Monitor and Protect Wigwam River Bull Trout for Koocanusa Reservoir

Wigwam River Juvenile Bull Trout and Fish Habitat Monitoring Program

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B O N N E V I L L E P O W E R A D M I N I S T R A T I O N

Wigwam River Juvenile Bull Trout and Fish Habitat Monitoring Program: 2001 Data Report.

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Executive Summary

The Wigwam River juvenile bull trout and fish habitat monitoring program is a co-operative initiative of the British Columbia Ministry of Water, Land, and Air Protection and Bonneville Power Administration. The Wigwam River has been characterized as the single most important bull trout spawning stream in the Kootenay Region. This report provides a summary of results obtained during the second year (2001) of the juvenile bull trout enumeration and fish habitat assessment program. This project was commissioned in planning for fish habitat protection and forest development within the upper Wigwam River valley. The broad intent is to develop a better understanding of juvenile bull trout and Westslope cutthroat trout recruitment and the ongoing hydrologic and morphologic processes in the upper Wigwam River, especially as they relate to spawning and rearing habitat quality.

Five permanent sampling sites were established August 2000 in the Wigwam river drainage (one site on Bighorn Creek and four sites on the mainstem Wigwam River). At each site, juvenile (0^+ , 1^+ and 2^+ age classes) fish densities and stream habitat conditions were measured over two stream meander wavelengths.

Bull trout represented 95.1% of the catch and the mean density of juvenile bull trout was estimated to be 20.7 fish/100m² (range 0.9 to 24.0 fish/100m²). This compares to 17.2 fish/100m² (+20%) for the previous year. Fry (0^+) dominated the catch and this was a direct result of juvenile bull trout ecology and habitat partitioning among life history stages. Site selection was biased towards sample sites which favored high bull trout fry capture success.

Comparison of fry density estimates replicated across both the preliminary survey (1997) and the current study (Cope and Morris 2001) illustrate the stable nature of these high densities. Bull trout populations have been shown to be extremely susceptible to habitat degradation and over-harvest and are ecologically important as an indicator of watershed health. As such, the upper Wigwam River watershed remains relatively pristine, and maintains high water quality and high habitat capability. Conservative angling regulations have been successful in preventing over-harvesting. To date, the forest licensee has harvested 36% of the allowable cut identified in the forest development plan.

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1 Introduction

The Wigwam River bull trout (*Salvelinus confluentus*) and fish habitat monitoring program is a trans-boundary initiative implemented by the British Columbia Ministry of Water, Land, and Air Protection (MWLAP), in cooperation with Bonneville Power Administration (BPA). The Wigwam River is an important fisheries stream located in southeastern British Columbia that supports healthy populations of both bull trout and Westslope cutthroat trout (Figure 1.1). This river has been characterized as the single most important bull trout spawning stream in the Kootenay Region (Baxter and Westover 2000, Cope 1998). In addition, the Wigwam River supports some of the largest Westslope cutthroat trout (*Oncorhynchus clarki lewisi*) in the Kootenay Region. These fish are highly sought after by anglers (Westover 1999a, 1999b).

Bull trout populations have declined in many areas of their range within Montana and throughout the northwest including British Columbia. Bull trout were blue listed as vulnerable in British Columbia by the B.C. Conservation Data Center (Cannings 1993) and although there are many healthy populations of bull trout in the East Kootenays they remain a species of special concern. Bull trout in the United States portion of the Columbia River were listed as threatened in 1998 under the Endangered Species Act by the U.S. Fish and Wildlife Service. The upper Kootenay River is within the Kootenai sub-basin of the Mountain Columbia Province, one of the eleven Eco-provinces that make up the Columbia River Basin. MWLAP applied for and received funding from BPA to assess and monitor the status of wild, native stocks of bull trout in tributaries to Lake Koocanusa (Libby Reservoir) and the upper Kootenay River. This task is one of many that were undertaken to "Monitor and Protect Bull Trout for Koocanusa Reservoir" (BPA Project Number 2000-04-00).

1.1 Objectives

Five permanent sampling sites were established in the Wigwam river drainage in August 2000 (one site on Bighorn Creek and four sites on the mainstem Wigwam River). At each site, juvenile fish densities and stream habitat conditions have been measured annually. The broad intent of this project was to develop a better understanding of inter-annual variation in juvenile bull trout and Westslope cutthroat trout recruitment and the ongoing hydrologic and morphologic processes in the upper Wigwam River, especially as they relate to spawning and rearing habitat quality and timber harvest development. The August 2001 sampling program represents a continuation of the study into year 2.

Figure 1. Location of Wigwam River Study Area

1.2 Study Area

The Wigwam River originates in the Rocky Mountains within the state of Montana and flows northwest between the Galton and MacDonald ranges in British Columbia for approximately 47 km until it empties into the Elk River, a tributary to Lake Koocanusa (Figure 1.1). The headwaters of the Wigwam drainage originate at an elevation of 2,135 m and declines to 763 m. The Wigwam River valley is characterized by four biogeoclimatic zone variants; Kootenay dry mild interior Douglas-fir, dry cool montane spruce, Kootenay moist cool interior cedar hemlock, and dry cool Engelmann spruce sub-alpine fir (Braumandl and Curran 1992).

The flow regime of the Wigwam River is comparable to most interior systems with high annual run-off reaching it's peak in May (peak mean daily discharge $74 \text{ m}^3/\text{s}$ on 24 May 2000) and expected low flows in late fall and winter ($2.1 \text{ m}^3/\text{s}$; Prince and Cope 2001). Freeze up generally occurs in mid to late November; however, areas of groundwater infiltration remain open in most years. The temperature signature recorded in the mainstem Wigwam River in the vicinity of the spawning grounds was indicative of groundwater and daily maximum temperatures within the upper Wigwam River do not exceed 14.5°C (Prince and Cope 2001, 2000).

The upper reaches of the Wigwam River occupy a glacial outwash channel that is bounded by glacial till terraces and silt seams. The occurrence of lacustrine silt deposits overlain by highly permeable glacial till within adjacent terraces has contributed to a predominance of sub-surface flow that reaches the mainstem as groundwater. The influence of groundwater has been a large factor in the maintenance of cool stream temperatures and annual low flows (Prince and Cope 2000, 2001). A number of natural disturbance events over time appear to have contributed a substantial volume of coarse sediment to the river including: wildfires in the 1930's, a slide in 1993, and the 1995 flood event thought to occur every 100 to 200 years (Oliver and Cope 1999). Sediment aggradation throughout a broad, alluvial floodplain is associated with channel-confining bedrock outcrops. The combination of frequent lateral migration and erosion of adjacent terraces and coarse sediment delivery to the mainstem river has created a braided channel comprised of sorted gravels and cobbles that provide prime spawning habitat for bull trout (Oliver and Cope 1999). The provision of suitably sized bed materials ($<20 \text{ mm}$) in a low gradient, low water velocity location with

associated groundwater have been identified as repeating patterns of preferred bull trout spawning habitat (McPhail and Baxter 1996).

1.2.1 Forest Development Status

Forest harvesting and accompanying road development in the Wigwam basin have, to date, been undertaken primarily in Montana, where approximately 20% of the watershed was logged (with extensive road network) in the 1950's and 1960's with subsequent 'green-up' ongoing to the present day (Anon. 1999). In the Canadian portion of the watershed, logging has been limited to the Rabbit Creek sub-basin (< 100 ha), with some helicopter logging in the 1990's near the confluence of the Wigwam River with the Elk River. Conventional logging occurred approximately 20 years ago in the vicinity of the confluence with the Elk River, and in the Bighorn Creek sub-basin. British Columbia Watershed Restoration Program (WRP) activities have been on-going within the Bighorn Creek watershed since 1995 (Cope 2000).

The original Tembec Forest Development Plan (FDP; Tembec 1999) has gone through several iterations in response to stakeholder concerns. The current plan (commonly referred to as amendment 5) calls for logging a total of 657.3 ha (0.89% of the entire watershed) or 163,816 m³ of harvest volume, over a three to four year period after which no further harvesting is planned for 20 years. Forest development activities for the 2000 works windows included the construction of approximately 30 km of mainline Forest Service Road, spur roads, and the installation of five bridges; including one full span crossing of the upper Wigwam River. Harvesting commenced in December 2000, and as of 10 November, 2001 a total of 36% (231.5 ha) of the planned harvest volume was harvested. Lodgepole pine is the predominant species being harvested. All cutblocks are on glacial till terraces in the valley bottom and are to be clear-cut.

Forest development plans for the Wigwam River watershed have come under considerable scrutiny because of potential impacts to bull trout habitat. The issues have largely centered on block size, water temperature, increased sediment yield, and base flow levels in the mainstem river. The creation of extensive openings in a largely even-aged, lodgepole pine forest are intended to mimic a natural stand initiating event consistent with the valley's wildfire history. The size of the proposed clear-cuts however, are perceived to alter basin hydrology, affect the annual flow regime (both peak and base flows) and encourage surface erosion that could lead to fine sediment delivery.

1.2.2 Fisheries Resource Status

When compared to other bull trout systems, it can be argued that the Wigwam River may be the most prolific bull trout population in the species distribution range. Juvenile densities are some of the highest densities reported within the literature (Cope 1998) and spawning escapements consistently exceed 1,000 fish (Baxter and Westover 2000). Baxter and Westover (2000) provide a thorough review of the biology, population status, and scientific studies to date for this population. The principle concerns for the Wigwam River population center around the potential impacts of forest harvesting. Bull trout are adapted to cold water temperatures and thrive in waters that are too cold, unproductive or too steep in gradient for other fish. Bull trout are not found in streams where maximum monthly water temperatures exceed 18°C and are most abundant where water temperatures are 12°C or less (Goetz 1989, Ford *et. al.* 1995, McPhail and Baxter 1996, Buchanan and Gregory 1997). This preference for cooler water manifests in the frequent association of bull trout with cold perennial springs (Oliver 1979, Goetz 1989, McPhail and Baxter 1996, Buchanan and Gregory 1997). In general, the species does not occur in high densities, a tendency that is partly due to the life-history strategy and the environment in which they live. Low population densities, slow growth, delayed maturation and high quality habitat requirements (water temperatures < 14°C, spawning gravel with low % fines) make bull trout sensitive to habitat degradation and over-harvesting (Goetz 1989, Fraley and Shepard 1989, Ratliff *et. al.* 1996, Ford *et. al.* 1995, McPhail and Baxter 1996).

Westslope cutthroat trout are also typical of cold, nutrient poor streams (Liknes and Graham 1988). The Wigwam River population of Westslope cutthroat trout contains appreciable numbers of large individuals with adults attaining 450 mm fork length (Westover and Conroy 1997). Although the distribution and abundance of Westslope cutthroat trout have drastically declined from its historic range during the last 100 years, the abundance and size of the current Wigwam River population may be attributed to the combination of special regulations designed to limit harvest and high quality available habitat.

2 Methods

Five permanent sampling sites were established in the Wigwam river drainage in August, 2000 (reaches 5, 6, 7, and 9 of the Wigwam River, and reach 1 of Bighorn Creek, Appendix A, 1:50,000 TRIM map). Sampling sites were a minimum of 20 channel widths in length or a distance equal to two stream meander wavelengths. At each site the following reference points were permanently established, geo-referenced and marked with a combination of metal tree tag, tree blaze, fluorescent tree paint, and flagging tape:

- Upstream and downstream elevation benchmarks. Elevation benchmarks were also represented by a lag bolt imbedded in the base of a large, stable, riparian tree,
- Upstream and downstream limits of the longitudinal survey,
- Riffle and pool cross-sectional reference points, and
- Electrofishing habitat units.

The following methods outline the specific assessments completed at each of the five permanently established sites.

2.1 Juvenile Enumeration

Estimates of juvenile fish density (number of fish/100 m²) were determined using closed, maximum-likelihood removal estimates (Riley and Fausch 1992). For each site, three habitat units (riffle, pool and run) were individually sampled for fish densities over a minimum of 100 lineal meters and/or 500 m². This methodology allows for habitat unit comparisons as well as reach comparisons through pooling of habitat units to obtain a mean. A Smith-Root Mark 12POW backpack electroshocker was used for successive depletions within each closed sample unit. Although bull trout are the main focus of this project, densities of all fish captured were reported.

All sampling was conducted at the permanent stations established in 2000. The project biologist and lead technician were also members of the original enumeration crew further ensuring consistency and minimization of sampler bias.

Catch results from individual habitat units were summed, by pass, at each representative reach location. These results were then used to estimate the number of fry (0⁺ age class) and juveniles (1⁺ and 2⁺ age classes) within the composite enclosure area. Population estimates were calculated using the "Microfish" software package (Van Deventer and Platts

1990). Population estimates and their 95% confidence interval were then reported as a standard numerical density (number fish/100 m²).

2.2 Fish Habitat Assessment

A standard suite of habitat parameters were collected using the Resource Inventory Committee (RIC) approved Fish Habitat Assessment Procedures (FHAP), Level 1, Form 4 - Habitat Survey Data Form (Johnston and Slaney 1996). The level 1 FHAP a purposive field survey of current habitat conditions for the target species in select reaches. This form has been developed for interpretation of habitat sensitivity and capability for fish production and includes prominent physical features such as pool and riffle ratios, residual pool depths, channel stability, flood indicators, cover components, abundance of large woody debris (LWD), and riparian vegetation.

