 2003) even though the amount of available stream power was below the 100 ω threshold of recovery of sinuosity (Magilligan 1992) or the 35 ω level of persistent erosive adjustments (Brookes 1985).

To evaluate potential instability in alluvial rivers methods including site evaluations and GIS based input was used to evaluate the magnitude of and type of instability in the evaluation of large basin areas (Simon and Downs 1995). This method evaluated the basin using available stream power and identified a threshold between erosion and deposition and the level of critical stream power as basin area increased.

Mined streams are susceptible to incision caused by excess stream power for the amount of available sediment. The nature of channel incision in disturbed alluvial systems and some of the drivers include incision (Simon and Rinaldi 2006). Incision was placed into a broader context of drivers and resisting forces governing channel adjustment by analyzing channel changes as an imbalance between sediment load and stream power.

Stream patterns have been examined to determine with evaluated peak flows and stream power if the channel is susceptible to change over time (Schumm 1985). Morphological effects such as upstream and downstream incision of the mined areas in turn cause hydrological effects such as water table lowering and reduced flood frequency. Incision causes increased sediment downstream and reduced flow into estuaries in turn causing loss of riparian and aquatic habitat, and a variety of physical, ecological and environmental effects (Rinaldi et al. 2005).

Previous studies indicated a relationship between change such as channel migration and stream power in fluvial systems (Nanson and Hickin 1986). Richard et al. (2005) summarized the relationship between lateral migration rates and channel-form variables from previous studies (Table 3.10) and indicated as flow energy increases lateral migration rates also increase (Nanson and Hickin 1986; Lawler et al 1999). Lateral migration rates were determined to be correlated with active channel width and total stream power (Richard et al (2005).

Methods

To determine stream power the discharge of the river was calculated. A two year flood return was used as a baseline for this analysis. In most rivers this value is close to the bankfull flow (Knighton 1998) and the $Q_{1.5}$ year flood (Leopold et al. 1964).

Discharge

The two methods of calculation stream discharge were used: Landers –Wilson (1991) and Log-Pearson using peak discharge. The first step in determining stream discharge was to calculate drainage area. To accomplish this task, 10 meter resolution Digital Elevation Model (DEM) imagery were downloaded from Mississippi Automated Resource Information System (MARIS). The DEMs were combined to create one mosaic DEM for easier analysis. The DEMs were converted to raster in ArcGIS toolbox using the DEM to raster tool. The rasterized DEMs were used for the remaining analysis. ArcGIS 9.2 Spatial Analysis Hydrology tools were used to, determine flow direction, fill sinks, calculate flow accumulation, delineate watersheds, and create stream networks.

ArcHydro extension was loaded in ArcGIS to delineate sub-basin area according to the predetermined reaches. Discharge points were created where the stream intersects the reach block using the Sub-Basin tool in ArcHydro. The sub-basin area was recalculated using Hawth's Analysis Tools version 3.27 to insure accuracy in calculation. The slope of the reach was determined by calculating Rise/Run using the information tool in ArcGIS to determine the elevation value on the DEM for the stream network. The elevation value was converted from feet to meters for each reach intersection and the slope was determined by the following formula.

$$S = (E_o - E_r) / L_{cl}$$

Where S slope, E_o is the elevation at the top of the reach block, Er is the elevation at the end of the reach block, and L_{cl} is the centerline length from the beginning of the reach block to the end of the reach block. In most stream power calculations the bankfull discharge is used. The bankfull discharge has a reported recurrence interval of 1.5 years in the United States (Leopold et al. 1964).

To determine discharge for each reach block outlet, several methods were used to determine the best method. Landers and Wilson in Flood Characteristics of Mississippi Streams (1991) defines Q_2 for a drainage area greater than 800 mi^2 as $Q_2 = 131(A)^{0.97} * (S)^{0.21} * L^{-0.47}$ and for drainage areas less than 800 mi^2 for Eastern Mississippi as $Q_2 = 296\ (A)^{0.81} * (S)^{0.03} * (L)^{-0.36}$ where Q_2 is the discharge in Ft^3/ s for a two year flood return, S is slope, and L is centerline length. To make these calculations, all calculations were converted to English measurements to ensure compatibility to the Landers and Wilson document. The final calculations were converted to metric measurements for comparison to other methods.

According to the Interagency Advisory Committee on Water Data (1982), the Log-Pearson Type III Distribution is the recommended technique for flood frequency analysis. The Log-Pearson Type III distribution from the website:

http://water.oregonstate.edu/streamflow/analysis/floodfreq/index.htm

The website instructions were used as a comparison method to Landers and Wilson (1992). The Log-Pearson Type III distribution is used to fit flood frequency data to predict the design flood for a river at some site. Historic data was used to calculate bank full discharge for a two year flood return by using instantaneous peak stream flow data for the available gauging stations from the USGS website http://water.usgs.gov/nwis/peak. For details of how the Log_Pearson Type III distribution was used to calculate two year flood return discharge see Appendix B. Gauging station data used in the analysis (Table 3-1) shows the name, discharge area and the number of years of available data of the. The discharge area as specified by the USGS gauge information and historical peak discharge data was used to determine the two year flood frequency (Q_2) discharge using the Log-Pearson Type III distribution.

The flood frequency calculations for Q_2 were plotted against drainage area to determine a trend line and formula (Figures 3-1).

$$Y = 0.1437x + 70.05$$

Where Y is the Q_2 two year flood return discharge and x is drainage area.

The Q_2 discharges for all seven gauging stations were recalculated using the above formula to determine discharge. Methods of calculating stream discharge were compared for Landers-Wilson, Log-Pearson Type III and the trend line of the Log-Pearson Type III analysis (Figure 3-2). In comparison to the Landers-Wilson method the trend line of Log-Pearson Type III utilized peak stream data captured after 1990 and the Log-Pearson Type III was only calculated at available gauging stations. Since discharge for each reach outlet was required the trend line of the Log-Pearson Type III distribution was used to calculate the two year flood return discharge

Stream power

Stream power was calculated using the trend line formula $Q_2 = 0.1437x + 70.05$ for estimation of discharge with a two year flood return, slope, width and the weight of water.

$$\omega = (\gamma * Q_2 * S) / W$$

Where ω is stream power, γ is (9800 N m^{-3}) the specific weight of clear water at 10 C, where N is force measured in Newton; Q_2 is the discharge for a two year flood return at each reach block (m^3/second); S is local slope (Δ Elevation/centerline length) and W width in meters. Stream power was then compared to stream change characteristics (Table 3-2) for the Leaf River, Bogue Homo River and Thompson Creek. Slope, width and discharge varies for each defined stream reach.

Statistical Analysis

The statistical analysis was performed using SigmaPlot 11.1 software (Systat Software Inc., San Jose, CA). The Shapiro-Wilk test for normally was run for the specific stream power and slope data to determine the type of correlation to run on the stream characteristic variables. Correlations were done using the Spearman Rank Order tests because the data failed tests for normality.

Results

Except for average channel width, which was used to compute specific stream power a cursory review of the graphs did not show a strong visual correlation between stream power and stream planform characteristics on the Leaf River (Figures 3-3 to 3-9) and Thompson Creek (Figures 3-10 to 3-16). Bogue Homo River (Figures 3-17 to 3-23) appeared to act as expected for an undisturbed stream with low specific stream power variables (Schumm 1985, Magilligan 1992).

For the Leaf River (Figure 3-3) stream power was in the range of 75 to 120 ω indicating active channel change (Brookes 1985). The upper Leaf River from km 14 to km 60 fluctuated around an average of 90 ω. At km 60 to 78 specific stream power increases to 120 ω and then decreases to 80 ω at km 80. The middle Leaf River from km 80 to 94 shows a peak in specific stream power of 110 ω upstream of the confluence of the Bowie River and after the confluence the stream power goes down to an average of just below 80 ω. At the beginning of the lower reaches of the Leaf River, specific stream power again peaks to 110 ω at km 114 and settles to an average specific stream power of 100 ω to km 144. When comparing specific stream power to slope of the Leaf River channel stream, the variation of stream power throughout the basin did not appear to have a visual correlation.

The Bogue Homo River (Figure 3-17) had a stream power calculation range from 19 ω to 13 ω indicating little work occurring. In areas identified with increasing point bar areas stream power did not fluctuate. The increase in point bar area possibly indicates the additional of sediment possibly coming from Tiger Creek.

Thompson Creek (Figure 3-10) stream power increased at the beginning of the analyzed area from 145 to 165 ω at km 5 to 6. The mined areas of the stream at km 10 to 16 showed a slow increase in stream power from 85 to 105 ω. Stream power increased notability to 140 ω near the confluence with the Leaf River. When plotting specific stream power against slope through the basin the mined areas with variable slope through the mined areas (km10 to 16) showed a flattening of stream power at 90 ω even when the slope increased slightly through the reach.

Stream power was plotted against slope (Figures 3-24 to 3-27) for the basin. The upper Leaf River appeared to correspond to an increase in slope with increased specific stream power downstream until the lower section of the reach at km 66 where Lowrey Creek joins the drainage area. At this confluence stream power appears to increase from 80 ω to 120 ω. The middle Leaf River slope appeared to flatten even though the stream power was increasing with no increase in drainage area just upstream of the Bowie River confluence. The middle Leaf River section ends with the addition of East Tallahala Creek at km 114. The lower Leaf River specific stream power assumes a downward trend of stream power as the river widens downstream.

The middle Leaf River showed a variation from the upper Leaf River where the slope stayed consistent but stream power increased. This same pattern was seen in the lower Leaf River and in Thompson Creek (Figure 24). This may indicate slope as not being a factor in the change in stream power but is expected in the lower reaches of a stream due to hydraulic geometry downstream.

Bogue Homo River showed a specific stream power level between 13 to 17 ω resulting in an expected trend of specific stream power lowering going downstream (Figure 3-26) even with fluctuating widths, slope and discharge. When comparing the Bogue Homo River specific stream power to the Leaf River upper reaches, some of the differences seen are related to scale. The Bogue Homo River is 31 km long while the upper reaches of the Leaf River is over 80 km long. More variation will occur when you have a longer reach with more small tributaries entering into the system causing the variation seen in the Leaf River specific stream power analysis.

When specific stream power was plotted against slope for Thompson Creek varying levels of stream power 85 to 180 ω were identified for the same slope. In the mined reaches between km 10 to 16 the stream widens and specific stream power lowers dramatically just upstream of the mined reach of 105 ω to 85 ω in the mined reaches. Stream power increases to over 140 ω just downstream of the mined reaches.

Statistical Analysis

In order to quantify the results a statistical analysis was necessary to create any conclusions on the analyzed rivers. A test for normality was run for the three rivers for slope and specific stream power (Table 3-3) and failed for Leaf River slope and Thompson Creek specific stream power. Normality test indicated Spearman Rank Order correlation had to be used in the analysis.

Statistical analysis was run for slope, specific stream power, sinuosity, point bar area, change indices and average lateral migration for the three rivers analyzed. Spearman Rank Order Correlation was used because the strength of association needed to be determined and the all data being compared was not normally distributed.

The Leaf River upper reaches (km 14 to 80) showed lateral migration, sinuosity and erosion change indices as significant to the 90th percentile when compared to specific stream power. Lateral migration and erosion change indices showed a moderate negative correlation, while sinuosity showed a moderate positive correlation. The middle reaches of the Leaf River (km 41 to 114) between and erosion change indices showed statistical significance to the 90th percentile when compared to specific stream power. Between change indices showed a relatively strong positive correlation to specific stream power and erosion change indices showed a strong positive correlation when compared to specific stream power. The lower Leaf River (km 116 to 158) showed no characteristics significant to specific stream power.

The Bogue Homo River showed erosion change indices as being significant to the 90 percentile when compared to specific stream power and a moderate positive correlation to specific stream power.

Thompson Creek lateral migration and point bar area showed significance to the 90th percentile when compared to specific stream power. Both had a strong negative correlation when compared to specific stream power.

Comparing stream power to stream change characteristics for mined rivers was visually inconclusive. However for streams with stream power above 70 ω to 120 ω, slope is not as evident as on the Leaf River that stream power was a determining factor. Thompson Creek has stream power between 80 ω to 180 ω but the slope was relatively the same for this range of stream power varying from 0.001 and 0.0012 mm^{-1}. The same was determined for Thompson Creek (Figures 3-10 to 3-16) with a stream power calculation in the range of 90 to 170 ω. The Leaf River and Thompson Creek have active change occurring as determined by the stream change characteristics.

Discussion

In the basin analyzed, low power streams with an external source of disturbance did concur with Urban and Rhoads (2003) as being not conducive to rapid channel change. Stream with stream power above 100 ω showed significant changes occurring especially in areas that were undisturbed but showed little lateral migration and sinuosity. Streams with the highest stream power did not indicate an increase in slope or channel width as the cause of increasing stream power. Mined steams showed a lower level of stream power in the mined reaches due to widening of the channel in the mined reaches. Upstream of the mined reaches did not show significant narrowing but downstream of the mined reach did show a narrower channel. The stream power threshold between erosion and deposition did show significance in areas of the stream that indicated erosion due to large mined areas in an adjacent stream.

Stream pattern was necessarily not a predictor of stream power. Areas with high levels of stream power (above 100 w) did not show significance when compared to sinuosity either in undisturbed or disturbed landscapes. The disturbed landscapes did indicate a pattern and level of moderate stream power that has a relatively low stability factor (Schumm 1985).

Utilizing a basin model to evaluate stability may not show the individual characteristics of a human disturbed landscape. A large model may be a starting point but could not be the only method for predicting change that occurs within individual streams in the basin.

Conclusions

Stream power showed to be a useful tool in determining the amount of stability in a stream basin. This comparison is limited by the unpredictable characteristics of in-stream mining areas. Further study could include evaluation of width depth ratios and stream power in mined areas. Geology and vegetation, which provide resistance, must also be evaluated to determine how stream power is restricted with constrained areas of stream with in-stream mining.

In mined rivers stream power in relation to hydraulic geometry downstream is changed because of the human induced changes that occur in the stream basin. Some of the in-stream mining pits can be shallow or very deep causing unpredictable results when calculation specific stream power. Perhaps a better method should have been using channel depth measurements to more accurately calculating the amount of stream power through the mined reaches.

Table 3-1. Peak discharge data at USGS gauging stations

Gauging Station	River	Years	Entries
Near Collins	Leaf	1900-2006	70
Hattiesburg	Leaf	1900-2006	103
Near Mclain	Leaf	1900-2006	68
Near New Augusta	Leaf	1900-2006	29
Near Raleigh	Leaf	1900-2006	55
Near Taylorsville	Leaf	1900-2006	42
Near Richton	Thompson	1998-2006	9

Table 3-2. Stream change characteristics

Characteristic
Width
Point Bar Area
Change Indices
Sinuosity
Lateral Migration

Table 3-3. Shapiro-Wilk Test for normality

	W-Statistic	P	Result
Leaf River Slope reach 1-40	0.913	0.010	Failed
Leaf River Slope reach 41-57	0.967	0.763	Passed
Leaf River Slope reach 58-79	0.939	0.188	Passed
Leaf River Specific Stream power reach 1-40	0.921	0.017	Failed
Leaf River Specific Stream power reach 41-57	0.899	0.066	Passed
Leaf River Specific Stream power reach 58-79	0.932	0.134	Passed
Bogue Homo River Slope	0.966	0.493	Passed
Bogue Homo River Specific Stream power	0.966	0.493	Passed
Thompson Creek Slope	0.959	0.677	Passed
Thompson Creek Specific Stream power	0.847	0.016	Failed

Table 3-4. Leaf River reaches 7-40 Spearman Rank Order Correlation in comparison to stream power

	Lat Mig	Sinuosity	PB area	CI 96-05 B	CI 96-05 D	CI 96-05 E	CI 96-05 U
Corr Coeff	-0.423	0.418	-0.167	-0.0996	-0.269	-0.441	0.269
P Value	0.0129	0.0141	0.344	0.572	0.122	0.00922	0.122
# Samples	34	34	34	34	34	34	34

Table 3-5. Leaf River reaches 41-57 Spearman Rank Order Correlation in comparison to stream power

	Lat Mig	Sinuosity	PB area	CI 96-05 B	CI 96-05 D	CI 96-05 E	CI 96-05 U
Corr Coeff	-0.225	0.346	0.221	0.606	-0.152	0.809	0.152
P Value	0.377	0.169	0.387	0.00988	0.553	0.0000002	0.553
# Samples	17	17	17	17	17	17	17

Table 3-6. Leaf River reaches 58-79 Spearman Rank Order Correlation in comparison to stream power

	Lat Mig	Sinuosity	PB area	CI 96-05 B	CI 96-05 D	CI 96-05 E	CI 96-05 U
Corr Coeff	-0.0457	0.214	-0.351	0.198	0.0096	0.333	-0.0096
P Value	0.836	0.334	0.108	0.372	0.964	0.128	0.964
# Samples	22	22	22	22	22	22	22

Table 3-7. Bogue Homo River Spearman Rank Order Correlation in comparison to stream power

	Lat Mig	Sinuosity	PB area	CI 96-05 B	CI 96-05 D	CI 96-05 E	CI 96-05 U
Corr Coeff	0.311	-0.0372	-0.135	0.222	-0.0855	0.498	0.0855
P Value	0.113	0.851	0.498	0.262	0.668	0.00841	0.668
# Samples	27	27	27	27	27	27	27

Table 3-8. Thompson Creek Spearman Rank Order Correlation in comparison to stream power

	Lat mig	Sinuosity	PB Area	CI 96-05 B	CI 96-05 D	CI 96-05 E	CI 96-05 U
Corr Coef	-0.789	0.429	-0.836	-0.075	-0.411	0.075	0.411
P Value	0.0000002	0.107	0.0000002	0.783	0.124	0.783	0.124
#Samples	15	15	15	15	15	15	15

Table 3-9. Confluence and mining pond list

River	Intersecting Stream	Location (km)
Leaf River	West Tallahala Creek	20
Leaf River	Fisher Creek	34
Leaf River	Oakahay Creek	46
Leaf River	Big Creek	60
Leaf River	Lowrey Creek	66
Leaf River	Bowie River	94
Leaf River	No Name Creek	100
Leaf River	East Tallahala Creek	118
Leaf River	Bogue Homo River	124
Leaf River	Thompson Creek	136
Leaf River	Gaines Creek	144
Bogue Homo River	Tiger Creek	8
Bogue Homo River	Buck Creek	18
Thompson Creek	Mining pond	6
Thompson Creek	Mining ponds	10 to 16

Table 3-10. Summary of published relationships between lateral migration rates and other parameters. Adapted from Richard et al. 2005.

Source	Significant Relationship	Additional notes	Definitions
Hooke (1979)	M ~ Q_{peak}, API		M = migration rate API = antecedent precipitation index
Hooke (1980)	M ~ A		A = drainage area
Nanson and Hickin (1983)	M ~ Q and S M ~ W and S	Also identified bank texture, planform and sediment supply rate as important	S = slope W = width
MacDonald (1991)	M ~ Q		Q = discharge
Lawler et al. (1999)	M ~ L	Also found stream power and bank material to be important	L = distance downstream
Richard et al. (2005)	M ~ W M ~ QS		QS = total stream power

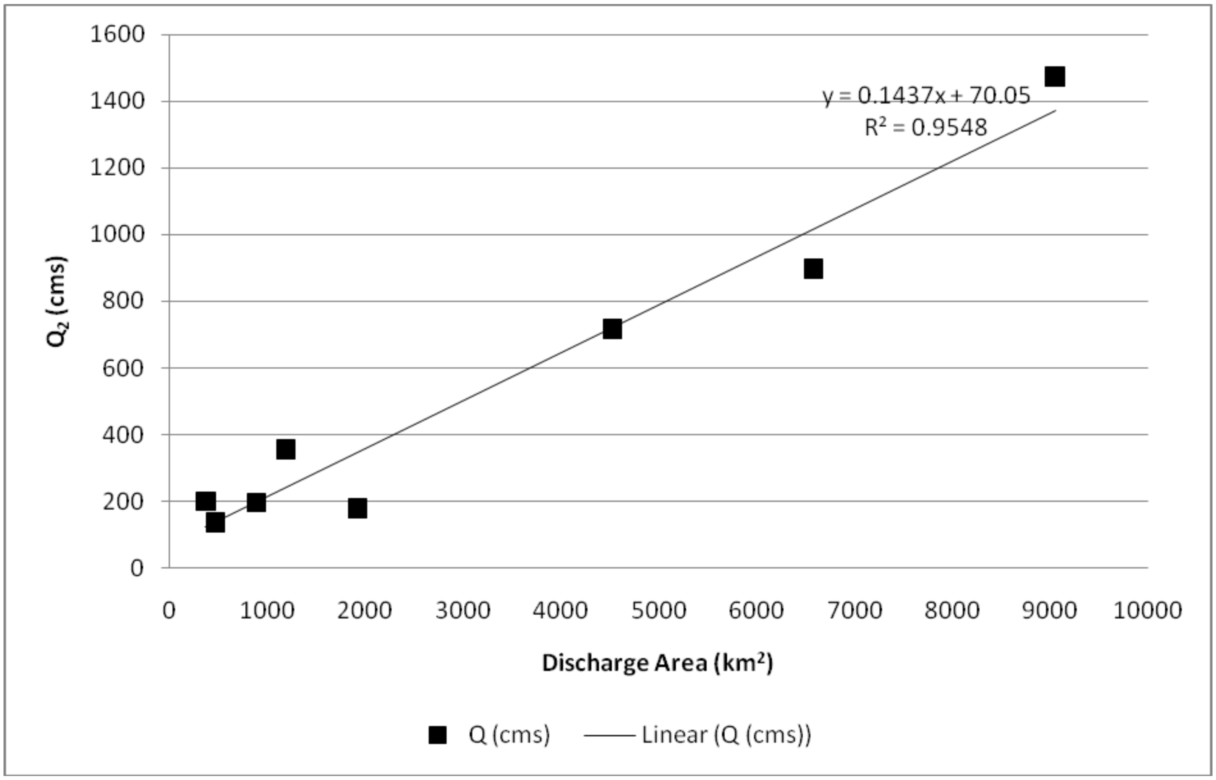

Figure 3-1. Two year flood return for USGS gauge stations calculated using Log-Pearson Type III distribution vs drainage area measured at gauge stations