Following methods described in Rosgen (1996) the following measurement of channel bed, channel bank and fish habitat parameters were also completed again in 2001:

- A longitudinal Profile (two stream meander wavelengths) of the stream bed following the thalweg of the stream channel and water surface (slope);
- Stream cross-sections on both a riffle and pool segment;
- Modified Wolman pebble count, and
- Stream discharge and bank full width.

Geomorphic surveys were completed using a level (Topcon AT-G7 Auto Level) and standard differential hydrometric survey techniques (Anon. 1998). Benchmarks permanently established in 2000 were used. A differential loop was used to accurately determine benchmark elevations. In the previous sampling year, a laser level (Laser plane 220 leveling station and target rod) was used for the survey. The laser level may not be as accurate as the Auto level over long distances and inclement weather conditions because of the refraction of the laser beam over the distance. Use of the Topcon Auto Level should result in a more accurate determination of benchmark elevations. The UTM coordinates were overlain on the digital NAD 83 Forest Cover TRIM Sheet and the elevation data corrected to this datum. At 10m intervals, following the thalweg of the stream channel, the elevation of the stream bed and the water surface was surveyed over the length of the study area. All stream and habitat unit gradients were calculated from differences in water surface elevation. Cross sectional profiles were surveyed at 1 m intervals and extended

5m beyond the bankfull width. The elevation of the bankfull channel was also noted at each cross section location. All survey loops were closed and error levels expressed to ensure quality control.

Channel bed material characterization employed the modified Wolman method outlined in Rosgen (1996). Briefly, this procedure uses a stratified, systematic sampling method based on the frequency of riffle/pools and step/pools occurring within a channel reach that is approximately 20-30 bankfull channel widths in length (or two meander wavelengths). The modified method adjusts the material sampling locations so that various bed features are sampled on a proportional basis along a given stream reach. In total, 10 transects are established and ten substrate particles are selected at systematic intervals across the bankfull channel width, for a total sample size of 100. The intermediate axis of the particle was measured such that the particle size selected would be retained or pass a standard sieve of fixed opening. The composite particle distribution was used to represent the site. To avoid potential bias, the actual particle was selected on the first blind touch, rather than visually selected.

Stream discharge was estimated at each location using a Price 1210AA velocity meter and wading rod calibrated bi-annually by the National Calibration Service of the National Water research Institute. All methods meet national and provincial standards and have demonstrated precision levels of less than +/- 5% (Prince and Cope 2000, 2001).

3 Results

The upper and lower geo-reference points (uncorrected) for each sample site are summarized below in Table 1. For the corrected UTM coordinates see the attached 1:50,000 TRIM map (Appendix A). The corresponding site numbers of the preliminary sampling program (Cope 1998) and MWLAP Environmental Monitoring System (EMS) sites (Prince and Cope 2000, 2001) were also included for reference between these complimentary monitoring programs. Sample sites established in the 2000 sampling year (Prince and Cope 2001) in reaches five, six, seven, nine of the Wigwam river and reach one of Bighorn Creek were again sampled in August, 2002.

Additional background data of varying levels of applicability and accuracy (*i.e.* previous streambed and cross-sectional surveys, pebble counts, water quantity and quality data) can be accessed through the EMS data storage initiative (MWLAP, Nelson, B.C.) and the British Columbia WRP program (MWLAP, Cranbrook, B.C.).

Table 1. Schedule of program field components for the Wigwam River bull trout and fish habitat monitoring program, 2000-2001.

Program Component	Date	
	Year 1 (2000)	Year 2 (2001)
Establishment of Permanent Sample Sites	August 9 – 14	
Juvenile Fish Density Sampling	August 9 – 14	August 3-9
Level 1 FHAP Form 4 Measurements and Channel Surveys	September 20– October 4	September 14 – October 5
Aerial Reconnaissance Survey (Channel Dewatering, Groundwater Influence, Forest Development)	January 22	

Table 2. Summary of permanently established bull trout and fish habitat sample sites within the Wigwam River study area and associated site designations for on-going and previous surveys conducted in the immediate vicinity.

Sample Site	UTM (Zone.Easting.Northing)	1997 Site No. ¹	EMS No. ²	Additional Habitat Data ³
Wigwam R. Reach 5 Site 1	11.648335.5449685 11.648110.5449910	2	E238242 ^a	
Wigwam R. Reach 6 Site 2	11.653886.5441349 11.653802.5441896	4 & 5 ^b		CS1
Wigwam R. Reach 7 Site 3	11.655471.5438625 11.654977.5439074	6 & 7	E238246	
Wigwam R. Reach 9 Site 4	11.661031.5432738 11.660942.5432911		E238250	CS2
Bighorn Cr. Reach 1 Site 1	11.648335.5449685 11.649089.5449439	13 ^c		WRP1

¹ – Site numbers from preliminary bull trout and fish habitat monitoring program (Cope 1998). Data includes juvenile enumeration, RIC inventory site card, pebble count and discharge estimation.

² – MWLAP EMS site numbers from ongoing upper Wigwam River water quantity and quality inventory project (Prince and Cope 2000, 2001). Data includes water quantity and quality monitoring data.

³ – CS1 and CS2 site numbers from upper Wigwam River water quantity and quality inventory project (Prince and Cope 2000). Data includes FHAP Form 4, longitudinal and cross-sectional profiles, pebble counts and discharge estimation. WRP1 represents Watershed Restoration Program level II FHAP longitudinal (900 lineal meters) and cross-sectional profiles (n=11) (Cope and Prince 2000).

^a – Hydrometric and automated water quality grab station located 1 km upstream.

^b – Site 4 was 200 m downstream (dewatered due to down-cutting) and Site 5 was 400 m upstream.

^c – Site 13 was 300 m upstream.

3.1 Juvenile Fish Sampling

3.1.1 Species Composition and Distribution

In total, 14 habitat units were sampled across five reaches (36,450 seconds of backpack electrofishing effort over 2,502 m²; Appendix B). In year 1 effort was 41,454 seconds over 2,599 m². Both bull trout and Westslope cutthroat trout were captured in all reaches sampled; Westslope cutthroat trout were captured in all reaches except for Reach 6. A total of 470 fish were captured within the Wigwam River and Bighorn Creeks during the sample period 3 -9 August 2001 (as compared with 419 in 2000 – Prince and Cope 2001). Bull trout were the dominant species encountered, representing 95.1% (n = 447) of the total catch. The remaining 4.9% of the total catch was represented by Westslope cutthroat trout (n = 23). Bull trout fry were the target species and life stage and as such, the catch composition reflects bias associated with site selection for this capture target. Rocky mountain whitefish (*Prosopium williamsoni*) and rainbow trout (*Oncorhynchus mykiss*) have been reported in lower reaches and were not encountered in the summer 2001 sampling program.

3.1.2 Bull Trout

In total, 447 bull trout were captured and sampled for life history information (Table 3.3). All captured bull trout were juveniles and ranged in age class from 0⁺ to 1⁺ (Figure 3.1). These fish ranged in fork length from 35 mm to 112 mm and the modal class, in 10 mm intervals, was 51-60 mm. This size class represents the young-of-the-year cohort (fry, 0⁺). The relative proportions of age classes comprising the total bull trout catch were 95.1% fry (0⁺) and 4.9% (1⁺). Mean fork lengths of each age class (estimate) were 50.7 (0⁺) and 99.7 (1⁺) mm. The corresponding mean weights for bull trout age classes were 1.5 and 10.7 g respectively (Table 3.3). The growth rate of juvenile bull trout in the Wigwam River study area was described by the equation:

$$\text{Log}_{10}\text{Weight} = -4.6343 + 2.7971 \text{ Log}_{10}\text{Length (Figure 3.2).}$$

Mean density of juvenile bull trout (ages 0⁺ to 1⁺) was estimated to be 20.7 fish/100m² with a range of 0 to 24.0 fish/100m² (Appendix B). Fry (0⁺) abundance represents the 2000 brood year egg-to-fry recruitment and mean density was estimated to be 18.1 fry/100m² ranging from 5.4 to 28.6 fry/100m² (Table 3.4). The small increase in estimated fry density resulted from a large increase in Bighorn Creek bull trout fry densities (Table 3.4). Trends

in abundance appeared to be related to proximity to spawning areas, bed material size, water depth, cover and macro-habitat type sampled (i.e. glide margin).

Bull trout captures of the 1⁺ age class were far less abundant than those of fry. Captures were not sufficient to generate density estimates. Low densities were largely due to electrofishing capture inefficiencies

Table 3. Summary of fork length and weight data, by estimated age cohort, collected from bull trout captured within the Wigwam River drainage, 3 - 9 August 2001.

	Age-Group	
	0 ⁺	1 ⁺
Mean Fork Length (mm)	50.7	99.7
Standard Error	0.25	2.0
Range	35-66	79-112
N	425	22
Mean Weight (g)	1.5	10.7
Standard Error	0.026	0.93
Range	0.4-4	5.8-16.4
N	361	13

Figure 2. Length frequency distribution and estimated age cohorts for Wigwam River juvenile bull trout (0⁺ to 2⁺ age classes).

Figure 3. Length-weight regression for bull trout captured within the upper Wigwam River watershed, - August 2001.

Table 4. Mean density estimates (+/- 95% confidence interval) for bull trout fry within the upper Wigwam River permanent sample sites, 9 – 14 August 2000, 3 – 9 August 2001.

Bull trout sample site location	Density Estimate:	
	Number of fry/100m ² (+/- 95% confidence interval)	
	August 2000	August 2001
Wigwam River - Reach 5, Site 1	17.1 (14.7 – 19.8)	16.7 (14.6 – 19.3)
Wigwam River - Reach 6, Site 2	26.9 (23.3 – 30.4)	25.7 (22.0 – 29.4)
Wigwam River - Reach 7, Site 3	16.4 (16.0 – 17.3)	18.6 (15.3 – 23.1)
Wigwam River - Reach 9, Site 4	9.2 (8.6 – 10.5)	5.8 (5.4 – 6.9)
Bighorn Creek – Reach 1, Site 1	15.6 (10.5 – 24.1)	32.5 (28.6 – 36.4)

associated with juvenile bull trout ecology and habitat partitioning among life history stages. Site selection was biased towards electrofishing sample sites which favored high bull trout fry capture success. Such sites typically have lower 1⁺ and 2⁺ age class bull trout densities.

3.1.3 Westslope Cutthroat Trout

In total, 23 Westslope cutthroat trout were captured and sampled for life history information (Table 3.5). Cutthroat trout ranged in age from 0⁺ to 1⁺ indicating the primary use of sampled habitat was by rearing juveniles. Cutthroat fork lengths ranged from 21 mm to 63 mm. Mean fork length was 24.4 (0⁺) and 79.7 (1⁺) mm. The modal length, in 10 mm intervals, was 21-30 mm and the length-frequency histogram illustrates the fry (0⁺) life-stage dominated the catch (Figure 3.3). The relative contribution to the catch was 73.9% fry and 26.1% (1⁺). The corresponding mean weights were 0.22, and 5.9 g, respectively (Table 3.5). The growth rate of Westslope cutthroat trout in the Wigwam River study area was described by the equation:

$$\text{Log}_{10}\text{Weight} = -2.7142 + 1.8842 \text{Log}_{10}\text{Length} \text{ (Figure 3.4).}$$

Table 5. Summary of fork length and weight data, by estimated age cohort, collected from Westslope cutthroat trout captured within the Wigwam River drainage, - August 2001.

	<i>Age-Group</i>	
	0 ⁺	1 ⁺
Mean Fork Length (mm)	24.4	79.7
Standard Error	0.74	3.25
Range	21-32	63-92
N	13	10
Mean Weight (g)	0.22	5.9
Standard Error	0.034	0.6
Range	0.1-0.4	2.7-9.1
N	13	10

Figure 4. Length frequency distribution and estimated age cohorts for Wigwam River Westslope cutthroat trout juveniles.

Figure 5. Length-weight regression for Westslope cutthroat trout captured within the upper Wigwam River watershed, 3- 9 August 2001.

Westslope cutthroat trout captures were not sufficient to generate density estimates (Appendix B). Low densities (mean density = 0.8 fish/100 m²) resulted in low precision (95% confidence interval 0.5 to 1.6 fish/100 m²). This was generally due to either; a non-descending removal pattern, all fish captured in a single pass, or no captures. Maximum likelihood estimation was not possible under these conditions.

3.2 Physical Habitat Monitoring

3.2.1 Water Temperature and Discharge

Discharge estimates within the upper Wigwam River ranged from 0 to 3.12 m³/s (Table 3.6). Mean monthly discharge in 2001 was significantly lower from April to November than during the same period in 2000 (Prince and Morris 2002). Discharge at the upper Wigwam River hydrometric station (reach five) during fish sampling (3 – 9 August) ranged from 2.94 to 4.86 m³/s (mean = 3.61 m³/s) for the month of August, compared with 3.86 to 6.93 m³/s (mean = 5.16 m³/s) for the month of August, 2000. The lowest discharge was observed for reach seven, which was observed dewatered on 24 August (Prince and Morris 2002; Appendix A). Similar to observations made in the previous sampling (Prince and Cope 2001). Anecdotal reports have suggested this reach dewatered in low water yield years. This was the second annual observation of this event and was attributed to low snow pack and significantly lower water yield resulting in decreased groundwater recharge (Cope and Morris 2001). The relationship between river stage at this location and the hydrometric station below the primary spawning grounds are represented in Figure 3.6.