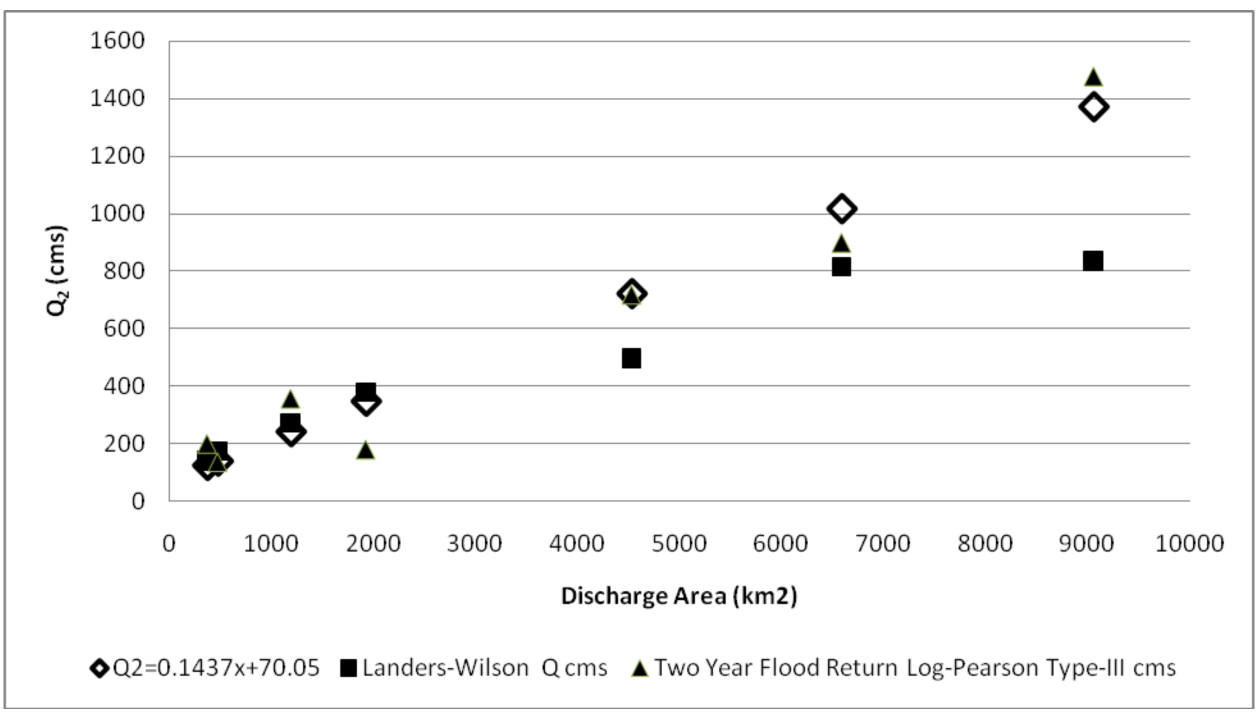

Figure 3-2. Comparison of discharge calculations methods

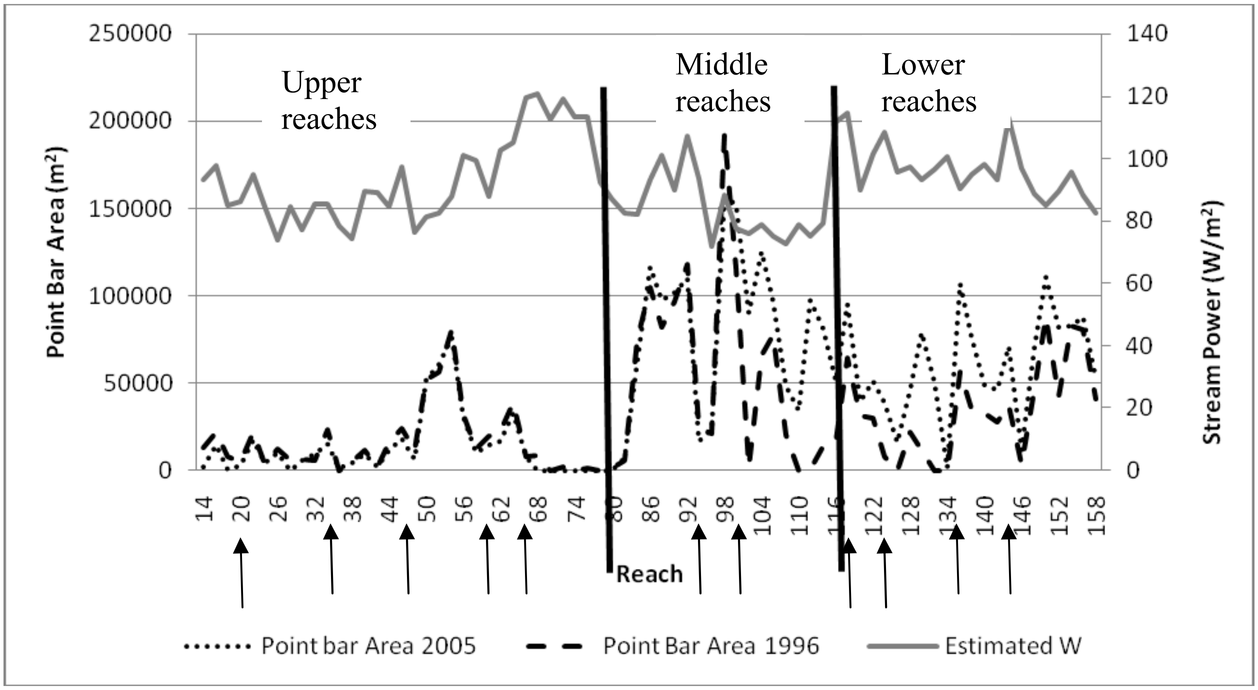

Figure 3-3. Point bar area vs stream power for Leaf River. For notes on arrows see Table 3-9.

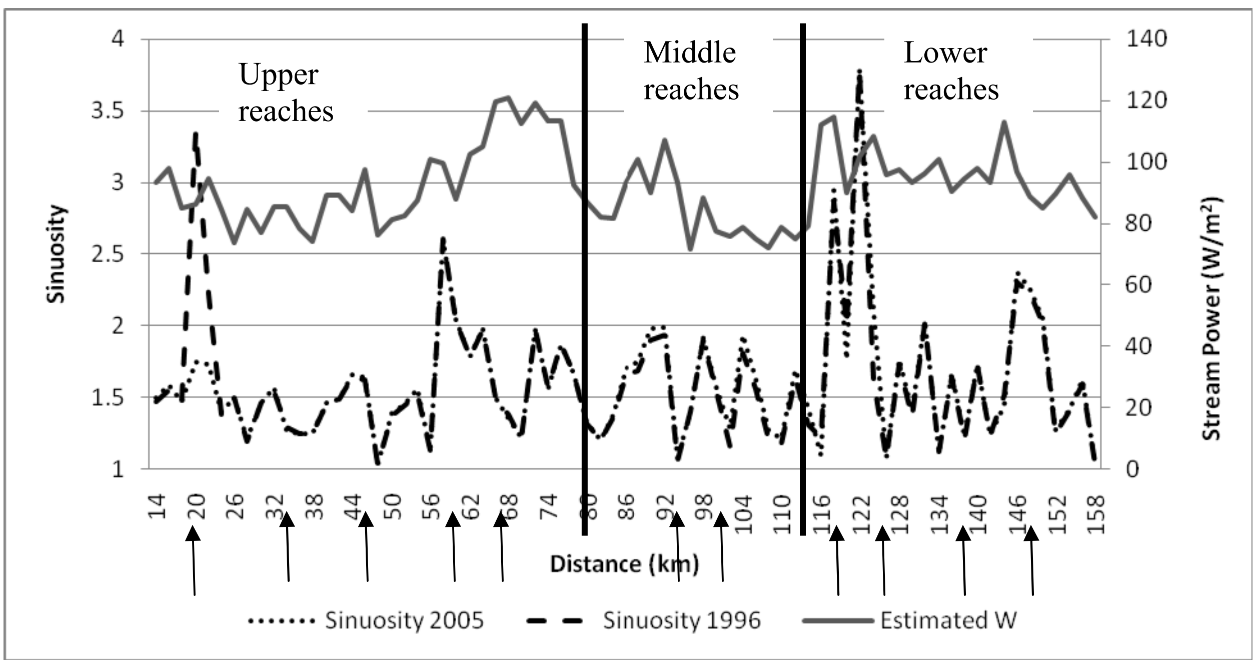

Figure 3-4. Sinuosity vs stream power for Leaf River. For notes on arrows see Table 3-9.

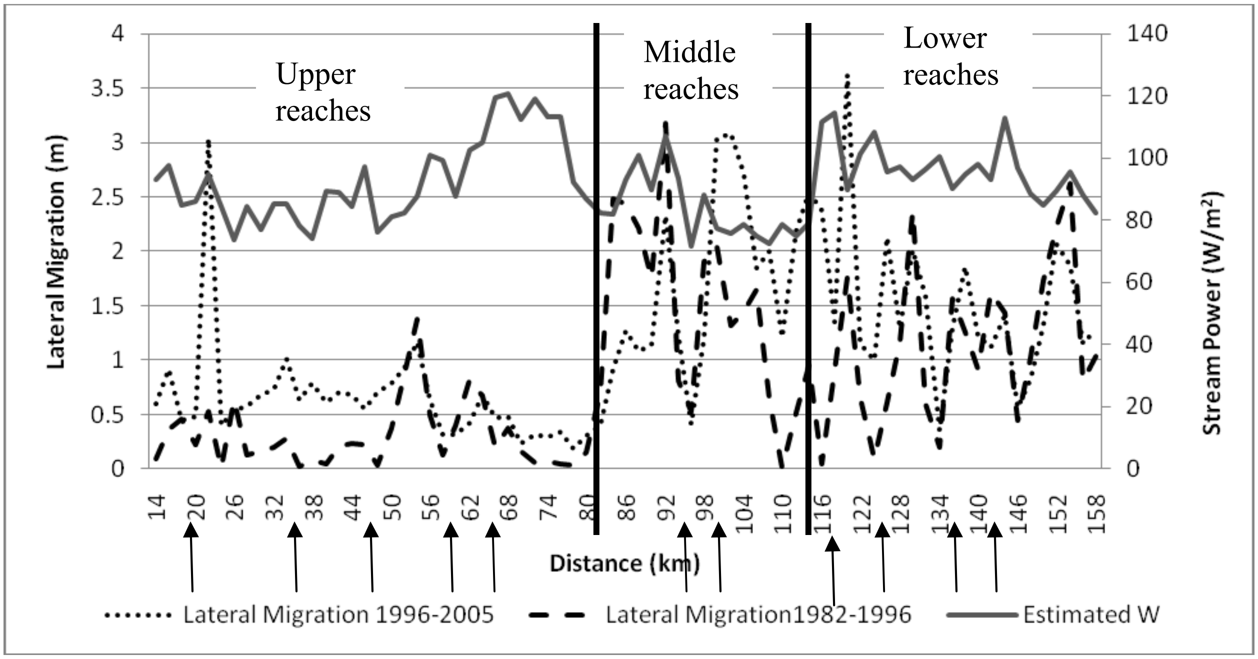

Figure 3-5. Lateral migration vs stream power for Leaf River. For notes on arrows see Table 3-9.

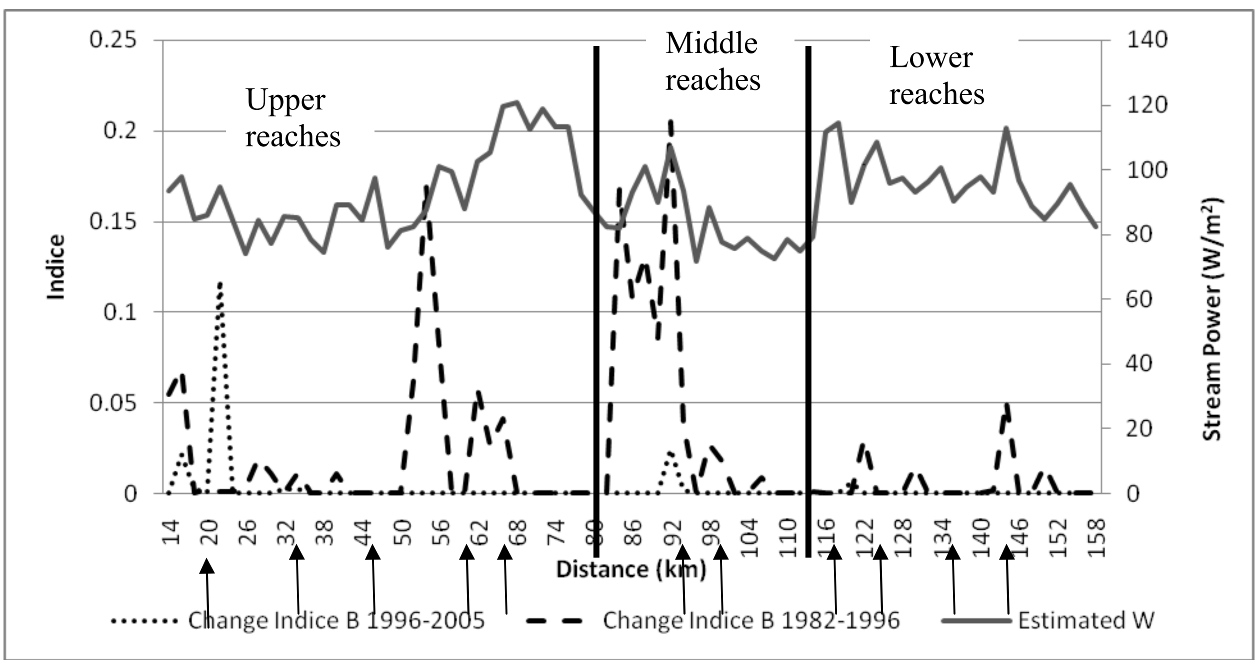

Figure 3-6. Between change indices vs stream power for Leaf River. For notes on arrows see Table 3-9.

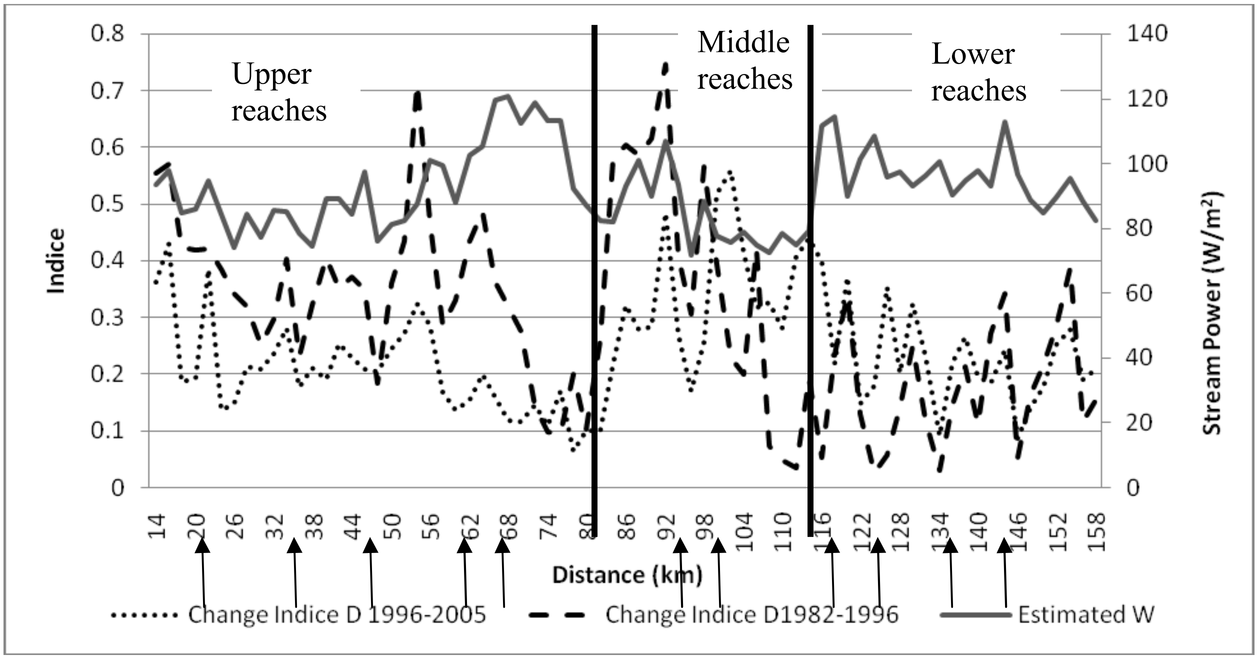

Figure 3-7. Deposition change indices Leaf River vs stream power. For notes on arrows see Table 3-9.

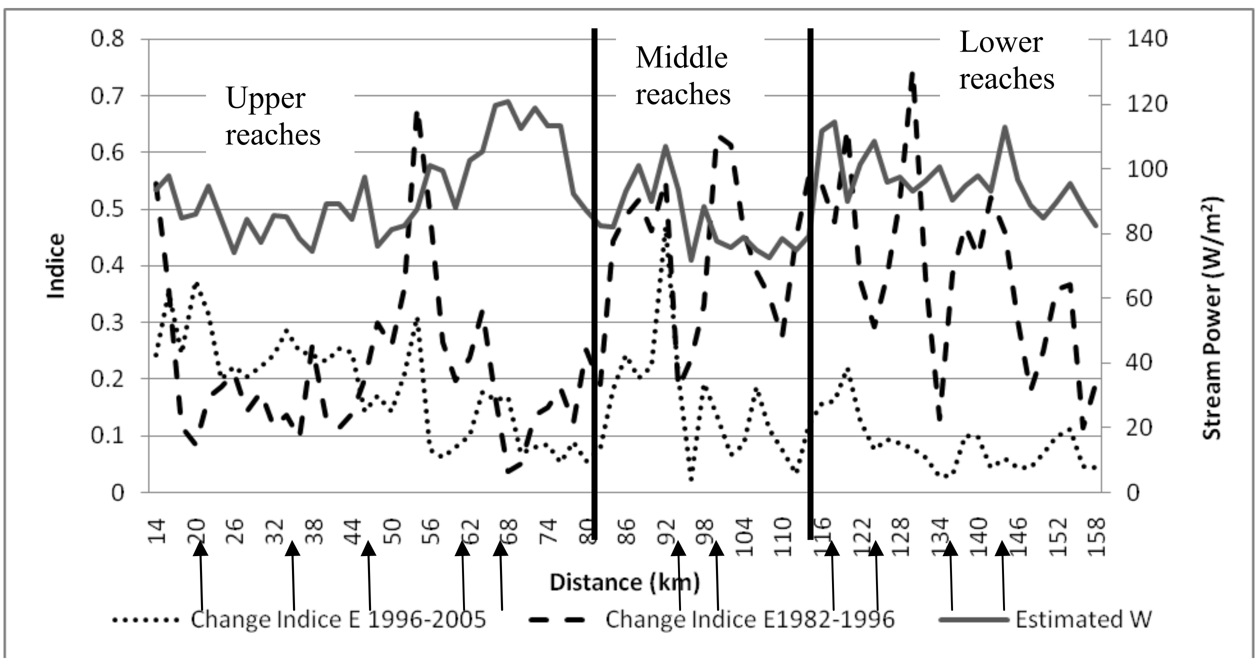

Figure 3-8. Erosion change indices Leaf River vs stream power. For notes on arrows see Table 3-9.

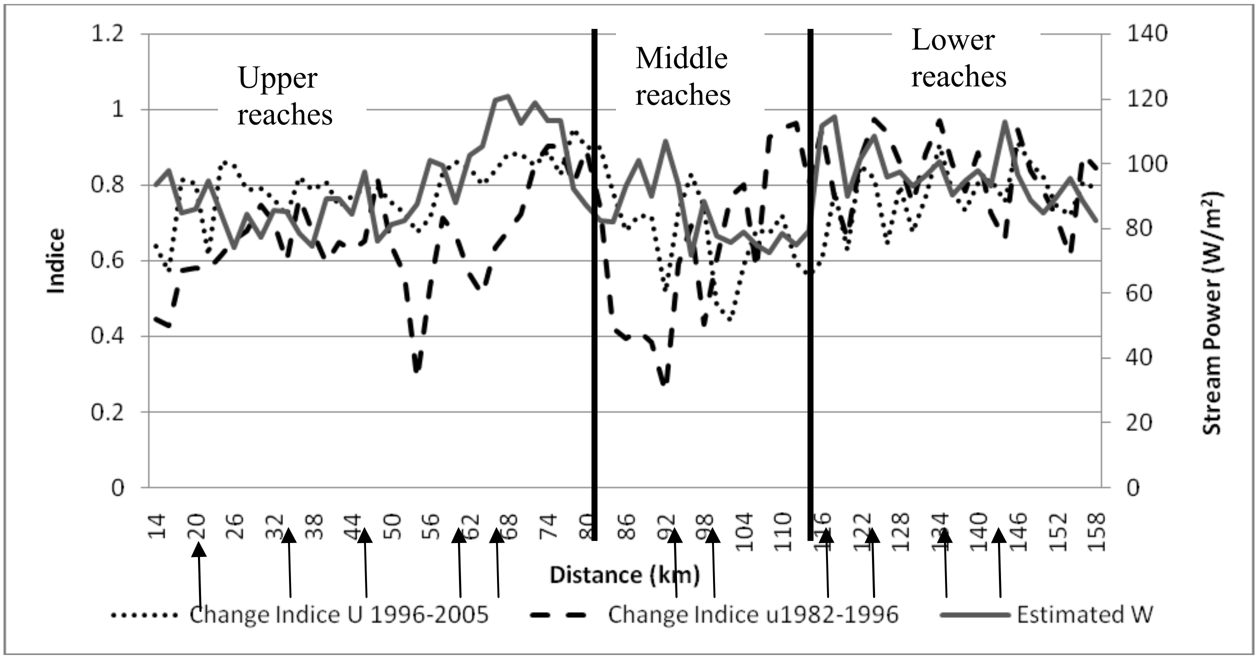

Figure 3-9. Unchanged change indices vs stream power for Leaf River. For notes on arrows see Table 3-9.

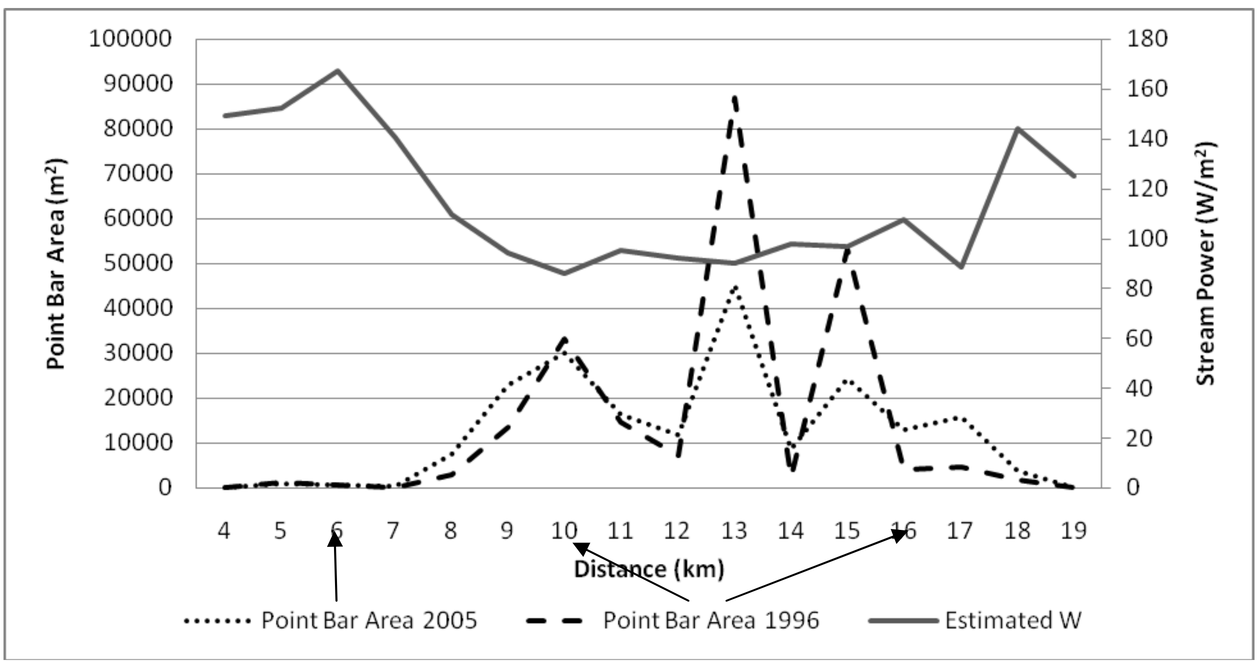

Figure 3-10. Point bar area vs stream power for Thompson Creek. For notes on arrows see Table 3-9.

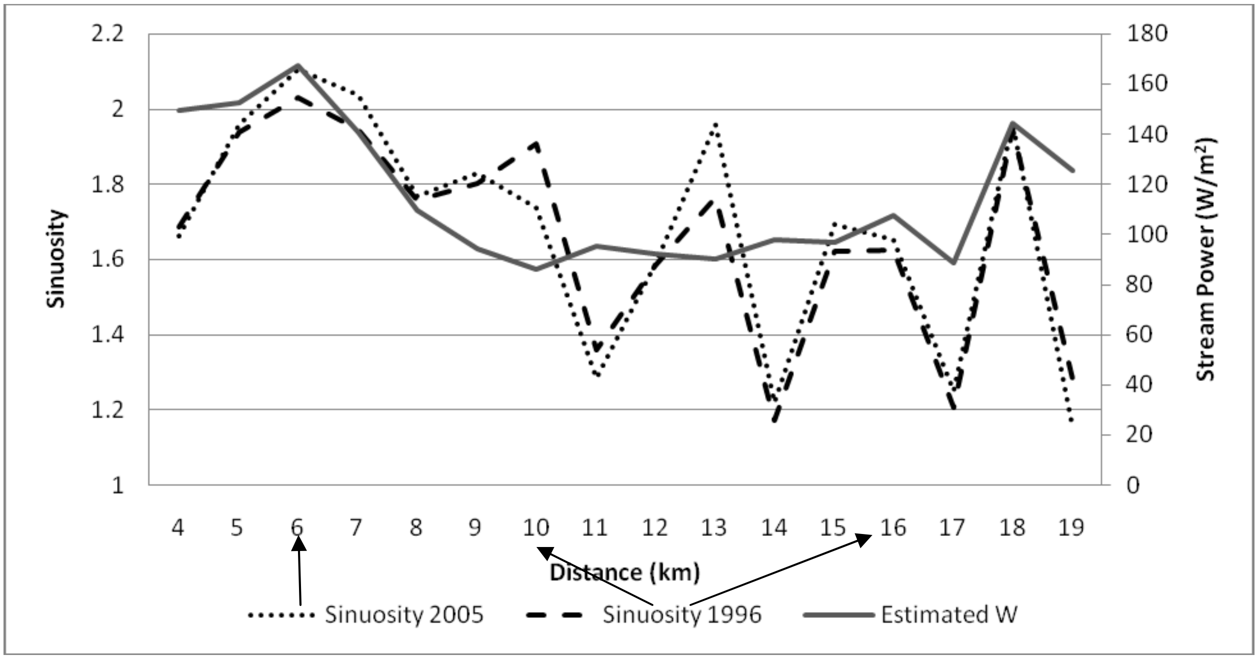

Figure 3-11. Sinuosity vs stream power for Thompson Creek. For notes on arrows see Table 3-9.