Table 6. Summary of water temperature, mean velocity, and discharge measurements for the Wigwam River fish habitat monitoring sites.

Date	Stream	Reach	Site	Discharge (m ³ /s)	Mean Velocity (m/s)	Water Temp. (°C)
3 Oct.	Wigwam	5	1	3.12	0.35	13.2 ^a /8.0 ^b
5 Oct.	Wigwam	6	2	1.12	1.12	11.0 ^a /5.0 ^b
4 Oct.	Wigwam	7	3	0	0	11.8 ^a /7.0 ^b
4 Oct.	Wigwam	9	4	0.49	0.49	12.4 ^a /5.0 ^b
14 Sept.	Bighorn	1	1	0.57	0.57	7.0 ^a /7.0 ^b

^a – Spot water temperature during electrofishing (August 9 – 14; Prince and Cope 2001).

^b – Spot water temperature during habitat survey (Sept 19 – Oct. 4; Prince and Cope 2001).

Figure 6. Mean daily discharge and total precipitation for the Wigwam River in 1999, 2000, and 2001 (Prince and Morris 2001).

Figure 7. Mean daily water levels recorded at the hydrometric (Wigwam River bridge @ km 45) station and groundwater station (Reach 7, EMS No. 238246), 2000 (Prince and Morris 2002).

Spot temperatures during the first year of sampling (2000) were well within bull trout tolerance limits ($<18^{\circ}\text{C}$) and in general, were indicative of cold perennial springs preferred by bull trout ($<12^{\circ}\text{C}$). Peak mean weekly maximum water temperatures for the Wigwam River at the hydrometric station occurred during the week of 05-11 August and reached 13°C . Water temperatures did not exceed the provincial guideline of 15°C for streams with bull trout, within the provincial guidelines for bull trout rearing (Prince and Morris 2002). Mean daily, and mean weekly maximum water temperatures for the Wigwam River at the hydrometric and groundwater stations (2001) are summarized in Figures 8 and 9. As in previous years, water temperatures at the hydrometric station were significantly correlated with air temperatures and air temperatures did not significantly differ among years (Prince and Morris 2002).

Figure 8. Daily maximum water temperatures recorded at the hydrometric station (Reach 5, EMS No. E238242) and the groundwater station (Reach 7, EMS No. 238246), 2000 (Prince and Cope 2001).

Figure 9. Mean daily water temperatures for the Wigwam River hydrometric and groundwater stations, 2001(Prince and Morris 2002).

Figure 10. Mean weekly maximum water temperatures for the Wigwam River recorded at the hydrometric and groundwater stations, 2001 (Prince and Morris 2002).

3.2.2 Substrate Pebble Counts

The preferred spawning reaches (Wigwam River reach five, six and reach one of Bighorn) were dominated by small cobble and large gravel substrate ranging in particle size from 32 mm to 96 mm (Table 3.7) and did not vary significantly from the previous year. Reach seven was dominated by large cobble and reach nine was dominated by small boulder. With a low flood peak and lower than average snow pack, larger (i.e. bankfull or channel forming) flows were not present and likely resulted in less channel movement. There were slightly higher levels of fines observed compared with those documented in the previous year (Prince and Morris 2002).

Table 7 Summary of substrate pebble counts (mode, D50, D90) for the Wigwam River fish habitat monitoring sites.

Stream	Reach	Site	Mode (Particle Class mm)	D ₅₀ (Particle class mm)	D ₉₀ (Particle class mm)
Wigwam	5	1	64 – 96	64 – 96	192 – 256
Wigwam	6	2	48 – 64	32 - 48	96 - 128
Wigwam	7	3	128 – 192	64 – 96	192 – 256
Wigwam	9	4	256 – 384	128 - 192	512 – 1024
Bighorn	1	1	32 – 48	24 - 32	64 - 96

3.2.3 Channel Surveys

Channel longitudinal and cross sectional profiles were again completed for each of the sample stations. While the channel cross sections and longitudinal sections changed slightly (as expected), the degree of change was minimal. Lower than average flows for the period from April to November would suggest that the effect of the freshet on channel movement (lateral and down-cutting) was minimal; channel forming flows may not have occurred in the spring and early summer of 2001 (or 2000 for that matter) and this has resulted in stable channel cross and longitudinal sections. The variation between sections may be an artifact of the change from a laser level to the Topcon Level, or from small differences in setup/rod placement.

3.2.3 Fish Habitat Survey (FHAP Form 4)

The Level 1 Fish Habitat Assessment Procedure (FHAP) is a purposive field survey of current habitat conditions for the target species in select reaches. In this study, the Level 1 FHAP Form 4 was completed for the representative sample sites (two meander wavelengths) within the selected reaches. The output of the WRP data reporting tool are presented in Appendix C and have been archived for long-term trend monitoring. Generic diagnostic data have been summarized as descriptors of present habitat condition (Table 3.8). Note that regional criteria for habitat conditions do not exist and current WRP diagnostic criteria to evaluate habitat condition are exclusive of bull trout and Westslope cutthroat trout data.

Notwithstanding these limitations, diagnostic data clearly indicate the high quality spawning and rearing habitat ratings for reach six of the Wigwam River and reach one of Bighorn Creek. These reaches demonstrate the importance of LWD and its relationship to habitat diversity and substrate storage and diversity. Reach five pool habitat features were under-represented by site-selection bias for juvenile bull trout and the limitation of two meander wavelengths (400 m) to accurately represent 10.4 km of stream channel. Reaches seven and nine of the Wigwam River were accurately represented as more confined, higher energy reaches with lower habitat diversity. A brief reach and site summary was provided in the preliminary report for year one of the study (Cope and Morris 2001). Photo-documentation was also recorded on standard MWLAP forms and submitted under separate cover.

Table 8. Diagnostics of salmonid habitat condition at the reach level (from Johnston and Slaney 1996). Note that the individual cell format represents value/rating.

	Habitat Parameter											
	Pool % (by area)	Pool Frequency (mean spacing)	LWD Pieces per Bankfull Channel Width	% Wood Cover in Pools	% Boulder Cover in Riffles	% Overhead Cover	Substrate Rearing Habitat (interstitial rating)	Off- Channel Habitat (< 3% gradient)	Holding Pools (> 1 m deep, good cover)	Spawning Gravel Quantity	Spawning Gravel Quality	Redd Scour Potential
Reach 5 Wigwam R.	0 P	0 P	13.8 G	N/a	< 10 P	0 P	Clear G	Some F	None G	Limited G	Suitable G	Low G
Reach 6 Wigwam R.	31.0 F	1.2 G	27.5 G	30 G	< 10 P	< 10 P	Clear G	Extensive G	Adequate G	Extensive G	Suitable G	Low G
Reach 7 Wigwam R.	Reach was dry on date of habitat sampling											
Reach 9 Wigwam R.	0.0 P	0.0 P	10.5 G	N/a	30 G	< 10 P	Clear G	Absent P	Few P	Absent P	Absent P	Extensive P
Reach 1 Bighorn Cr.	32.0 G	4.8 P	8.67 G	5 F	< 10 P	< 10 P	Clear G	Some G	Adequate P	Extensive G	Suitable G	Potential F

Note: regional standards are not available and diagnostic ratings (G – good, F – fair, P – poor) are generalized ratings from Johnston and Slaney (1996) for streams with a bankfull channel width of less than 15 m.

Note: two representative meander lengths were surveyed, not the entire reach.

4 Discussion

The five permanent sampling sites established in summer 2000 in the Wigwam river drainage (one site on Bighorn Creek and four sites on the mainstem Wigwam River) were again sampled in 2001. The 2001 project year represents the second year of a long-term bull trout monitoring program and current studies focused on collecting baseline information. Forest development within the Canadian portion of the upper Wigwam River commenced in August 1997 (road development) and the first cut-blocks were harvested in the winter of 2000/2001. Approximately 36% of the allowable cut was harvested as of 10 November, 2001 (Volume: 231.5 ha; Prince and Morris 2002).

Relative to co-existing species, bull trout densities usually are low, and most broad faunal surveys indicate less than 5% of the total catch is made up of bull trout (McPhail and Baxter 1996, Reiman and McIntyre 1995). However, in the upper Wigwam River, bull trout represented 92.4% of the catch in 2000, and 95.1% of the catch in 2001. The mean density of all juvenile bull trout was estimated to be 20.7 fish/100m² in 2001 (range 0.9 to 24.0 fish/100m²) as compared to 17.2 fish/100m² (range 0 to 26.9 fish/100m²) in 2000. The increase resulted from an increase in Bighorn Creek fry densities. Wigwam River mainstem sites remained remarkably consistent. It was interesting to note that last winter Reach 7, Site 3 dewatered yet fry density was 18.6 fish/100m². This year this site dewatered 92 days earlier. Fry again dominated the catch and this was a direct result of juvenile bull trout ecology and habitat partitioning among life history stages. Site selection was biased towards electrofishing sample sites which favored high bull trout fry capture success.

Areas with juvenile bull trout densities greater than 1.5 fish/100m² have been cited as critical rearing areas (Goetz 1989), and previously reported juvenile densities within the upper Wigwam River are some of the highest recorded (Cope 1998). Comparison of fry density estimates replicated across both the preliminary survey (Cope 1998) and years 1 and 2 of the current study illustrate the stable nature of these high densities (Table 4.1). To eliminate spatial and sampler bias, the identical habitat units were sampled within reaches five and seven using the same personnel and methods.

Table 9. Comparative bull trout fry density estimates for 1997, 2000, and 2001 surveys.

	Density Estimate (mean +/- 95% confidence Interval)		
	1997	2000	2001
Reach 5	15.6 (13.5 – 18.6)	17.1 (14.7 – 19.8)	16.7 (14.6 – 19.3)
Reach 7	16.8 (14.8 – 18.9)	16.4 (16.0 – 17.3)	18.6 (15.3 – 23.1)

When compared to other bull trout systems, the large spawning escapement (Baxter and Westover 2000) and high juvenile densities provide a strong case that the Wigwam River may be the most prolific bull trout population in the species distributional range. At the very least, it can be concluded that the pre-forest harvesting population of upper Wigwam River bull trout represent a large and stable population with high juvenile bull trout densities. Bull trout populations have been shown to be extremely susceptible to habitat degradation and over harvest (McPhail and Baxter 1996, Ratliff et al. 1996) and are ecologically important as an indicator of watershed health (Baxter 1997). As such, the upper Wigwam River watershed remains relatively pristine, and maintains high water quality (Prince and Cope 2001), high habitat capability (Oliver and Cope 1999) and, conservative angling regulations have been successful in preventing over-exploitation (Baxter and Westover 2000).

While discharge followed a similar pattern between years, mean monthly discharge in 2001 was significantly lower from April to November 2000 than during the same period in 2000. Conversely there was a 26% increase in precipitation from April to November 2001 over the same period in 2000. Snowpack is not currently monitored in the Wigwam River, but regionally, 2001 was said to have only 50-53% of normal levels (Environment Canada 2001). It appears that annual snow pack and groundwater recharge largely determine the hydrograph of the Wigwam River (Prince and Morris 2002). While Reach 7 dewatered earlier than noted in previous years, the effects appear to have been masked by increased escapement and slightly higher fry densities. It will be important to compare fry densities and overall recruitment with bull trout redd numbers over the study period as the study progresses, to determine what role (if any) the dewatering plays in redd density and juvenile production. The annual dewatering and associated high recruitment/fry numbers may emphasize the importance of groundwater and/or subsurface (interflows) in providing important fry/juvenile habitat for bull trout populations.

Maximum summer water temperatures of 14 – 18°C appear to limit bull trout distribution (Baxter and McPhail 1996). Furthermore, the inverted temperature profile across seasons between upper and lower temperature monitoring locations further demonstrates the influence of groundwater and/or sub-surface streambed flow in maintaining preferred bull trout spawning and incubation temperatures within the upper Wigwam River valley (Prince and Cope 2001). Any increase in water temperature and/or decrease in groundwater could result in limitations to juvenile bull trout distribution.

Trends in abundance appeared to be related to proximity to spawning areas, bed material size, water depth and LWD. The association of bull trout fry with shallow (5 – 20 cm), low velocity (<0.3 m/s), cobble dominated stream margin habitat has been previously documented within the Wigwam River (Cope 1998). The upper Wigwam River is comprised of sorted gravels and small cobbles with a very low percentage of fines that provide prime spawning and rearing habitat. Extensive groundwater and sub-surface streambed exfiltration maintains water temperatures and base winter flows.

The range of morphological stream types (B2, C3, C4, D4) encompass the depositional (aggrading) to degrading and sensitive to resilient spectrum and vary from very low to very high bedload sediment yields. A number of site-specific disturbance features of note included sediment wedges, extensive unvegetated bars and lateral instability. Aerial photographs (35 mm) within reach six dating to the late 1970's demonstrate remarkable similarity to recent photographs (Cope and Morris 2001). Although reach six appears to be aggrading these photographs suggest stability. This was in spite of the 1995 rain-on-snow event generally believed to represent a 1 in 150 year flood event. Minor shifting of braids and some down-cutting has occurred since 1995 but no major change in geo-morphology or bed material size class has occurred since the late 1970's. While the reach may appear unstable at first glance, the above observations suggest the D4 stream channel (usually unstable and aggrading), although a very high sediment storage and bedload yield reach, is currently in equilibrium and relatively stable. This reach contains some of the prime bull trout spawning grounds found in the Wigwam River and should be considered very sensitive. The diagnostics summary table (Table 8) demonstrates the importance of LWD to stream structure and sediment storage, habitat diversity, and stability within this reach.