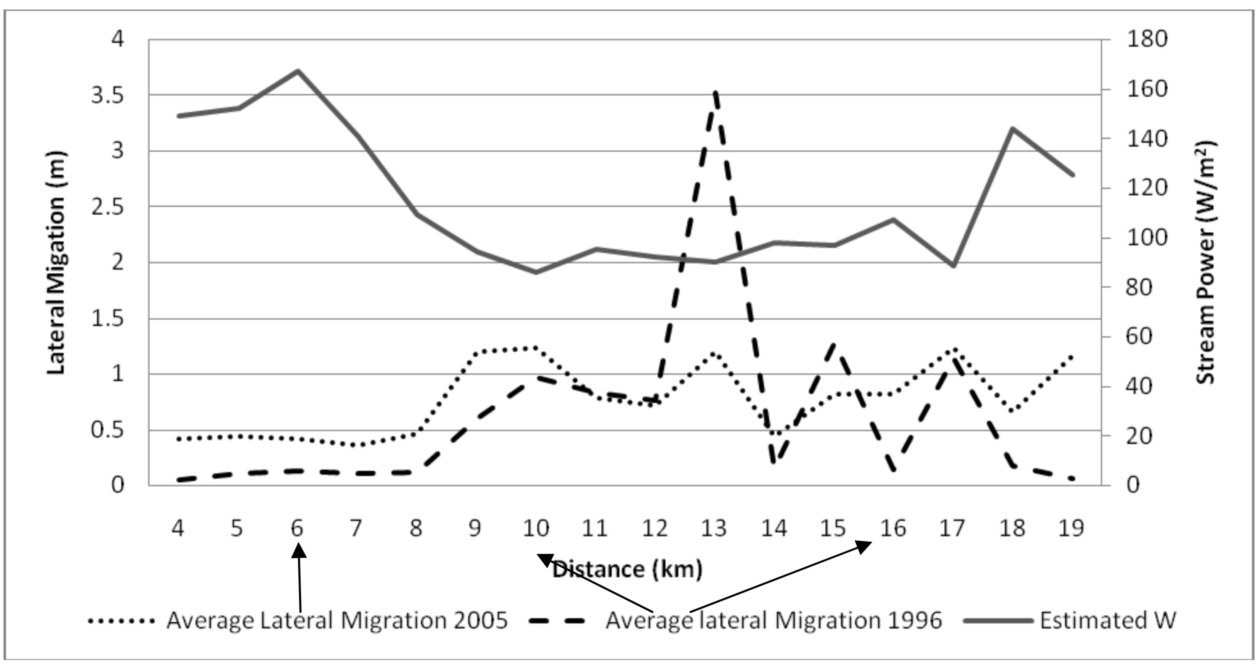

Figure 3-12. Average lateral migration vs stream power for Thompson Creek. For notes on arrows see Table 3-9.

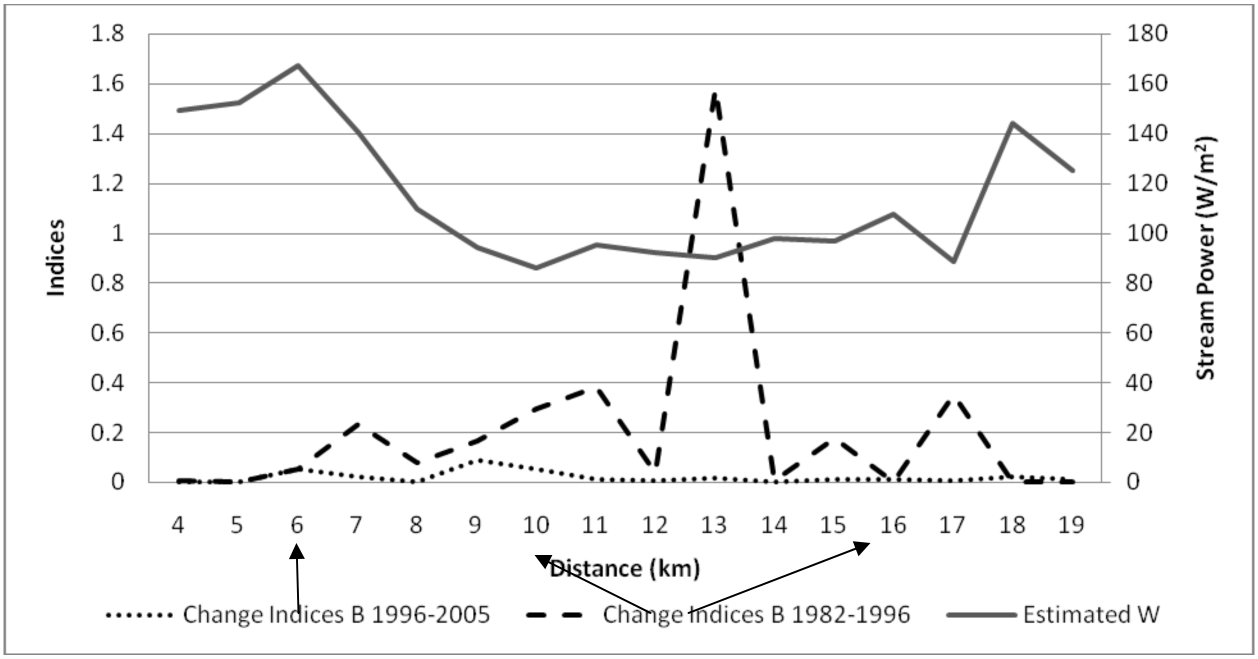

Figure 3-13. Between change indices vs stream power for Thompson Creek. For notes on arrows see Table 3-9.

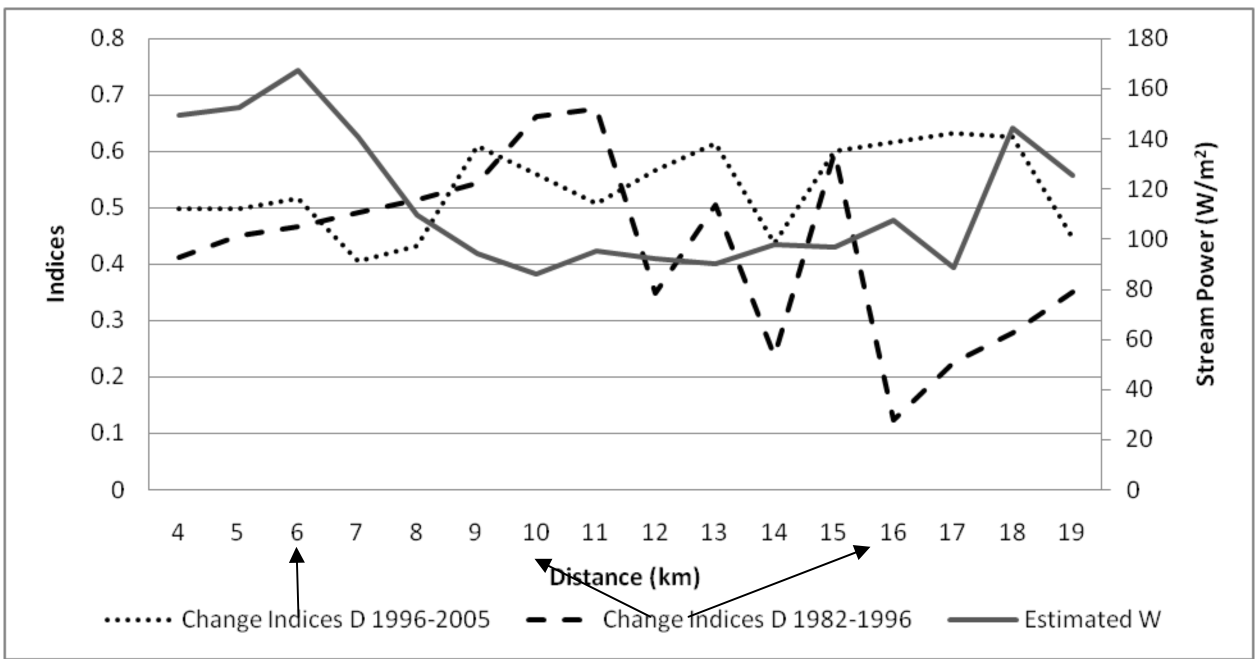

Figure 3-14. Deposition change indices vs stream power for Thompson Creek. For notes on arrows see Table 3-9.

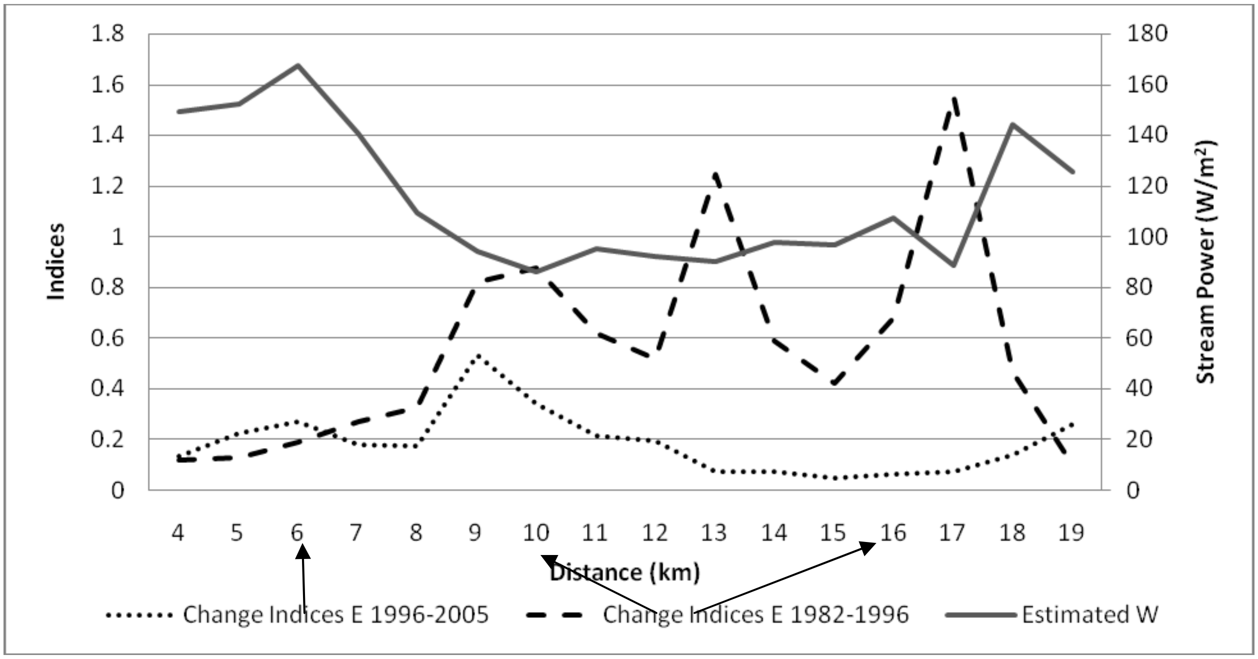

Figure 3-15. Erosion change indices vs stream power for Thompson Creek. For notes on arrows see Table 3-9.

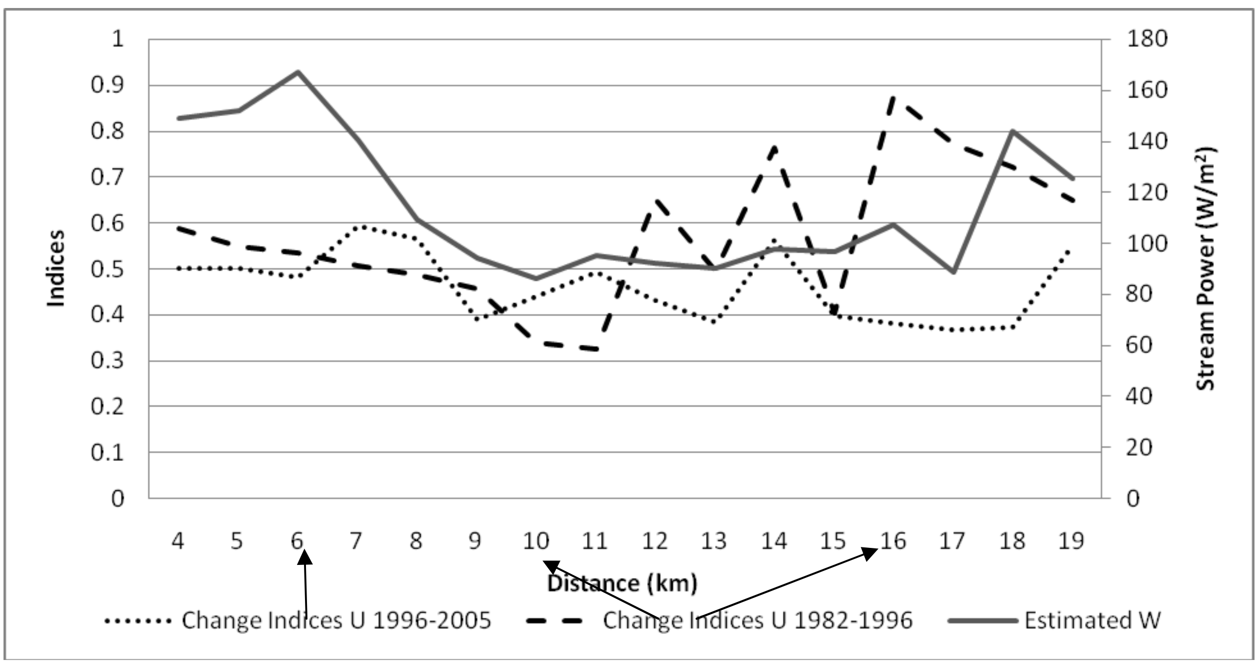

Figure 3-16. Unchanged change indices vs stream power for Thompson Creek. For notes on arrows see Table 3-9.