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Appendix A

1:50,000 TRIM Map

Appendix B

Fish Capture Data

Table B1. Summary of electroshocking sample effort and catch in the Wigwam River and Bighorn Creek, 3 to 9 August 2001.

Reach No.	Site No.	Haul No.	Sample Effort		Catch (number of fish)				Total Catch
			Time (s)	Area m2	BT ¹ fry ³	WCT ² fry ³	BT ¹ juv. ⁴	WCT ² juv. ⁴	
1 ^a	1	1	1395	240	58			1	59
1 ^a	1	2	1284	240	23				23
1 ^a	1	3	1004	240	19				19
1 ^a	2	1	1172	215.6	17				17
1 ^a	2	2	1004	215.6	11				11
1 ^a	2	3	270	215.6	2				2
SUBTOTAL		1	2567	455.6	75	0	0	1	76
		2	2288	455.6	34	0	0	0	34
		3	1274	455.6	21	0	0	0	21
TOTAL			6129	455.6	130	0	0	1	131
5	1	1	1182	150	11	1			12
5	1	2	798	150	10	3			13
5	1	3	920	150	3	2			5
5	2	1	1154	208.8	21	2			23
5	2	2	1038	208.8	14	1			15
5	2	3	969	208.8	7	2			9
5	3	1	1169	180	10	3		1	14
5	3	2	571	180	3	0		3	6
5	3	3	0	180					0
SUBTOTAL		1	3505	538.8	42	6	0	1	49
		2	2407	538.8	27	4	0	3	34
		3	1889	538.8	10	4	0	0	14
TOTAL			7801	538.8	79	14	0	4	97
6	1	1	1147	195	32				32
6	1	2	881	195	9				9
6	1	3	984	195	10				10
6	2	1	1036	170	8				8
6	2	2	940	170	7				7
6	2	3	807	170	1				1
6	3	1	1317	176	25				25
6	3	2	1126	176	19		1		20
6	3	3	857	176	8				8
SUBTOTAL		1	3500	541	65	0	0	0	65
		2	2947	541	35	0	1	0	36
		3	2648	541	19	0	0	0	19
TOTAL			9095	541	119	0	1	0	120

^a Bighorn Creek

¹ Bull Trout

² Westslope Cutthroat Trout

³ 0+ age group

⁴ 1+, 2+, 3+ age groups combined

Cont...

Table B1. Contd.

Reach No.	Site No.	Haul No.	Sample Effort		Catch (number of fish)				Total Catch
			Time (s)	Area m2	BT ¹ fry ³	WCT ² fry ³	BT ¹ juv. ⁴	WCT ² juv. ⁴	
7	1	1	1503	208.25	18		3		21
7	1	2	1052	208.25	7				7
7	1	3	760	208.25	6				6
7	2	1	1134	137.8	14		3		17
7	2	2	849	137.8	6		3		9
7	2	3	962	137.8	6		1		7
7	3	1	731	105	5				5
7	3	2	775	105	5				5
7	3	3	770	105	2	1			3
SUBTOTAL		1	3368	451.05	37	0	6	0	43
		2	2676	451.05	18	0	3	0	21
		3	2492	451.05	14	1	1	0	16
TOTAL			8536	451.05	69	1	10	0	80
9	1	1	1029	255	4		5		9
9	1	2	849	255	6		3		9
9	1	3	806	255	6		1		7
9	2	1	686	140	7	1	1		9
9	2	2	747	140	4	1	2		7
9	2	3	566	140	0				0
9	3	1	816	121	4				4
9	3	2	762	121	0				0
9	3	3	0	121					0
SUBTOTAL		1	2531	516	15	1	6	0	22
		2	2358	516	10	1	5	0	16
		3	1372	516	3	0	0	1	4
TOTAL			4889	516	28	2	11	1	42
GRAND TOTAL			36450	2502.45	425	17	22	6	470

^a Bighorn Creek¹ Bull Trout² Westslope Cutthroat Trout³ 0+ age group⁴ 1+, 2+, 3+ age groups combined

Table B2. Summary of site population estimates and density estimates for bull trout (BT) within the Wigwam River study area, 3 to 9 August, 2001. Note that three pass removal-depletion method was used to estimate abundance (see catch summary).

Life Stage	Site Estimate						
	Population Estimate (No. of Fish)	Low 95% Confidence Interval (No. of Fish)	High 95% Confidence Interval (No. of Fish)	Density Estimate (No./100m ²)	Low 95% Confidence Interval (No./100m ²)	High 95% Confidence Interval (No./100m ²)	Capture Probability
Wigwam River, Reach 5, Site 1 (538.8 m ²)							
BT Fry	90	79	104.087	16.70378619	14.66221232	19.31829993	0.497
BT Juv.							
Wigwam River, Reach 6, Site 2 (541.0 m ²)							
BT Fry	139	119	159.135	25.69316081	21.99630314	29.41497227	0.472
BT Juv.							
Wigwam River, Reach 7, Site 3 (451.05 m ²)							
BT Fry	84	69	104.021	18.6232125	15.29763884	23.06196652	0.431
BT Juv.	10	10	11.944	2.217049108	2.217049108	2.648043454	0.667
Wigwam River, Reach 9, Site 4 (516.0 m ²)							
BT Fry	30	28	35.802	5.813953488	5.426356589	6.938372093	0.56
BT Juv.	11	11	12.755	2.131782946	2.131782946	2.471899225	0.688
Bighorn Creek, Reach 1, Site 1 (455.6 m ²)							
BT Fry	148	130.324	165.676	32.48463565	28.60491659	36.3643547	0.500
BT Juv.							
Mean Densities							
BT Fry				19.9	17.2	23.0	
BT Juv.				0.9	0.9	1.0	
Combined				20.7	18.1	24.0	

Table B3. Summary of site population estimates and density estimates for Westslope cutthroat trout (WCT) within the Wigwam River study area, 3 to 9 August, 2001. Note that three pass removal-depletion method was used to estimate abundance (see catch summary).

Life Stage	Site Estimate						
	Population Estimate (No. of Fish)	Low 95% Confidence Interval (No. of Fish)	High 95% Confidence Interval (No. of Fish)	Density Estimate (No./100m ²)	Low 95% Confidence Interval (No./100m ²)	High 95% Confidence Interval (No./100m ²)	Capture Probability
Wigwam River, Reach 5, Site 1 (538.8 m ²)							
WCT Fry	0						
WCT Juv.	1						
Wigwam River, Reach 6, Site 2 (541.0 m ²)							
WCT Fry	0						
WCT Juv.	0						
Wigwam River, Reach 7, Site 3 (451.05 m ²)							
WCT Fry	1						
WCT Juv.	0						
Wigwam River, Reach 9, Site 4 (516.0 m ²)							
WCT Fry	20	14	41.011	3.875968992	2.713178295	7.947868217	0
WCT Juv.	0						
Bighorn Creek, Reach 1, Site 1 (455.6 m ²)							
WCT Fry	0						
WCT Juv.	1						
Mean Densities							
WCT Fry				0.8	0.5	1.6	
WCT Juv.				0.0	0.0	0.0	
Combined				0.8	0.5	1.6	

Appendix C

FHAP Level 1 Form 4 Data

Level 1 - Habitat Summary Diagnosis Report

Form Number: 881	Forest District: CRANBROOK	
	Watershed Name: WIGWAM RIVER	
	Watershed Code: 349-248100-04900-00000-00000-0000-000-000-000-000-000	
Survey Date: 9/14/01	Weather: CLEAR	Survey Crew: SC/KM
Discharge: (cubic meters per second)		
Subsampling Fractions:		
Riffles	1 in 1	Pools 1 in 1
Glides	1 in 1	Cascades
Other		

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Grad (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth (m)	Crest (m)	Residual (m)	Pool Type
1	BIGHORN CR.	1	1	11	648335	5449685	743	R	1	11	0.5	1	0.32	32.6	6				
Comments :		LITTLE MORE WOOD, MORE FINES ALSO, AND GRAVEL DEPOSITED																	
2	BIGHORN CR.	1	1	11	649158	6449604	732	G	1	36	0.5	1.2	0.55	15.6	5.6				
Comments :		MUCH MORE FINES AND SAND DEPOSITED																	
3	BIGHORN CR.	1	1	11	545234	5505567	36	P	1	10	0.5	0.9	0.42	33.5	4.8	0.55	0.28	0.27	S
Comments :		1 REDD STARTING																	
4	BIGHORN CR.	1	1	11	649105	5449620	636	P	1	24	0.5	1.95	1	28.4	9.2	1.1	0.19	0.91	D
Comments :		LOG JAM GETTING CLOGGED UP WITH SWD - WILL BLOW OUT SOON																	
5	BIGHORN CR.	1	1	11	649084	5148613	612	R	1	13	0.5	1.2	0.31	36.1	4.3				
Comments :		COVER IN ADJACENT (?); BULL TROUT SPAWNING 1 FEMALE, 3 MALES, 1 BIG REDD																	
6	BIGHORN CR.	1	1	11	649147	5449419	599	P	1	22	0.5	1.9	1	35.9	10	1.1	0.18	0.92	S
Comments :		1 BT REDD																	
7	BIGHORN CR.	1	1	11	649064	5449590	577	P	1	26	0.5	1.2	0.84	14.9	7.5	0.84	0.08	0.76	S
Comments :																			
8	BIGHORN CR.	1	1	11	649089	5449439	551	R	1	69	0.36	0.8	0.2	36.6	4.9				
Comments :		SAME AS LAST YEAR; COTTONWOOD 1 FOOT HIGHER; STABLE HABITAT																	
9	BIGHORN CREEK	1	1	11	649089	5449439	551	R	2	69	0.36	0.6	0.13	36.6	4.9				
Comments :		FULL OF FRY; VERY STABLE CHANNEL																	

NTS Maps (1:50,000) :		082G02				BGS Maps (1:20,000) :				082G016																			
Bed Material Type						Total LWD Tally	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barriers						
Dom.	Sub-Dom.	D90 (mm)	Compaction	SG Type	SG Amt		10 - 20cm	20 - 50cm	>50c	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)				Type	Structure	Canopy Closure							
G	C	21	M	R	H		11	9	2		LWD	5	C	5	SC	G	300	1	2	3	M	MF		1	N				
G	S	18	M	R	L	7	4	1		C	5	OV	5							M	MF	1	N						
C	B	17	M	R	H	13	7			LWD	10	C	10				DW	WG		M	MF	1	N						
G	S	8	M	R	L	24	18	5	1	LWD	45	SWD	40				DW	JM	WG	M	MF	1	N						
G	C	30	M	R	H	6		1		OV	5						WG			M	MF	1	N						
G	S	25	M	R	L	6	4	2		DP	60	LWD		SC	G	300	EB	WG		M	MF	1	N						
S	G	16	M	R	L	3	3			DP	10	LWD	10				EB												
C	G	15	M	R	L	3	3			B		LWD					DW	EB	MB	M	MF	1	N						
G	C	15	M	R	L	5	4	1		LWD							DW	EB	MB	M	MF	1	N						

Level 1 - Habitat Summary Diagnosis Report

Form Number: 882		Forest District: CRANBROOK	
		Watershed Name: WIGWAM RIVER	
		Watershed Code: 349-248100-04900-00000-00000-0000-000-000-000-000-000	
Survey Date: 10/3/01		Weather: CLEAR	
Discharge: (cubic meters per second)		Survey Crew: SC/AP	
Subsampling Fractions:			
Riffles 1 in 1		Pools 1 in 1	
Glides 1 in 1		Cascades 1 in 1	
Other 1 in 1			

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Grad (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth (m)	Crest (m)	Residual (m)	Pool Type
1	WIGWAM RIVER	5	5	11	648335	5449685	0	R	1	100		1.5	0.48	45.9	18.2				
Comments :																			
2	WIGWAM RIVER	5	5				100	G	1	60		1.5	0.93	33.9	18.3				
Comments :																			
3	WIGWAM RIVER	5	5	11	648156	5449614	160	R	1	80		1.5	0.46		19.3				
Comments :																			
4	WIGWAM RIVER	5	5				240	G	1	110		1.5	0.78		19.8				
Comments : 20 BT REDDS; 1 PAIR LEFT; LWD CUT ON BAR FOR FIREWOOD - GETTING SMALLER																			
5	WIGWAM RIVER	5	5				350	R	1	50		1.5	0.48	48.2	21.1				
Comments :																			

NTS Maps (1:50,000) :		082G03		BGGS Maps (1:20,000) :		082G016																	
Bed Material Type						Total LWD Tally	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barriers
Dom.	Sub-Dom.	D90 (mm)	Compaction	SG Type	SG Amt		10 - 20cm	20 - 50cm	>50cm	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)	1	2	3	Type	Structure	Canopy Closure	
C	B	345	M	R	N	7	3	2		B	10	LWD	2	SC	P	100	DW	FP	DW	M	MF	1	N
B	C	350	M	R	L	8	5			DP	20	B	10	SC	P	60	DW	FP		C	MF	1	N
C	B	250		R	N	18	13	5		B	10	LWD	5	SC	P	80	EB			M	MF	1	N
G	C	210		R	H	16	14			SWD	5	C	5	SC	P	150	DW	FP		M	MF	1	N
C	B	320		R	N	20	13	3		B	5			SC	G	120	DW	FP	PD	M	MF	1	N

Level 1 - Habitat Summary Diagnosis Report

Form Number: 883	Forest District: CRANBROOK
	Watershed Name: WIGWAM RIVER
	Watershed Code: 349-248100-04900-00000-00000-00000-000-000-000-000-000
Survey Date: 10/5/01	Weather: CLEAR
Discharge: (cubic meters per second)	Survey Crew: SC/KM
Subsampling Fractions:	
Riffles 1 in 1	Pools 1 in 1
Glides 1 in 1	Cascades 1 in 1
Other	

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Grad (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth (m)	Crest (m)	Residual (m)	Pool Type
1	WIGWAM RIVER	6	6	11	653802	54418976	615	R	1	55		1	0.25	68	22.7				
Comments : K2:F4 D/S; F5 SPAWNING HAB. EXTENSIVE BAR;																			
2	WIGWAM RIVER	6	6	11	653770	5441871	600	P	1	15		2	1.3	73.5	9.8	1.4	0.35	1.05	S
Comments : NICE POOL; K2: FRAME 3 D/S; BT IN POOL																			
3	WIGWAM RIVER	6	6				560	R	1	40		0.9	0.28	78.1	10.8				
Comments : NEW UNIT; K2:F6 RIF. U/S																			
4	WIGWAM RIVER	6	6				520	G	1	40		1.35	0.61	88.2	11.5				
Comments : 20 BT REDDS; EF SITE; K2:F7 D/S GLIDE/SPAWNING HAB																			
5	WIGWAM RIVER	6	6	11	653835	5441798	460	R	1	50		1.1	0.9	88	11.2	0.9	0.3	0.6	S
Comments : APPROX. 5 BT IN POOL; K2:F8 X/C POOL																			
6	WIGWAM RIVER	6	6	11	653835	5441798	460	R	1	50		1.1	0.4	85	14				
Comments : 3 BT REDDS																			
7	IGWWAM RIVE	6	6				410	P	1	40		2.6	1.7	76.8	14	1.7	0.3	1.4	S
Comments : 7 BT REDDS; NICE POOL FOR BT & WCT; LWD SUBMERGED IN POOL; K2:F9 X/C POOL																			
8	WIGWAM RIVER	6	6				300	R	1	120		1.25	0.4	55	9.7				
Comments : LOTS OF LWD; 3 BT NEAR LWD; K2:F10 D/SA LONG RIFFLE																			
9	WIGWAM RIVER	6	6				230	P	1	70		2.1	1.1	130	15	1.5	0.4	1.1	S
Comments : APPROX. 10 BT REDDS; SC BLOCKED BY BD; K2:F11 X/S LWD P00																			
10	WIGWAM RIVER	6	6				160	R	1	70		1.3	0.4	150	11				
Comments : SC IS HENRY' STRIB; BT SPAWNING; K2:F12 X/C LUB-RUB																			
11	WIGWAM RIVER	6	6				70	G	1	90		1.3	0.45	130	15				
Comments : 10 BT REDDS ALL ALONG LUB; UNDER OV/CB																			
12	WIGWAM RIVER	6	6	11	653886	5441349	0	P	1	70		2.5	1.5			1.9	0.3	1.6	S
Comments : 2 BT REDDS; 7 BT IN POOL 7 1 WCT																			

NTS Maps (1:50,000) :		082G03		BGS Maps (1:20,000) :		082G006																	
Bed Material Type						Total	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barriers
Dom.	Sub-Dom.	D90 (mm)	Compaction	SG Type	SG Amt	LWD Tally	10 - 20cm	20 - 50cm	>50cm	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)				Type	Structure	Canopy Closure	
																	1	2	3				
G	C	150		R	H	20	9	5	2	LWD	2			SC	G	55	DW	MB	MC	M	MF	1	N
G	C	150		R	H	5	2	3		DP	60	LWD	20	SC	G	15	DW	MB	MC	M	MF	1	N
G	C	170		R	L	1								SC	G	40	DW	MB	MC	M	MF	1	N
G	C	150		R	H	7	5	2		LWD	2	DP	2	SC	G	40	DW			M	MF	1	N
G	C	100		R	H	24	21	2	1	DP	10	LWD	10	SC	G	20	DW			M	MF	1	N
G	C	120		R	H	10	6	1		LWD	2	C	2	SC	G	50	DW	MC		M	MF	1	N
G	C	160		R	H	43	31	10	2	LWD	30	DP	30	SC	G	40	DW			M	MF	1	N
C	G	180		R	L	53	23	25	5	LWD	5			SC	P	120	DW			M	MF	1	N
G	S	120		R	H	64	27	31	6	SWD	60	DP	30	SC	P	450	DW	WG		M	MF	1	N
C	G	220		R	L	38	24	13	1	LWD	2	C	2	SC	G	300	DW			M	MF	1	N
G	C	100		R	H	29	14	15		C	10	OV	5				DW			M	MF	1	N
G	S	80		R	H	39	20	16	3	LWD	15	DP	30				DW			M	MF	1	N

Level 1 - Habitat Summary Diagnosis Report

Form Number: 884		Forest District: CRANBROOK	
		Watershed Name: WIGWAM RIVER	
		Watershed Code: 349-248100-04900-00000-00000-0000-000-000-000-000-000	
Survey Date: 10/4/01		Weather: CLEAR	
Discharge: (cubic meters per second)		Survey Crew: SC/KM	
Subsampling Fractions:			
Riffles 1 in 1		Pools 1 in 1	
Glides 1 in 1		Cascades 1 in 1	
Other 1 in 1			

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Grad (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth (m)	Crest (m)	Residual (m)	Pool Type
1	WIGWAM RIVER	7	7	11	654977	5439074	0	R	1	70		1.25	0	25	0				
Comments :		ROLL#K1 FRAME 23																	
2	WIGWAM RIVER	7	7				70	G	1	110		1.25	0	40	0				
Comments :		ROLL# K1 FRAME 24																	
3	WIGWAM RIVER	7	7				180	P	1	20		1.9	0		0	0.9	0	0.9	S
Comments :		ROLL#K2 FRAME 1																	
4	WIGWAM RIVER	7	7				200	R	1	30		1.2	0	40	0				
Comments :																			
5	WIGWAM RIVER	7	7	11	655250	5438890	230	P	1	30		1.7	0	28.6	0	0.6	0	0.6	S
Comments :		ROLL #K2 FRAME 2																	
6	WIGWAM RIVER	7	7				260	G	1	40		1.4	0	26.1	0				
Comments :																			
7	WIGWAM RIVER	7	7	11	655186	5438950	300	R	1	270		1	0	20.9	0				
Comments :																			
8	WIGWAM RIVER	7	7	11	655471	5438625	570	G	1	80		1.8	0	33.1	0				
Comments :		K2 FRAME 3																	

NTS Maps (1:50,000) :		082G03		BGGs Maps (1:20,000) :		082G006																	
Bed Material Type						Total LWD Tally	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barriers
Dom.	Sub-Dom.	D90 (mm)	Compaction	SG Type	SG Amt		10 - 20cm	20 - 50cm	>50cm	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)	1	2	3	Type	Structure	Canopy Closure	
C	G	200		R	L	6	5	1		LWD	2	C	2				DW	FP		C	MF	1	N
G	C	200		R	L	8	3	1		C	10	SWD	5	SC	P	110	DW	FP		C	MF	1	N
C	G	200		R	L	7	6	1		DP	20	LWD	20	SC	P	20	DW	PD		C	MF	1	N
C	G	300		R	L	0				B	2			SC	P	30	DW			C	MF	1	N
C	G	550		R	L	0				B	20	DP	10				EB			C	MF	1	N
C	B	380		R	N	6	4	2		B	15						EB			C	MF	1	N
C	G	250		R	L	25	16	3	2	B	2	LWD	5				EB	PD		M	PS	1	N
C	B	380		R	L	6	6			B	2	LWD	2				DW	EB	WG	M	PS	1	N

Level 1 - Habitat Summary Diagnosis Report

Form Number: 885		Forest District: CRANBROOK	
		Watershed Name: WIGWAM RIVER	
		Watershed Code: 349-248100-04900-00000-00000-0000-000-000-000-000-000	
Survey Date: 10/4/01	Weather: CLOUDY PERIODS, COLD		Survey Crew: SC/KM
Discharge: (cubic meters per second)			
Subsampling Fractions:			
Riffles	1 in 1	Pools	1 in 1
Glides	1 in 1	Cascades	1 in 1
Other	1 in 1		

Detail No	Sub Basin Name	Reach No	Section No	UTM			Distance (m)	Habitat Unit		Length (m)	Grad (%)	Mean Depth		Mean Width		Pools Only			
				Zone	Easting	Northing		Type	Cat			Bankfull (m)	Water (m)	Bankfull (m)	Wetted (m)	Max Depth (m)	Crest (m)	Residual (m)	Pool Type
1	WIGWAM RIVER	9	9	11	660830	5433065	0	C	1	210		1.1	0.42	13.8	9.6				
Comments :		TERTAIKY LWD POOL - WILL BLOW OUT; 3NF PIECES OF LWD																	
2	WIGWAM RIVER	9	9	11	660942	5432911	210	R	1	80		1.12	0.4	17	12.3				
Comments :		tertiary cascade -																	

NTS Maps (1:50,000) :	082G03	BGGS Maps (1:20,000) :	082G007

Bed Material Type						Total	Functional LWD			Cover				Offchannel Habitat			Disturbance Indicators			Riparian Vegetation			Barriers
Dom.	Sub-Dom.	D90 (mm)	Compaction	SG Type	SG Amt	LWD Tally	10 - 20cm	20 - 50cm	>50cm	Cover Type 1	%	Cover Type 2	%	Type	Access	Length (m)	1	2	3	Type	Structure	Canopy Closure	
B	C	800		R	L	19	15	1		B	40	LWD	5							M	MF	1	

C	B	600		R	L	5	4	1		B	15	C	5							M	MF	1	
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Appendix D

FHAP Channel Survey Data

Longitudinal profile of a representative two meander lengths of Bighorn Creek in reach 1, study site 1.

Bighorn Long Survey

Longitudinal Survey

Location: Bighorn Creek

Reach: 1

Site: 1

UTM: 649255E, 5449395N

Crew: SC/KM

Date: 13/09/2001

Benchmark UTM:

BM2: 649256E, 5449358N

RP2: 649106E, 5449472N

RP3: 649150E, 5449385N

RP4: 649203E, 5449419N

Benchmark elevation:

BM2: 1124.459 RP3: 1121.934

RP2: 1120.448 RP4: 1123.364

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
BM2	0	2.559	0.470	2.089	1122.395	1122.865	gravel	pool	LWD has accumulated since last year
	10	2.600	0.510	2.090	1122.354	1122.864	sand	pool	tertiary pool
	20	2.624	0.675	1.949	1122.330	1123.005	sand	pool	tertiary pool
TP1	30	2.637	0.549	2.088	1122.317	1122.866	cobble	glide	
	40	2.626	0.465	2.161	1122.328	1122.793	gravel	glide	
	50	2.717	0.340	2.377	1121.766	1122.106	gravel	glide	
	60	2.267	0.465	1.802	1122.216	1122.681	gravel	riffle	one BT redd, LWD plunge pool
	70	2.395	0.438	1.957	1122.088	1122.526	gravel	riffle	LWD accumulation
	80	2.409	0.403	2.006	1122.074	1122.477	gravel	riffle	one BT redd at 0+73m
	90	2.671	0.425	2.246	1121.812	1122.237	gravel	riffle	nice cover
	100	2.552	0.180	2.372	1121.931	1122.111	gravel	riffle	
	110	2.698	0.200	2.498	1121.785	1121.985	gravel	riffle	corner
	120	3.122	0.420	2.702	1121.361	1121.781	gravel	pool	
	130	3.669	0.825	2.844	1120.814	1121.639	sand	pool	large log jam
	140	3.716	0.935	2.781	1120.767	1121.702	finer	pool	1 BT, 1WCT
	150	3.156	0.350	2.806	1121.248	1121.598	gravel	pool	pool tailout, 3 BT, 1BT redd
	160	3.933	1.035	2.898	1120.471	1121.506	finer	pool	3 BT (redds overnight)
	170	3.841	0.950	2.891	1120.563	1121.513	cobble	pool	
	180	3.533	0.610	2.923	1120.871	1121.481	finer	pool	
	190	3.642	0.710	2.932	1120.762	1121.472	gravel	pool	
	200	3.138	0.200	2.938	1121.266	1121.466	gravel	pool	tailout
	210	1.867	0.190	1.677	1121.199	1121.389	gravel	riffle	
	220	2.139	0.245	1.894	1120.927	1121.172	cobble	riffle	
	230	2.384	0.255	2.129	1120.682	1120.937	cobble	riffle	
	240	2.482	0.240	2.242	1120.584	1120.824	cobble	riffle	
	250	2.577	0.205	2.372	1120.489	1120.694	gravel	glide	one BT redd, LWD accumulation
	260	2.771	0.300	2.471	1120.295	1120.595	cobble	riffle	
	270	3.048	0.360	2.688	1120.018	1120.378	gravel	riffle

Cross sectional profile of a representative pool habitat unit of Bighorn Creek in reach 1, study site 1.