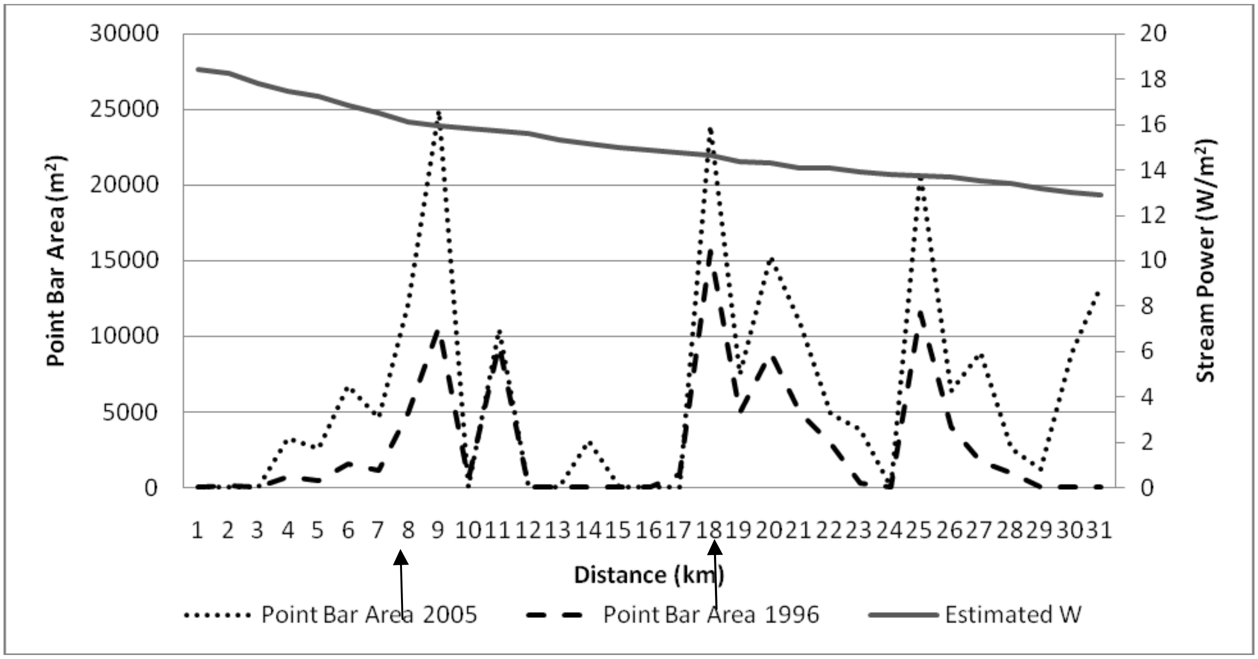

Figure 3-17. Point bar area vs stream power for Bogue Homo River. For notes on arrows see Table 3-9.

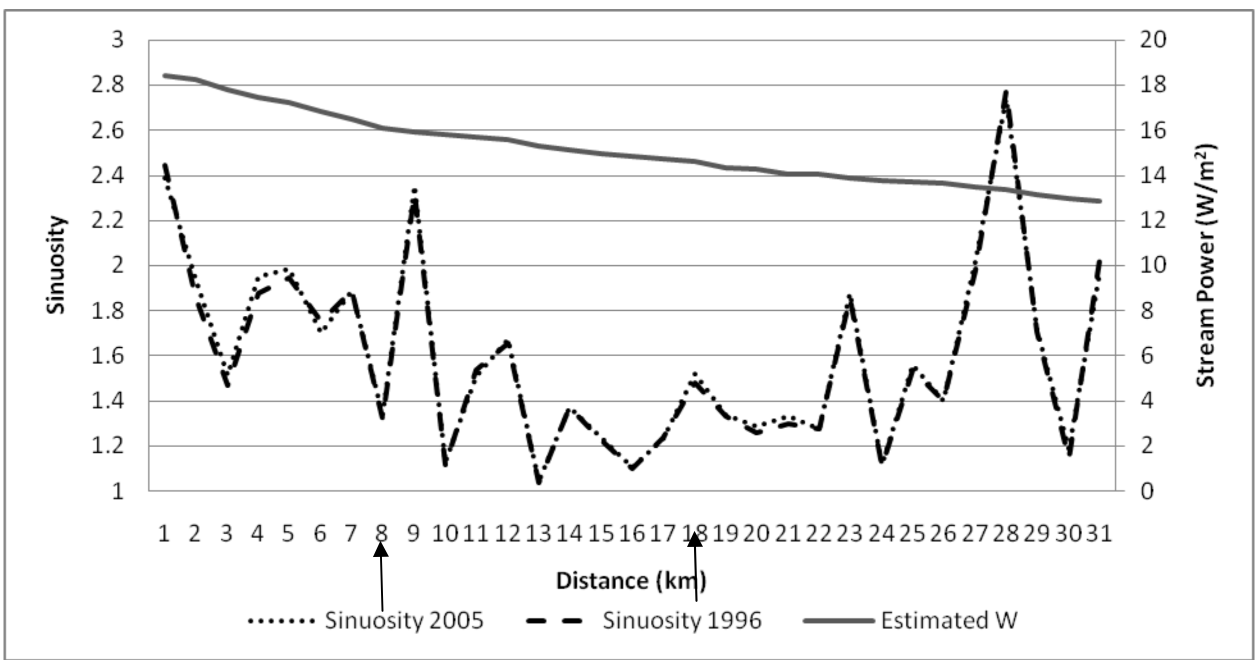

Figure 3-18. Sinuosity vs stream power for Bogue Homo River. For notes on arrows see Table 3-9.

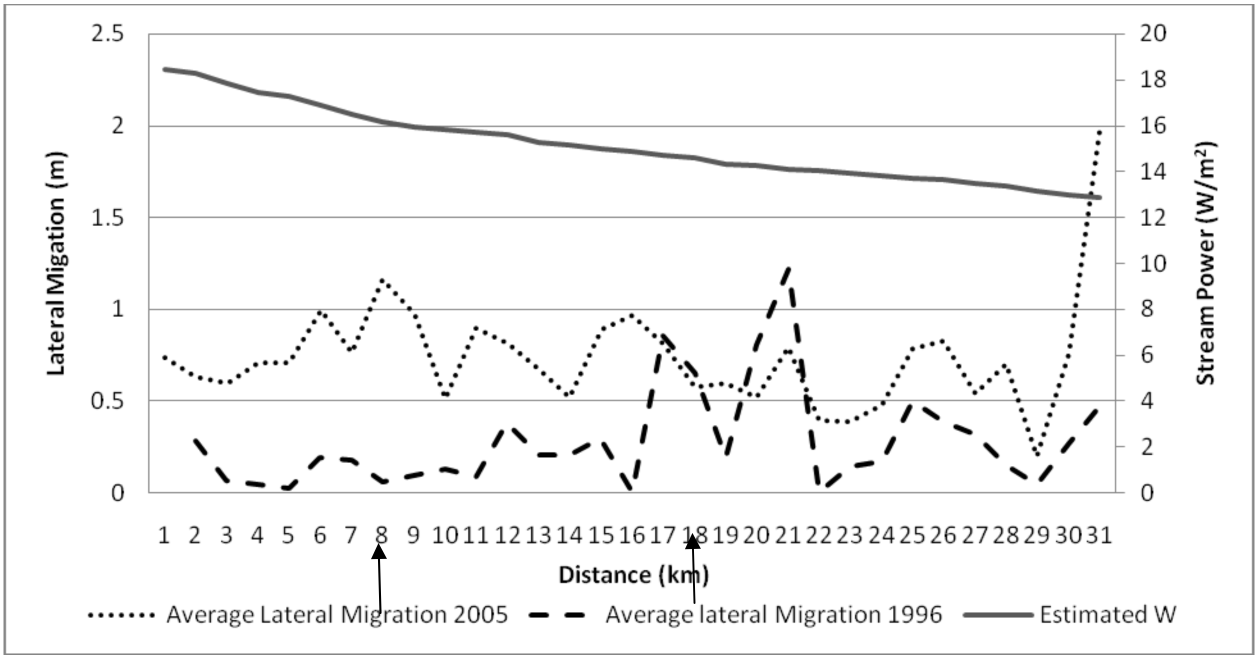

Figure 3-19. Average lateral migration vs stream power for Bogue Homo River. For notes on arrows see Table 3-9.

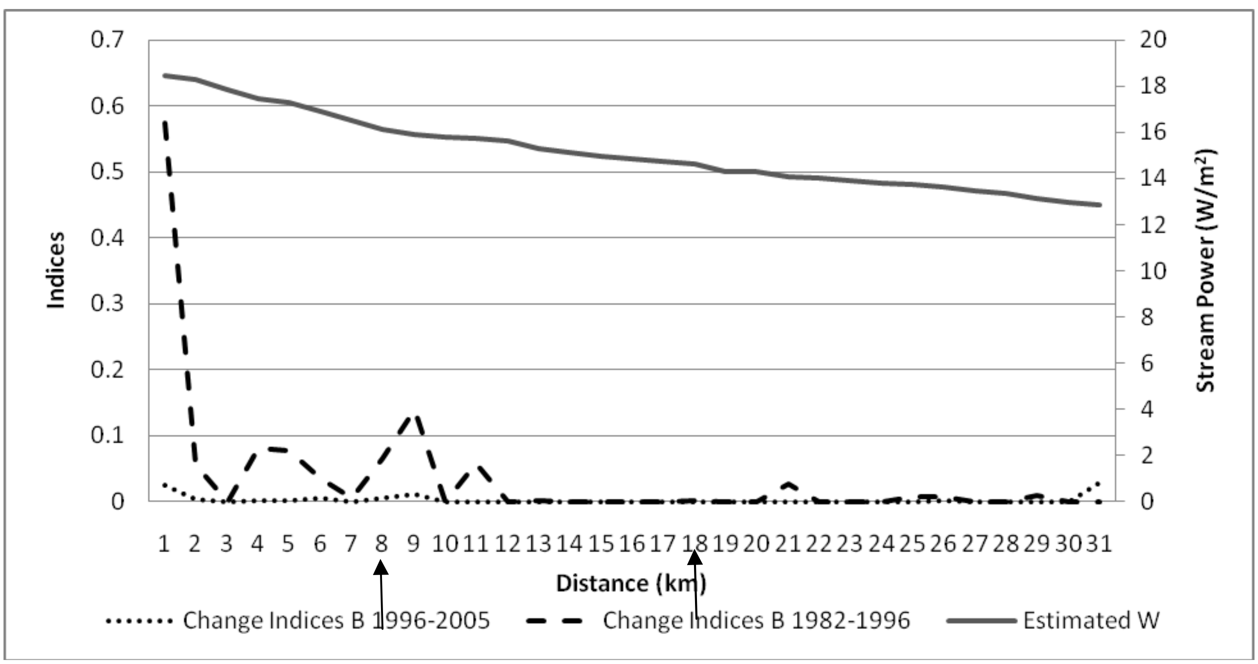

Figure 3-20. Between change indices vs stream power for Bogue Homo River. For notes on arrows see Table 3-9.