Bighorn Pool X-Sxn

Pool Cross Sectional Survey

Location: Bighorn Creek

Reach: 1

Site: 1

pool cross section located at 0+165 m from start of longitudinal survey

UTM: 649147E, 5449379N

Crew: KM/SC

Date: 14/09/2001

Benchmark UTM:

BM2: 649256E, 5449358N

RP3: 649150E, 5449385N

RP4: 649203E, 5449419N

Benchmark elevation:

BM2: 1124.459

RP3: 1122.038

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
RP3*	0.0	0.150			1123.930		vegetation	top of RUB bank
	4.0	0.452			1123.628		vegetation	
	5.0	2.040			1122.040		vegetation	RUB bankfull height
	6.0	2.578			1121.502		vegetation	
	6.3	2.608	0.000	2.608	1121.472	1121.472	clay	RUB wetted edge
	7.0	2.748	0.140	2.608	1121.332	1121.472	clay	
	8.0	2.722	0.120	2.602	1121.358	1121.478	clay	
	9.0	3.021	0.425	2.596	1121.059	1121.484	clay	LWD in channel
	10.0	3.252	0.644	2.608	1120.828	1121.472	clay	maximum pool depth, BT in pool
	11.0	3.211	0.605	2.606	1120.869	1121.474	clay	new redds overnight
	12.0	3.223	0.620	2.603	1120.857	1121.477	gravel	
	13.0	2.945	0.340	2.605	1121.135	1121.475	gravel	
	14.0	2.613	0.000	2.613	1121.467	1121.467	gravel	LUB wetted edge
	15.0	2.349			1121.731		sand	
	16.0	2.283			1121.797		sand	
	17.0	2.176			1121.904		sand	
	18.0	2.099			1121.981		sand	
	19.0	2.018			1122.062		cobble	LUB bankfull height, vegetation on bar
	20.0	1.812			1122.268		cobble	
	21.0	1.697			1122.383		gravel	
	22.0	1.631			1122.449		gravel	
	23.0	1.607			1122.473		sand	
	24.0	1.689			1122.391		sand	

*RP3 backsight = 2.042, height of instrument = 1124.08 m

Cross sectional profile of a representative riffle habitat unit of the Bighorn Creek in reach 1, study site 1.

Bighorn Riffle X-Sxn

Riffle Cross Sectional Survey

Location: Bighorn Creek

Reach: 1

Site: 1

riffle cross section located at 0+230 m of longitudinal survey

UTM: 649102E, 5449417N

Crew: KM/SC

Date: 14/09/2001

Benchmark UTM:

BM2: 649106E, 5449472N

RP3: 649150E, 5449385N

Benchmark elevations:

BM2: 1124.459

RP3: 1122.038

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments	
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
RP3*	0.0	0.677			1122.175		vegetation	RUB pin
	1.0	0.713			1122.139		vegetation	
	2.0	0.686			1122.166		vegetation	
	3.0	0.650			1122.202		vegetation	
	4.0	0.673			1122.179		vegetation	
	5.0	0.567			1122.285		vegetation	
	6.0	0.438			1122.414		vegetation	undercut bank
	7.0	1.552			1121.300		vegetation	RUB bankfull height, undercut bank
	7.2	2.163	0.000	2.163	1120.689	1120.689	gravel	RUB wetted edge
	8.0	2.361	0.205	2.156	1120.491	1120.696	gravel	thalweg
	9.0	2.264	0.120	2.144	1120.588	1120.708	gravel	
	10.0	2.282	0.135	2.147	1120.570	1120.705	gravel	
	11.0	2.294	0.150	2.144	1120.558	1120.708	gravel	
	12.0	2.218	0.070	2.148	1120.634	1120.704	gravel	
	13.0	2.155	0.000	2.155	1120.697	1120.697	gravel	LUB wetted edge
	14.0	2.019			1120.833		gravel	vegetated bar
	15.0	1.893			1120.959		gravel	vegetated bar
	16.0	1.919			1120.933		gravel	vegetated bar
	17.0	1.773			1121.079		gravel	
	18.0	1.709			1121.143		cobble	
	19.0	1.663			1121.189		cobble	
	20.0	1.757			1121.095		cobble	
	21.0	1.724			1121.128		cobble	
	22.0	1.792			1121.060		cobble	
	23.0	1.558			1121.294		cobble	
	24.0	1.608			1121.244		cobble	
	25.0	1.601			1121.251		cobble	
	26.0	1.545			1121.307		cobble	LUB bankfull height
	27.0	1.511			1121.341		cobble	
	28.0	1.478			1121.374		cobble	
	29.0	1.472			1121.380		cobble	
	30.0	1.552			1121.300		cobble	

Bighorn Riffle X-Sxn

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments	
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
	31.0	1.768			1121.084		cobble	1121.3
	32.0	1.730			1121.122		cobble	1121.3
	33.0	1.713			1121.139		gravel	1121.3
	34.0	1.712			1121.140		gravel	1121.3
	35.0	1.768			1121.084		gravel	1121.3
	36.0	1.906			1120.946		gravel	1121.3
	36.1	1.928	0.000	1.928	1120.924	1120.924	gravel	wetted edge 1121.3
	37.0	1.951	0.010	1.941	1120.901	1120.911	gravel	1121.3
	38.0	1.962	0.025	1.937	1120.890	1120.915	gravel	unvegetated bar 1121.3
	39.0	2.039	0.105	1.934	1120.813	1120.918	gravel	1121.3
	40.0	2.022	0.085	1.937	1120.830	1120.915	gravel	1121.3
	41.0	1.931	0.000	1.931	1120.921	1120.921	cobble	LUB wetted edge 1121.3
	42.0	1.621			1121.231		cobble	1121.3
	43.0	1.554			1121.298		gravel	LUB bankfull height 1121.3
	43.6	1.346			1121.506		gravel	unvegetated bar
	44.0	1.038			1121.814		gravel	
	45.0	0.883			1121.969		gravel	start of riparian vegetation
	46.0	0.838			1122.014			
	47.0	0.859			1121.993			
	48.0	0.728			1122.124			
	49.0	0.635			1122.217			LUB Pin

14, height of instrument = 1122.852

Bighorn Differential Level Loop

Bighorn Creek

Differential Levelling Loop - Reach 1, Site 1

Date: 14/09/2001

Field (Arbitrary) Elevations (m)

Station	Backsight	Height of Instrument	Foresight	Elevation
BM2	0.495	5.495		5.000
TP1	1.013	5.024	1.484	4.011
RP4	1.018	4.945	1.097	3.927
RP3	1.031	3.607	2.369	2.576
RP2			2.471	1.136
RP2	2.505	3.641		1.136
RP3	2.366	4.948	1.059	2.582
RP4	1.092	5.026	1.014	3.934
TP1	1.475	5.481	1.02	4.006
BM2			0.484	4.997
				error= -0.003

True Elevations (m)

Station	Backsight	Height of Instrument	Foresight	Elevation
BM2	0.495	1124.954		1124.459
TP1	1.013	1124.483	1.484	1123.470
RP4	1.018	1124.404	1.097	1123.386
RP3	1.031	1123.066	2.369	1122.035
RP2			2.471	1120.595
RP2	2.505	1123.100		1120.595
RP3	2.366	1124.407	1.059	1122.041
RP4	1.092	1124.485	1.014	1123.393
TP1	1.475	1124.940	1.02	1123.465
BM2			0.484	1124.456
				error= -0.003

Benchmark Elevations (m)		
	2000	2001
BM2	1124.459	1124.459
RP2	1120.448	1120.595
RP3	1121.934	1122.038
RP4	1123.364	1123.39

(BM2 elevation from 1999 survey)

Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 5, study site 1.

Reach 5, Site 1 Long Survey

Longitudinal Survey

Location: Wigwam River

Reach: 5

Site: 1

UTM: start 648335E, 5449685N

end 648110E, 5449910N

Crew: SC/KM

Date: 17/09/2001

Benchmark UTM:

BM1: 648333E, 5449663N

BM2: 648108E, 5449915N

Benchmark Elevations:

BM1: 1120.000

BM2: 1116.955

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
BM1	0	2.039	0.215	1.824	1118.043	1118.258	cobble	riffle	
	10	2.238	0.275	1.963	1117.844	1118.119	cobble	riffle	
	20	2.431	0.270	2.161	1117.651	1117.921	cobble	riffle	
	30	2.727	0.300	2.427	1117.355	1117.655	cobble	riffle	
	40	3.013	0.520	2.493	1117.069	1117.589	cobble	riffle	
	50	3.071	0.545	2.526	1117.011	1117.556	cobble	riffle	
	60	3.102	0.450	2.652	1116.980	1117.430	boulder	riffle	
	70	3.244	0.450	2.794	1116.838	1117.288	boulder	riffle	
	80	3.412	0.481	2.931	1116.670	1117.151	boulder	riffle	
	90	3.588	0.554	3.034	1116.494	1117.048	cobble	riffle	
TP1	100	3.756	0.735	3.021	1116.326	1117.061	cobble	riffle	
	110	2.679	1.010	1.669	1116.020	1117.030	gravel	pool	~10 BT in pool
	120	2.561	0.870	1.691	1116.138	1117.008	boulder	pool	
	130	2.39	0.710	1.680	1116.309	1117.019	boulder	pool	
	140	2.411	0.720	1.691	1116.288	1117.008	boulder	pool	pool tail out
	150	2.244	0.530	1.714	1116.455	1116.985	cobble	glide	
	160	2.109	0.390	1.719	1116.590	1116.980	cobble	glide	
	170	2.219	0.450	1.769	1116.480	1116.930	cobble	riffle	
	180	2.211	0.450	1.761	1116.488	1116.938	cobble	riffle	
	190	2.195	0.375	1.820	1116.504	1116.879	cobble	riffle	
	200	2.363	0.370	1.993	1116.336	1116.706	cobble	riffle	
	210	2.482	0.360	2.122	1116.217	1116.577	cobble	riffle	
	220	2.606	0.350	2.256	1116.093	1116.443	cobble	riffle	
	230	2.861	0.550	2.311	1115.838	1116.388	cobble	riffle	
	240	2.964	0.645	2.319	1115.735	1116.380	cobble	riffle	
	250	2.849	0.490	2.359	1115.850	1116.340	cobble	riffle	
	260	2.903	0.520	2.383	1115.796	1116.316	cobble	riffle	

Reach 5, Site 1 Long Survey

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
TP2	270	2.709	0.800	1.909	1115.513	1116.313	cobble	glide	
	280	2.737	0.810	1.927	1115.485	1116.295	cobble	pool	
	290	2.686	0.720	1.966	1115.536	1116.256	cobble	glide	
	300	2.605	0.650	1.955	1115.617	1116.267	cobble	glide	
	310	2.776	0.830	1.946	1115.446	1116.276	cobble	pool	
	320	2.652	0.705	1.947	1115.570	1116.275	cobble	pool	~77 BT in pool
	330	2.733	0.782	1.951	1115.489	1116.271	cobble	glide	
	340	2.458	0.502	1.956	1115.764	1116.266	cobble	glide	
	350	2.343	0.340	2.003	1115.879	1116.219	cobble	glide	
	360	2.389	0.295	2.094	1115.833	1116.128	cobble	riffle	
	370	2.598	0.360	2.238	1115.624	1115.984	cobble	riffle	
	380	2.843	0.520	2.323	1115.385	1115.905	cobble	riffle	
TP3	390	2.99	0.565	2.425	1115.238	1115.803	boulder	riffle	
	400	3.032	0.510	2.522	1115.196	1115.706	boulder	riffle

Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 5, study site 1

Reach 5, Site 1 Pool X- Sxn

Pool Cross Sectional Survey

Location: Wigwam River

Reach: 5

Site: 1

UTM: 648080E, 5449780N

Crew: KM/LC

Date: 25/09/2001

Benchmark UTM:

BM1: 648333E, 5449663N

BM2: 648108E, 5449915N

pool cross section location at 0+140m of longitudinal profile

Benchmark Elevations:

BM2 1116.955

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
BM2*	2.0	1.075			1117.571		vegetation RUB bank, riparian veg.
	3.0	1.290			1117.356		vegetation
	4.0	1.226			1117.420		vegetation
	5.0	1.014			1117.632		vegetation
	6.0	1.041			1117.605		vegetation
	7.0	1.148			1117.498		vegetation
	7.6	1.639			1117.007		vegetation bankfull height
	8.0	2.053			1116.593		vegetation
	9.0	2.280			1116.366		fines
	9.4	2.361	0	2.361	1116.285	1116.285	cobble RUB wetted edge
	10.0	2.451	0.05	2.401	1116.195	1116.245	fines
	11.0	2.467	0.105	2.362	1116.179	1116.284	fines
	12.0	2.470	0.11	2.36	1116.176	1116.286	gravel
	13.0	2.597	0.235	2.362	1116.049	1116.284	cobble
	14.0	2.843	0.48	2.363	1115.803	1116.283	fines
	15.0	2.921	0.57	2.351	1115.725	1116.295	fines
	16.0	3.091	0.74	2.351	1115.555	1116.295	cobble
	17.0	3.132	0.79	2.342	1115.514	1116.304	cobble
	18.0	3.191	0.85	2.341	1115.455	1116.305	cobble
	19.0	2.999	0.66	2.339	1115.647	1116.307	cobble
	20.0	2.904	0.55	2.354	1115.742	1116.292	cobble
	21.0	2.833	0.47	2.363	1115.813	1116.283	cobble
	22.0	2.715	0.37	2.345	1115.931	1116.301	cobble
	23.0	2.667	0.3	2.367	1115.979	1116.279	cobble
	24.0	2.637	0.27	2.367	1116.009	1116.279	cobble
	25.0	2.596	0.23	2.366	1116.050	1116.280	cobble
	26.0	2.547	0.175	2.372	1116.099	1116.274	cobble
	27.0	2.463	0.095	2.368	1116.183	1116.278	gravel
	28.0	2.455	0.08	2.375	1116.191	1116.271	cobble
	29.0	2.468	0.09	2.378	1116.178	1116.268	cobble
	30.0	2.394	0.02	2.374	1116.252	1116.272	cobble

Reach 5, Site 1 Pool X- Sxn

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	30.2	2.369	0	2.369	1116.277	1116.277	LUB wetted edge
	31.0	2.271			1116.375		cobble
	32.0	2.308			1116.338		cobble
	33.0	2.282			1116.364		vegetation
	34.0	2.196			1116.450		vegetation
	35.0	2.191			1116.455		cobble
	36.0	2.167			1116.479		cobble
	37.0	2.068			1116.578		cobble
	38.0	2.032			1116.614		cobble
	39.0	1.938			1116.708		cobble
	40.0	1.777			1116.869		cobble
	41.0	1.894			1116.752		cobble
	42.0	1.815			1116.831		cobble
	43.0	1.682			1116.964		cobble
	44.0	1.675			1116.971		cobble
	45.0	1.607			1117.039		cobble
	46.0	1.618			1117.028		cobble
	47.0	1.691			1116.955		cobble
	48.0	1.676			1116.970		cobble
	49.0	1.694			1116.952		cobble
	50.0	1.743			1116.903		cobble
	51.0	1.835			1116.811		cobble
	52.0	1.867			1116.779		cobble
	53.0	1.900			1116.746		gravel
	54.0	1.941			1116.705		gravel
	55.0	1.978			1116.668		cobble
	56.0	1.970			1116.676		cobble
	57.0	1.981			1116.665		cobble
	58.0	1.946			1116.700		cobble
	59.0	1.923			1116.723		cobble
	60.0	1.943			1116.703		cobble
	61.0	1.974			1116.672		cobble
	62.0	1.982			1116.664		cobble
	63.0	1.998			1116.648		cobble
	64.0	2.023			1116.623		cobble
	65.0	2.122			1116.524		cobble
	66.0	2.242			1116.404		cobble
	67.0	2.528			1116.118		cobble
	67.1	2.542	0	2.542	1116.104	1116.104	side channel wetted edge
	68.0	2.726	0.16	2.566	1115.920	1116.080	cobble

Reach 5, Site 1 Pool X- Sxn

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	68.9	2.564	0	2.564	1116.082	1116.082	cobble side channel wetted edge
	69.0	2.457			1116.189		cobble
	70.0	2.168			1116.478		finer
	71.0	1.634			1117.012		vegetation bankfull height, riparian veg
	72.0	1.253			1117.393		vegetation

*BM2 backsight = 1.691, height of instrument = 1118.646

Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 5, study site 1

Reach 5, Site 1 Riffle X-Sxn

Riffle Cross Sectional Survey

Location: Wigwam River

Reach: 5

Site: 1

UTM: 648156E, 5449814 N

Crew: SC/KM

Date: 17/09/2001

Benchmark UTM:

BM1: 648333E, 5449663N

BM2: 648108E, 5449915N

Benchmark elevations:

TP1: 1117.994

riffle cross section location at 0+190 m of longitudinal profile

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
TP1*	3.0	0.609			1117.893		vegetation
	4.0	0.579			1117.923		
	5.0	0.702			1117.800		
	6.0	0.683			1117.819		
	7.0	0.570			1117.932		
	8.0	0.417			1118.085		
	8.5	0.584			1117.918		cobble
	9.0	0.846			1117.656		cobble bankfull height
	10.0	1.451			1117.051		cobble
	11.0	1.738			1116.764		cobble
	11.5	1.829	0	1.829	1116.673	1116.673	cobble wetted edge
	12.0	1.929	0.105	1.824	1116.573	1116.678	cobble
	13.0	1.901	0.08	1.821	1116.601	1116.681	cobble
	14.0	1.829	0	1.829	1116.673	1116.673	cobble wetted edge
	15.0	1.794			1116.708		cobble
	16.0	1.693			1116.809		gravel
	17.0	1.663			1116.839		gravel
	18.0	1.709			1116.793		gravel
	19.0	1.680			1116.822		gravel
	19.5	1.797	0	1.797	1116.705	1116.705	gravel wetted edge
	20.0	1.827	0.03	1.797	1116.675	1116.705	cobble
	21.0	1.966	0.09	1.876	1116.536	1116.626	cobble
	22.0	2.037	0.27	1.767	1116.465	1116.735	cobble
	23.0	2.075	0.305	1.770	1116.427	1116.732	cobble
	24.0	2.091	0.38	1.711	1116.411	1116.791	cobble
	25.0	2.178	0.42	1.758	1116.324	1116.744	cobble
	26.0	2.176	0.4	1.776	1116.326	1116.726	cobble
	27.0	2.199	0.46	1.739	1116.303	1116.763	cobble
	28.0	2.095	0.33	1.765	1116.407	1116.737	cobble
	29.0	2.153	0.38	1.773	1116.349	1116.729	cobble
	30.0	2.126	0.37	1.756	1116.376	1116.746	cobble
	31.0	2.133	0.38	1.753	1116.369	1116.749	cobble
	32.0	2.043	0.27	1.773	1116.459	1116.729	cobble

Reach 5, Site 1 Riffle X-Sxn

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
	33.0	2.006	0.25	1.756	1116.496	1116.746	cobble	
	34.0	2.038	0.275	1.763	1116.464	1116.739	cobble	
	35.0	1.984	0.2	1.784	1116.518	1116.718	cobble	
	36.0	1.879	0.1	1.779	1116.623	1116.723	cobble	
	37.0	1.773	0.03	1.743	1116.729	1116.759	cobble	
	38.0	1.758	0	1.758	1116.744	1116.744	cobble	wetted edge
	39.0	1.559			1116.943		cobble	
	40.0	1.638			1116.864		boulder	
	41.0	1.331			1117.171		boulder	start log jam
	42.0	1.212			1117.290		sand	logjam
	43.0	1.082			1117.420		sand	end log jam
	44.0	1.009			1117.493		sand	
	45.0	0.998			1117.504		sand	
	46.0	0.921			1117.581		gravel	
	47.0	0.969			1117.533		sand	
	48.0	0.999			1117.503		sand	
	49.0	1.237			1117.265		sand	
	50.0	1.372			1117.130		sand	
	51.0	1.300			1117.202		gravel	
	52.0	1.285			1117.217		cobble	
	53.0	1.258			1117.244		gravel	
	54.0	1.262			1117.240		gravel	
	55.0	1.317			1117.185		gravel	
	56.0	1.357			1117.145		sand	
	57.0	1.109			1117.393		vegetation	
	58.0	0.959			1117.543		vegetation	
	59.0	0.852			1117.650		vegetation	bankful height
	60.0	0.801			1117.701		vegetation	
	61.0	0.826			1117.676		vegetation	

*TP1 backsight = 0.508 m, height of instrument = 1118.502 m

R5, S1 Differential Level Loop

Differential Levelling Loop - Reach 5, Site 1

Date: 17/09/2001

Field (Arbitrary) Elevations (m)

Station	Backsight	Height of Instrument	Foresight	Elevation
BM1	0.082	5.082		5.000
TP1	0.708	3.699	2.091	2.991
TP2	1.512	3.222	1.989	1.710
TP3	1.895	3.228	1.889	1.333
BM2		1.955	1.273	1.955
BM2	1.273	3.228		1.955
TP3	1.853	3.185	1.896	1.332
TP2	1.971	3.679	1.477	1.708
TP1	2.081	5.078	0.682	2.997
BM1			0.077	5.001
				error =+0.001

True Elevations (m)

Station	Backsight	Height of Instrument	Foresight	Elevation
BM1	0.082	1120.082		1120.000
TP1	0.708	1118.699	2.091	1117.991
TP2	1.512	1118.222	1.989	1116.710
TP3	1.895	1118.228	1.889	1116.333
BM2		1116.955	1.273	1116.955
BM2	1.273	1118.228		1116.955
TP3	1.853	1118.185	1.896	1116.332
TP2	1.971	1118.679	1.477	1116.708
TP1	2.081	1120.078	0.682	1117.997
BM1			0.077	1120.001
				error =+0.001

Benchmark Elevations (m)		
	2000	2001
BM1	1120.000	1120.000
BM2	1116.894	1116.955

Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 6, study site 2.

Reach 6, Site 2 Long Survey

Longitudinal Survey

Location: Wigwam River

Reach: 6

Site: 2

UTM: start 653886E, 5441349N

end 0+670m D/S from start

Crew: KM/LC

Date: 27/09/2001

Benchmark UTM:

BM1 653768E, 5441437N

BM2 653770E, 5441871N

BM3 653800E, 5441846N

Benchmark Elevations:

BM1 1200.000

BM2 1195.679

TP1 1198.379

BM3 1196.180

TP2 1197.690

TP3 1196.116

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
BM1	0	2.671	0.33	2.341	1198.067	1198.397	cobble	riffle	
	10	3.263	0.805	2.458	1197.475	1198.28	gravel	pool	back channel
	20	3.389	0.92	2.469	1197.349	1198.269	gravel	pool	3 BT in pool
	30	4.984	2.49	2.494	1195.754	1198.244	gravel	pool	deep pool, ~elev. & depth
	40	3.694	1.23	2.464	1197.044	1198.274	gravel	pool	1male BT, no visible redds
	50	2.963	0.47	2.493	1197.775	1198.245	gravel	pool	pool tailout
	60	2.713	0.25	2.463	1198.025	1198.275	gravel	glide	
	70	2.741	0.26	2.481	1197.997	1198.257	cobble	glide	
	80	2.812	0.23	2.582	1197.926	1198.156	cobble	pool	LWD scour pool
TP1	90	3.427	0.59	2.837	1197.311	1197.901	gravel	riffle	
	100	2.228	0.345	1.883	1197.454	1197.799	cobble	riffle	
	110	2.189	0.36	1.829	1197.493	1197.853	cobble	riffle	
	120	2.19	0.33	1.86	1197.492	1197.822	cobble	riffle	
	130	2.141	0.245	1.896	1197.541	1197.786	cobble	riffle	
	140	2.203	0.305	1.898	1197.479	1197.784	gravel	glide	
	150	2.206	0.3	1.906	1197.476	1197.776	gravel	glide	
	160	2.217	0.235	1.982	1197.465	1197.7	cobble	riffle	joining side channel
	170	2.378	0.25	2.128	1197.304	1197.554	cobble	riffle	
	180	2.631	0.31	2.321	1197.051	1197.361	cobble	riffle	
	190	2.788	0.35	2.438	1196.894	1197.244	cobble	riffle	
	200	2.92	0.475	2.445	1196.762	1197.237	cobble	riffle	
	210	2.878	0.39	2.488	1196.804	1197.194	cobble	riffle	
	220	2.951	0.22	2.731	1196.731	1196.951	cobble	riffle	
	230	3.574	0.72	2.854	1196.108	1196.828	gravel	pool	
	240	3.598	0.715	2.883	1196.084	1196.799	cobble	glide	
	250	3.497	0.59	2.907	1196.185	1196.775	finer	glide	