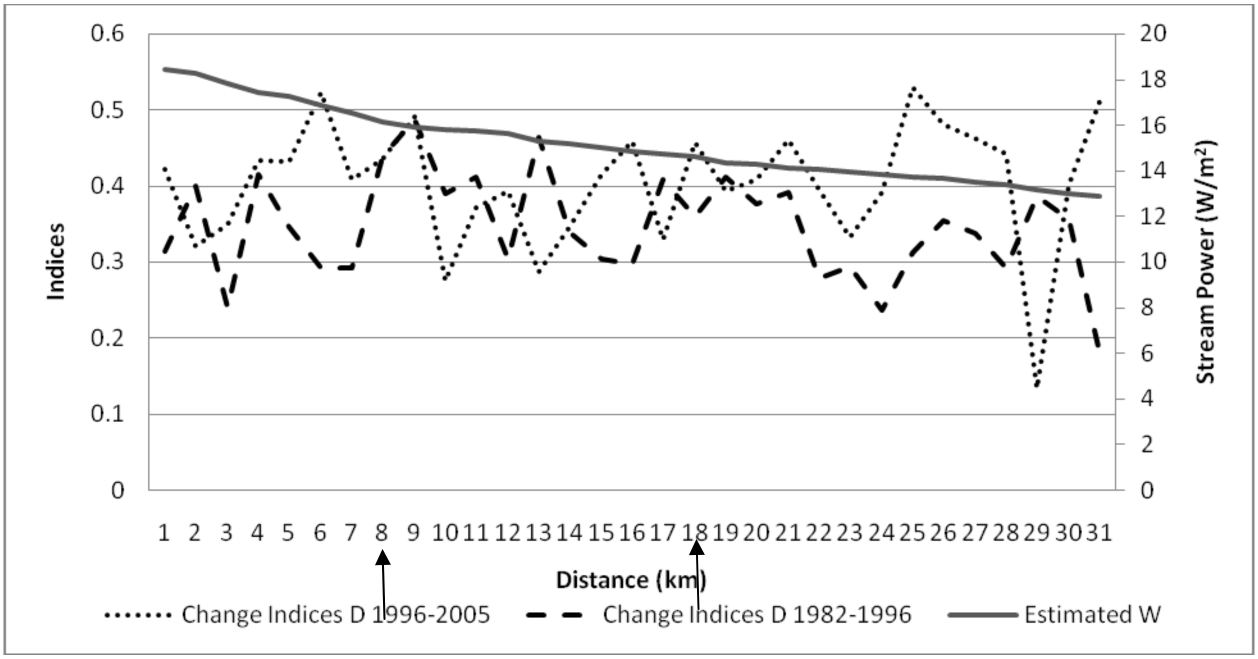

Figure 3-21. Deposition change indices vs stream power for Bogue Homo River. For notes on arrows see Table 3-9.

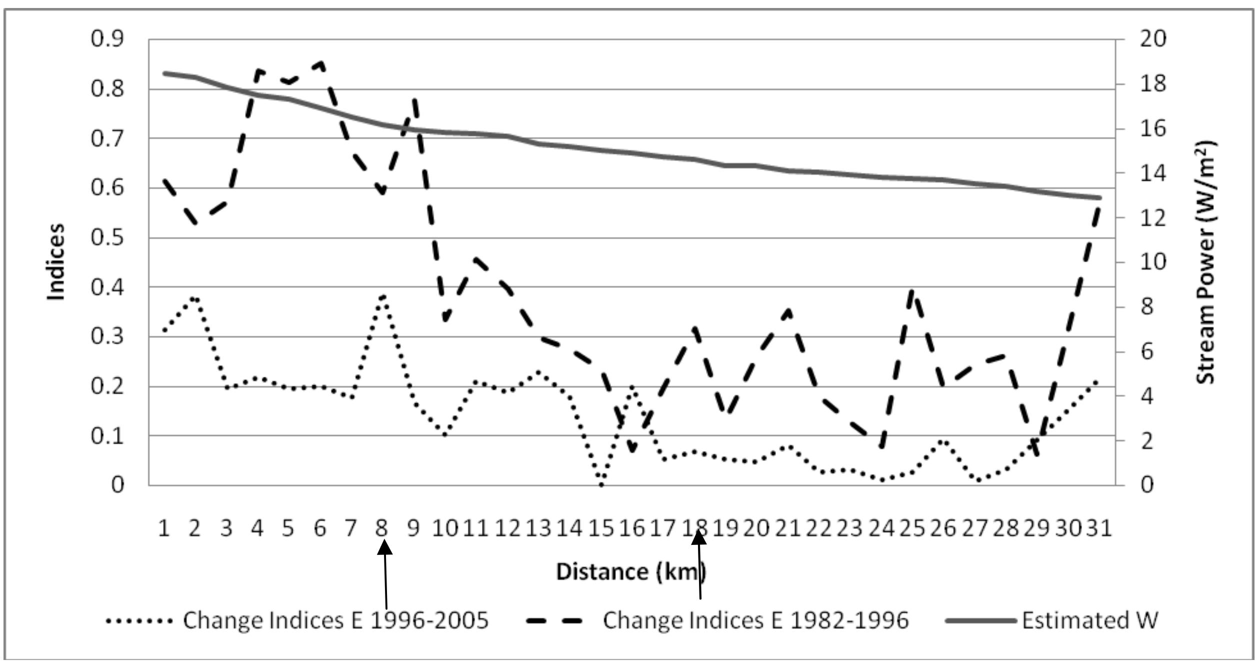

Figure 3-22. Erosion change indices vs stream power for Bogue Homo River. For notes on arrows see Table 3-9.

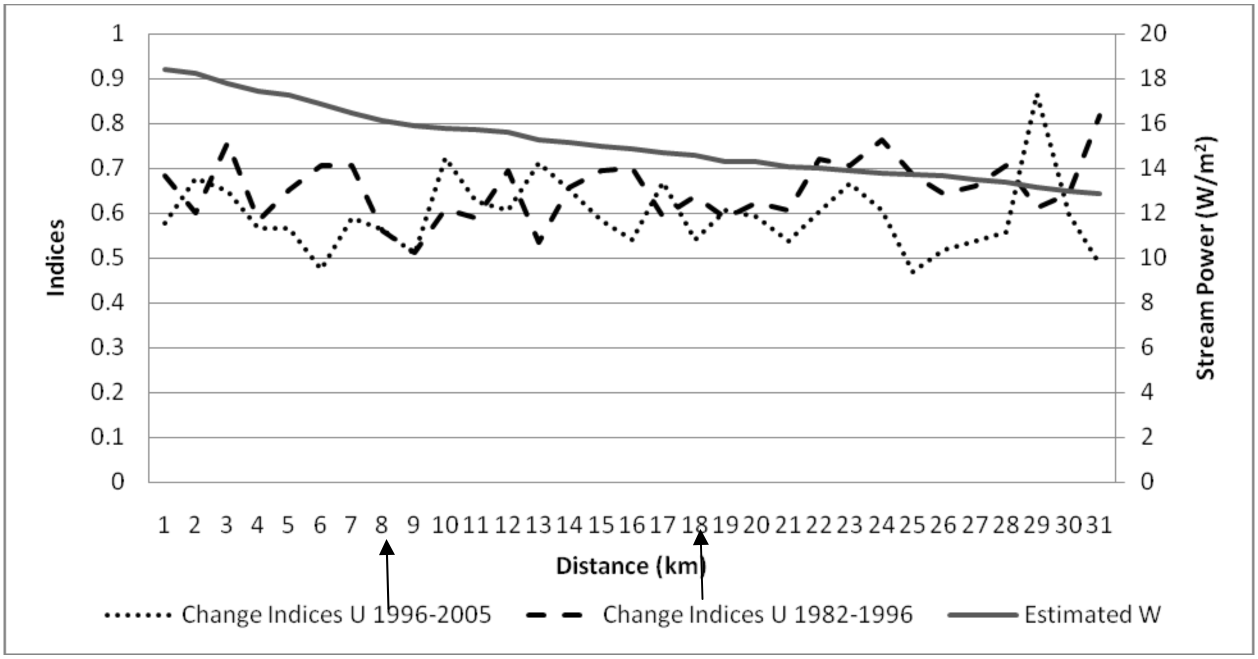

Figure 3-23. Unchanged change indices vs stream power for Bogue Homo River. For notes on arrows see Table 3-9.

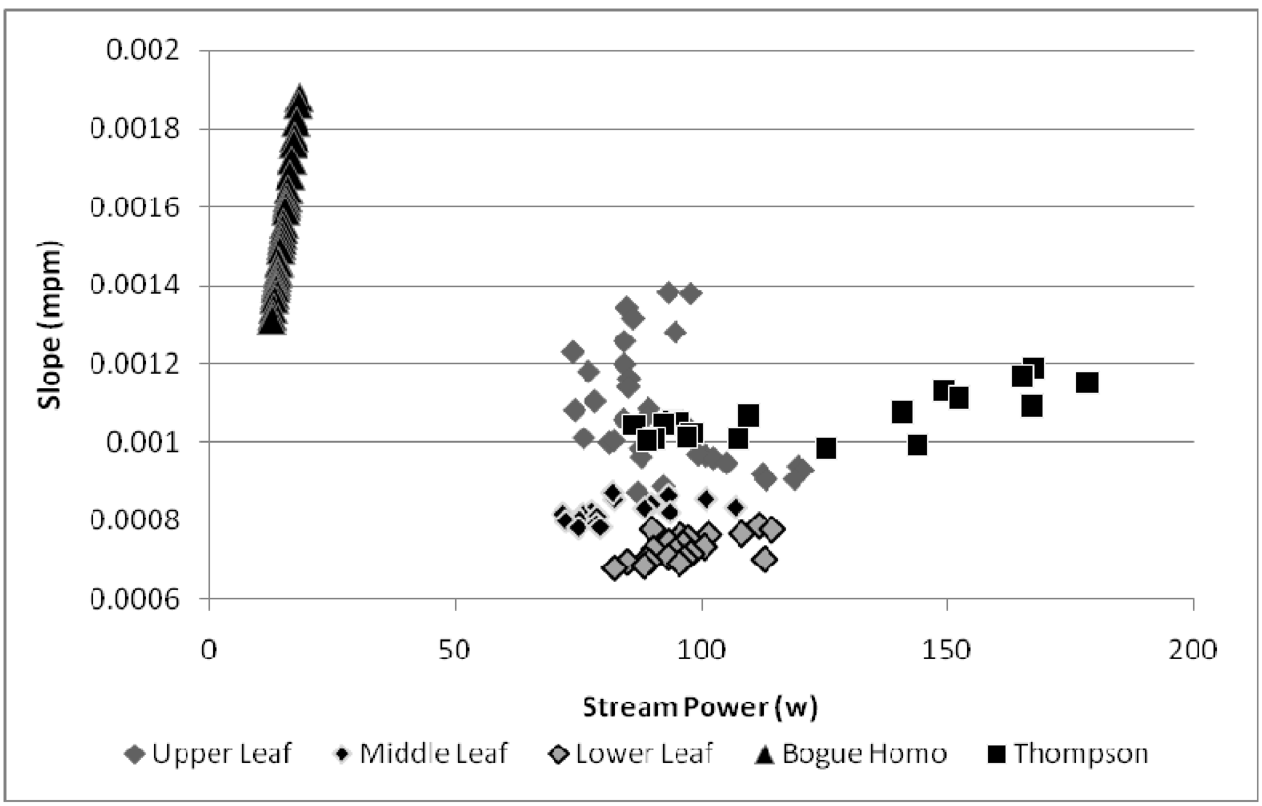

Figure 3-24. Stream slope vs stream power.

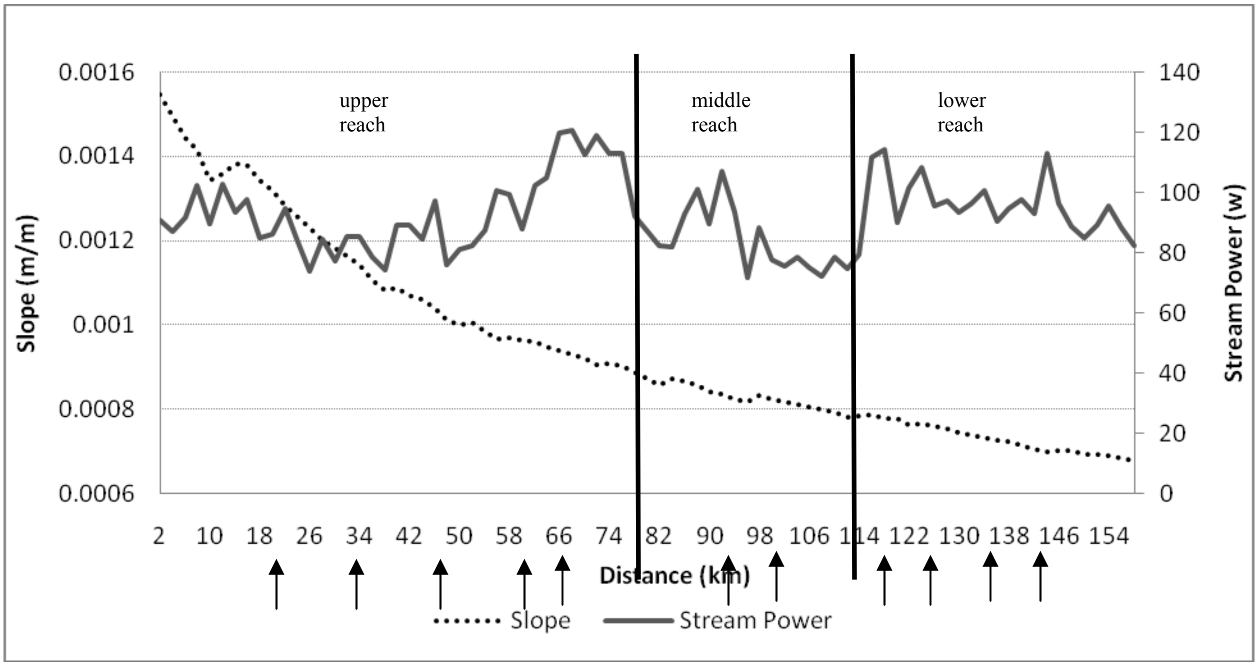

Figure 3-25. Leaf River: Slope and stream power by reach. For notes on arrows see Table 3-9.

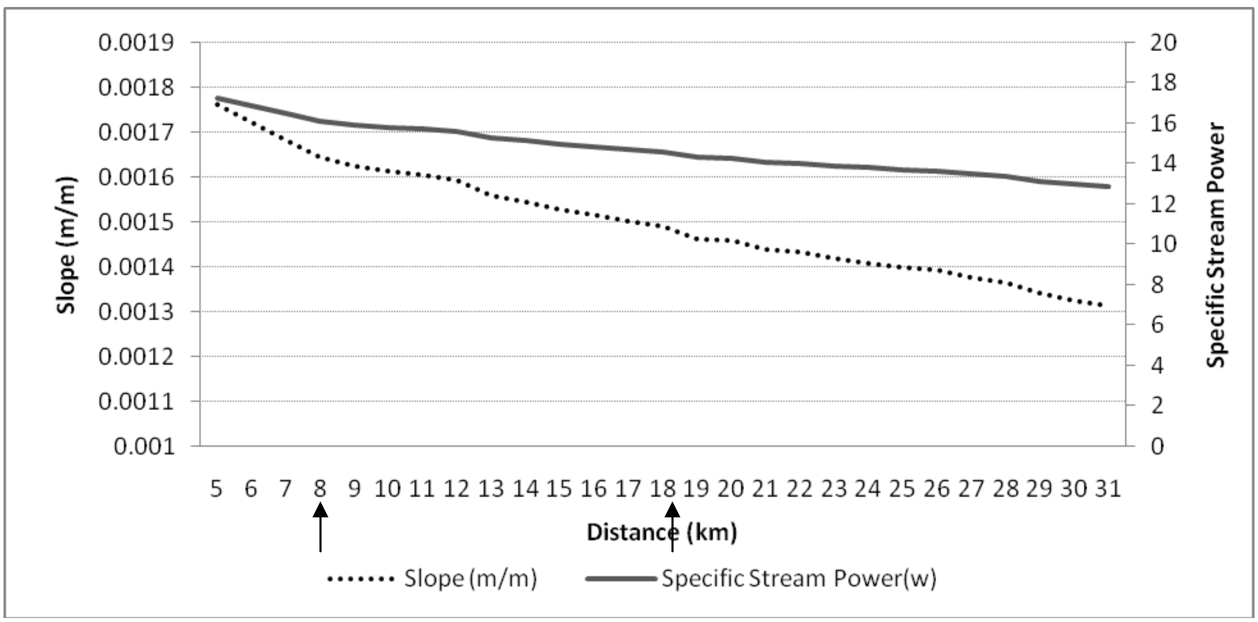

Figure 3-26. Bogue Homo River: Slope and stream power by reach. For notes on arrows see Table 3-9.

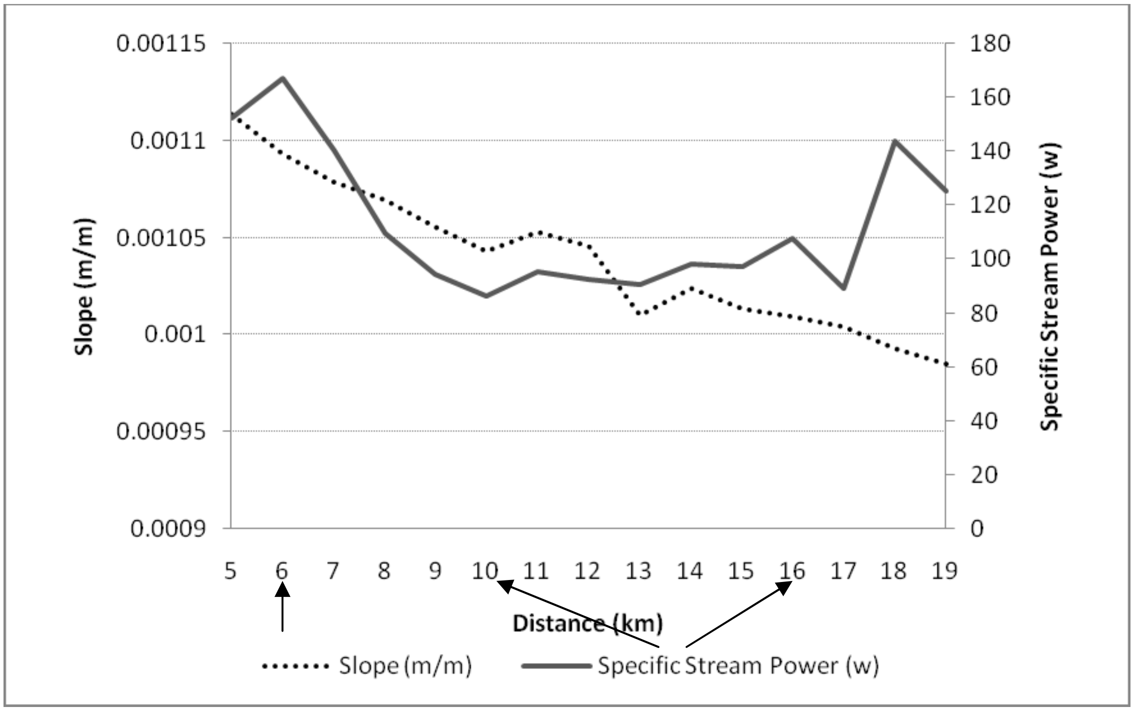

Figure 3-27. Thompson Creek: Slope and stream power by reach. For notes on arrows see Table 3-9.

CHAPTER 4
CONCLUSIONS

Stream flow through disturbed rivers is severely impacted due the amount of change occurring in the stream network. Evaluating stability or instability requires an examination of many factors including a number of planform variables, pattern and stream power. Stream characteristics such as stream power, sinuosity, lateral migration, point bar area, channel width and change indices are good indicators of the stability of a channel, but other factors such as adjacent disturbed rivers may cause variations of predicted outcomes. A decade in the lifetime of a river is too small of a timeframe to determine if a river has and become more stable in an environment that is very disturbed by human impacts.

River managers are encouraged to investigate the physical and environmental impacts that in-stream and floodplain mining has in a stream basin before allowing direct human impact to occur.

APPENDIX A
METHODOLOGY FOR CALCULATING AVERAGE YEARLY LATERAL MIGRATION

1. To calculate lateral migration using ArcGIS 9.2 Spatial Analyst tools follow these steps.

2. Add a field to the T1 and T0 centerline shapefile named Stream_ID and set the value to 1 for each feature.

3. In the centerline shapefile select by attribute each separate river centerline and create a centerline shapefile for each river.

4. In the ArcGIS Spatial Analyst extension menu, go to options and set the extent under the extent tab, analysis extent set to the river reach polygon shapefile (i.e.: BogueHomoRIDs and press OK.

5. Again under Spatial Analyst select convert, select feature to raster. A menu will come up. Input feature is the T1 river centerline shapefile (i.e.: BH1990sCntline), field is Stream_ID, an output cell size is 2, and then specify an output raster filename (i.e.: BH1990sRas).

6. Under Spatial Analyst select distance, then straight line and a menu will come up. Input the T2 river centerline file (i.e.: BH2005Cntline) for the Distance to field, output cell size as 2 and output raster input RiverT2Ras (i.e.: BH2005Ras)

7. Under Spatial Analyst select raster calculator and multiply the two raster files just created for straight line distance and the rasterized T1 or T2 file. (i.e.:BH1990sRas * BH2005cntlineRas)

8. The resulting output will be added to the Table of Contents in ArcGIS named Calculation. Right click the Calculation file in the table of contents, select data, make permanent, giving a relevant name the file (i.e.: BHLMcalc). Under Spatial Analyst select Zonal Statistics tool to summarize that distance raster using the original polygon layer as the zonal layer. Set zone dataset to the reach polygon shapefile (i.e.: BogueHomoRID), the zone field as Reach_ID and the value raster as the output from the calculation (i.e.: BHLMcalc). This will create a table and graph in ArcGIS.

9. Repeat steps 3-7 for each river.

APPENDIX B

CALCULATING INSTENTANIOUS PEAK FLOW DATA USING THE LOG-PEARSON TYPE III DISTRIBUTION

In Microsoft Excel perform the following steps:

Step 1: Obtain stream flow data

Step 2: Organize the information in a table.

Step 3: Rank the data from largest discharge to smallest discharge using the "sort" command. Add a column for Rank and number each stream flow value from 1 to n (the total number of values in your dataset).

Step 4: Create a column with the log of each max or peak stream flow using the Excel formula {log (Q)} and copy command.

Step 5: Calculate the Average Max Q or Peak Q and the Average of the log (Q)

Step 6: Create a column with the excel formula {(log Q – avg(logQ))^2}

Step 7: Create a column with the excel formula {(log Q – avg(logQ))^3

Step 8: Create a column with the return period (Tr) for each discharge using the Excel formula {(n+1)/m}. Where n = the number of values in the dataset and m = the rank.

Step 9: Complete the table with a final column showing the exceedence probability of each discharge using the excel formula {=1/Return Period or 1/Tr} and the copy command.

Step 10: Calculate the Sum for the {(logQ – avg(logQ))^2} and the {(logQ – avg(logQ))^3} columns.

Step 11: Calculate the variance , standard deviation , and skew coefficient as follows:

variance = $$\frac{\sum (\log Q - avg(\log Q))^2}{n-1}$$

standard deviation = $\sigma \log Q = \sqrt{variance}$

skew coefficient = $$\frac{n \times \sum (\log Q - avg(\log Q))^3}{(n-1)(n-2)(\sigma \log Q)^3}$$

Excel functions can also be used to calculate the variance (=VAR( )), standard deviation (=STDEV( )), and skewness coefficient (=SKEW( )). Note that you use these formulas with the data in the log(Q) column.

Step 12: Calculate weighted skewness

Step 13: Calculate K values. Use the frequency factor table and the skew coefficient to find the K values for the 2,5,10,25,50,100, and 200 recurrence intervals.

Step 14: Using the general equation, list the discharges associated with each recurrence interval general equation = $\log Q_{Tr} = avg(\log Q) + [K(Tr, Cs)] \times \sigma \log Q$

Step 15: Create table of Discharge values found using the log – Pearson analysis

Source: http://water.oregonstate.edu/streamflow/analysis/floodfreq/tutorial.htm

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BIOGRAPHICAL SKETCH

Ursula Garfield was born in Neptune, New Jersey, to Martha and Udo Anckarstrom-Bohm, immigrants from Germany. She has two brothers and three sisters and lived in Spring Lake, New Jersey until 1976 when her family moved to Lake Worth, Florida. Ursula completed high school at Lake Worth High School and went on to college at Broward Community College.

After working for 20 years in the information technology field, she returned to college to finish her Associate of Arts degree at Santa Fe Community College (Gainesville, Florida) in December 2002. Ursula entered the University of Florida as a transfer student in the Department of Geography where she finished her Bachelor of Arts in summer 2005. Ursula entered the master's degree program in the Department of Geography in fall 2005, and is planning to continue as a Ph.D. student.

Ursula is married to Albert Garfield and has two children: Stephen Albert Garfield and Andrew Johann Garfield. She currently lives in rural Marion County, Florida, just outside of Flemington on a 21-one acre farm.