Reach 6, Site 2 Long Survey

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
TP2	260	3.578	0.63	2.948	1196.104	1196.734	finer	pool	deep pool, LWD jam
	270	4.219	1.26	2.959	1195.463	1196.723	finer	pool	
	280	3.34	1.37	1.97	1195.320	1196.69	finer	pool	
	290	2.839	0.85	1.989	1195.821	1196.671	gravel	pool	
	300	2.411	0.4	2.011	1196.249	1196.649	gravel	pool	
	310	2.457	0.44	2.017	1196.203	1196.643	cobble	glide	
	320	2.482	0.425	2.057	1196.178	1196.603	cobble	glide	
	330	2.453	0.37	2.083	1196.207	1196.577	cobble	riffle	
	340	2.735	0.4	2.335	1195.925	1196.325	cobble	riffle	
	350	2.724	0.35	2.374	1195.936	1196.286	gravel	riffle	
	360	2.775	0.33	2.445	1195.885	1196.215	cobble	riffle	
	370	2.947	0.44	2.507	1195.713	1196.153	cobble	riffle	
	380	2.98	0.46	2.52	1195.680	1196.14	gravel	glide	
	390	2.953	0.395	2.558	1195.707	1196.102	gravel	glide	
	400	2.976	0.395	2.581	1195.684	1196.079	gravel	glide	
TP3	410	2.892	0.305	2.587	1195.768	1196.073	gravel	glide	1 BT 3 BT
	420	2.927	0.275	2.652	1195.733	1196.008	cobble	riffle	
	430	4.266	1.53	2.736	1194.394	1195.924	finer	pool	
	440	3.121	1.38	1.741	1194.461	1195.841	gravel	pool	rifle cross section
	450	2.461	0.745	1.716	1195.121	1195.866	cobble	glide	
	460	2.296	0.57	1.726	1195.286	1195.856	cobble	glide	
	470	2.501	0.69	1.811	1195.081	1195.771	cobble	riffle	pool EF site
	480	2.308	0.44	1.868	1195.274	1195.714	cobble	riffle	
	490	2.329	0.46	1.869	1195.253	1195.713	cobble	riffle	
	500	2.19	0.28	1.91	1195.392	1195.672	cobble	riffle	14 BT 3 BT redds 2 males, 1 female BT
	510	2.337	0.38	1.957	1195.245	1195.625	cobble	riffle	
	520	2.651	0.49	2.161	1194.931	1195.421	gravel	pool	
	530	3.115	0.88	2.235	1194.467	1195.347	gravel	pool	BT in pool LWD pool gravel accum. behind LWD
	540	2.807	0.57	2.237	1194.775	1195.345	gravel	pool	
	550	2.828	0.6	2.228	1194.754	1195.354	gravel	glide	
	560	2.874	0.645	2.229	1194.708	1195.353	gravel	glide	
	570	2.671	0.435	2.236	1194.911	1195.346	gravel	glide	
	580	2.584	0.335	2.249	1194.998	1195.333	gravel	glide	
	590	2.659	0.32	2.339	1194.923	1195.243	cobble	riffle	
	600	2.291	0.26	2.031	1195.291	1195.551	cobble	riffle	
	610	2.439	0.23	2.209	1195.143	1195.373	gravel	pool	
	620	3.624	1.74	1.884	1193.958	1195.698	gravel	pool	
	630	2.789	0.435	2.354	1194.793	1195.228	gravel	glide	

Reach 6, Site 2 Long Survey

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
	640	2.771	0.41	2.361	1194.811	1195.221	cobble	riffle	
	650	2.709	0.255	2.454	1194.873	1195.128	cobble	riffle	
	660	2.739	0.255	2.484	1194.843	1195.098	cobble	riffle	
	670	2.842	0.25	2.592	1194.740	1194.99	cobble	riffle	
	680	3.232	0.25	2.982	1194.350	1194.6	cobble	riffle

Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 6, study site 2.

Reach 6, Site 2 Long Survey

Longitudinal Survey

Location: Wigwam River

Reach: 6

Site: 2

UTM: start 653886E, 5441349N

end 0+670m D/S from start

Crew: KM/LC

Date: 27/09/2001

Benchmark UTM:

BM1 653768E, 5441437N

BM2 653770E, 5441871N

BM3 653800E, 5441846N

Benchmark Elevations:

BM1 1200.000

BM2 1195.679

TP1 1198.379

BM3 1196.180

TP2 1197.690

TP3 1196.116

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
BM1	0	2.671	0.33	2.341	1198.067	1198.397	cobble	riffle	
	10	3.263	0.805	2.458	1197.475	1198.28	gravel	pool	back channel
	20	3.389	0.92	2.469	1197.349	1198.269	gravel	pool	3 BT in pool
	30	4.984	2.49	2.494	1195.754	1198.244	gravel	pool	deep pool, ~elev. & depth
	40	3.694	1.23	2.464	1197.044	1198.274	gravel	pool	1male BT, no visible redds
	50	2.963	0.47	2.493	1197.775	1198.245	gravel	pool	pool tailout
	60	2.713	0.25	2.463	1198.025	1198.275	gravel	glide	
	70	2.741	0.26	2.481	1197.997	1198.257	cobble	glide	
	80	2.812	0.23	2.582	1197.926	1198.156	cobble	pool	LWD scour pool
TP1	90	3.427	0.59	2.837	1197.311	1197.901	gravel	riffle	
	100	2.228	0.345	1.883	1197.454	1197.799	cobble	riffle	
	110	2.189	0.36	1.829	1197.493	1197.853	cobble	riffle	
	120	2.19	0.33	1.86	1197.492	1197.822	cobble	riffle	
	130	2.141	0.245	1.896	1197.541	1197.786	cobble	riffle	
	140	2.203	0.305	1.898	1197.479	1197.784	gravel	glide	
	150	2.206	0.3	1.906	1197.476	1197.776	gravel	glide	
	160	2.217	0.235	1.982	1197.465	1197.7	cobble	riffle	joining side channel
	170	2.378	0.25	2.128	1197.304	1197.554	cobble	riffle	
	180	2.631	0.31	2.321	1197.051	1197.361	cobble	riffle	
	190	2.788	0.35	2.438	1196.894	1197.244	cobble	riffle	
	200	2.92	0.475	2.445	1196.762	1197.237	cobble	riffle	
	210	2.878	0.39	2.488	1196.804	1197.194	cobble	riffle	
	220	2.951	0.22	2.731	1196.731	1196.951	cobble	riffle	
	230	3.574	0.72	2.854	1196.108	1196.828	gravel	pool	
	240	3.598	0.715	2.883	1196.084	1196.799	cobble	glide	
	250	3.497	0.59	2.907	1196.185	1196.775	finer	glide	

Reach 6, Site 2 Long Survey

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
TP2	260	3.578	0.63	2.948	1196.104	1196.734	finer	pool	deep pool, LWD jam
	270	4.219	1.26	2.959	1195.463	1196.723	finer	pool	
	280	3.34	1.37	1.97	1195.320	1196.69	finer	pool	
	290	2.839	0.85	1.989	1195.821	1196.671	gravel	pool	
	300	2.411	0.4	2.011	1196.249	1196.649	gravel	pool	
	310	2.457	0.44	2.017	1196.203	1196.643	cobble	glide	
	320	2.482	0.425	2.057	1196.178	1196.603	cobble	glide	
	330	2.453	0.37	2.083	1196.207	1196.577	cobble	riffle	
	340	2.735	0.4	2.335	1195.925	1196.325	cobble	riffle	
	350	2.724	0.35	2.374	1195.936	1196.286	gravel	riffle	
	360	2.775	0.33	2.445	1195.885	1196.215	cobble	riffle	
	370	2.947	0.44	2.507	1195.713	1196.153	cobble	riffle	
	380	2.98	0.46	2.52	1195.680	1196.14	gravel	glide	
	390	2.953	0.395	2.558	1195.707	1196.102	gravel	glide	
	400	2.976	0.395	2.581	1195.684	1196.079	gravel	glide	
TP3	410	2.892	0.305	2.587	1195.768	1196.073	gravel	glide	1 BT 3 BT
	420	2.927	0.275	2.652	1195.733	1196.008	cobble	riffle	
	430	4.266	1.53	2.736	1194.394	1195.924	finer	pool	
	440	3.121	1.38	1.741	1194.461	1195.841	gravel	pool	rifle cross section
	450	2.461	0.745	1.716	1195.121	1195.866	cobble	glide	
	460	2.296	0.57	1.726	1195.286	1195.856	cobble	glide	
	470	2.501	0.69	1.811	1195.081	1195.771	cobble	riffle	pool EF site
	480	2.308	0.44	1.868	1195.274	1195.714	cobble	riffle	
	490	2.329	0.46	1.869	1195.253	1195.713	cobble	riffle	
	500	2.19	0.28	1.91	1195.392	1195.672	cobble	riffle	14 BT 3 BT redds 2 males, 1 female BT
	510	2.337	0.38	1.957	1195.245	1195.625	cobble	riffle	
	520	2.651	0.49	2.161	1194.931	1195.421	gravel	pool	
	530	3.115	0.88	2.235	1194.467	1195.347	gravel	pool	BT in pool LWD pool gravel accum. behind LWD
	540	2.807	0.57	2.237	1194.775	1195.345	gravel	pool	
	550	2.828	0.6	2.228	1194.754	1195.354	gravel	glide	
	560	2.874	0.645	2.229	1194.708	1195.353	gravel	glide	
	570	2.671	0.435	2.236	1194.911	1195.346	gravel	glide	
	580	2.584	0.335	2.249	1194.998	1195.333	gravel	glide	
	590	2.659	0.32	2.339	1194.923	1195.243	cobble	riffle	
	600	2.291	0.26	2.031	1195.291	1195.551	cobble	riffle	
	610	2.439	0.23	2.209	1195.143	1195.373	gravel	pool	
	620	3.624	1.74	1.884	1193.958	1195.698	gravel	pool	
	630	2.789	0.435	2.354	1194.793	1195.228	gravel	glide	

Reach 6, Site 2 Long Survey

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data			Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
	640	2.771	0.41	2.361	1194.811	1195.221	cobble	riffle	
	650	2.709	0.255	2.454	1194.873	1195.128	cobble	riffle	
	660	2.739	0.255	2.484	1194.843	1195.098	cobble	riffle	
	670	2.842	0.25	2.592	1194.740	1194.99	cobble	riffle	
	680	3.232	0.25	2.982	1194.350	1194.6	cobble	riffle

Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 6, study site 2.

Reach 6, Site 2 Pool X-Sxn

Pool Cross Sectional Survey

Location: Wigwam River

Reach: 6

Site: 2

UTM: 653836E, 5441375N

Crew: SC/KM

Date: 28/09/2001

Benchmark Elevations:

BM1 1200.000

pool cross section located at 0+27m of longitudinal profile

		Uncorrected Data		Corrected Data				
Ground Station No.	Distance from Start (m)	Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	Dominant Substrate	Comments
BM1*	0.3	1.696			1199.016		vegetation	RUB start
	1.0	1.698			1199.014			
	2.0	1.618			1199.094			
	3.0	1.577			1199.135			bankfull
	4.0	1.647			1199.065			
	5.0	1.723			1198.989			
	6.0	1.852			1198.860		gravel	
	7.0	1.901			1198.811		gravel	
	8.0	1.994			1198.718		gravel	
	9.0	1.945			1198.767		gravel	
	10.0	1.878			1198.834		gravel	
	11.0	1.899			1198.813		gravel	
	12.0	1.938			1198.774		gravel	
	13.0	2.009			1198.703		gravel	
	14.0	2.123			1198.589		gravel	
	15.0	2.238			1198.474		gravel	
	16.0	2.201			1198.511		gravel	
	17.0	2.047			1198.665		gravel	
	18.0	1.755			1198.957		gravel	vegetated gravel bar
	19.0	1.658			1199.054		gravel	
	20.0	1.672			1199.040		gravel	
	21.0	1.756			1198.956		gravel	
	22.0	1.873			1198.839		gravel	
	24.0	1.863			1198.849		gravel	
	26.0	1.875			1198.837		gravel	
	28.0	1.713			1198.999		gravel	
	30.0	1.638			1199.074		gravel	
	32.0	1.620			1199.092		gravel	
	34.0	1.421			1199.291		gravel	
	36.0	1.468			1199.244		gravel	
	38.0	1.530			1199.182		sand	

Reach 6, Site 2 Pool X-Sxn

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	40.0	1.566			1199.146		sand
	41.0	1.613			1199.099		gravel bankfull height
	42.0	1.733			1198.979		sand
	43.0	1.843			1198.869		sand
	44.0	1.937			1198.775		gravel
	45.0	1.999			1198.713		cobble
	46.0	2.076			1198.636		cobble
	47.0	2.150			1198.562		gravel
	48.0	2.218			1198.494		gravel
	48.7	2.428	0.000	2.428	1198.284	1198.284	gravel wetted edge
	49.0	2.619	0.180	2.439	1198.093	1198.273	sand
	50.0	3.118	0.675	2.443	1197.594	1198.269	cobble 3 redds in pool tail out
	51.0	3.572	1.135	2.437	1197.140	1198.275	cobble
	51.4	3.736	1.280	2.456	1196.976	1198.256	cobble at least 9 BT in pool
	57.0	4.728	2.300	2.428	1195.984	1198.284	finer
	58.0	4.119	1.690	2.429	1196.593	1198.283	gravel
	59.0	3.769	1.320	2.449	1196.943	1198.263	gravel
	60.0	3.621	1.220	2.401	1197.091	1198.311	cobble
	61.0	2.516	0.000	2.516	1198.196	1198.196	wetted edge
	61.5	1.853			1198.859		vegetation
	62.0	1.623			1199.089		vegetation bankfull
	63.0	1.574			1199.138		vegetation
	64.0	1.392			1199.320		vegetation
	65.0	1.532			1199.180		vegetation
	65.5	1.439			1199.273		vegetation LUB

* BM1 backsight = 0.712 m, height of instrument = 1200.712 m

Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 6, study site 2.

Reach 6, Site 2 Riffle X-Sxn

Riffle Cross Sectional Survey

Location: Wigwam River

Reach: 6

Site: 2

UTM: 653836E, 5441375N

Crew: KM/LC

Date: 27/09/2001

Benchmark Elevation

BM3

riffle cross section located at 0+ 480 m of longitudinal profile

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
BM3*	0.5	1.441			1196.398		vegetation start RUB bank
	1.0	1.526			1196.313		
	1.6	1.651			1196.188		bankfull height
	2.0	1.973			1195.866		finer
	2.2	2.109	0	2.109	1195.730	1195.730	gravel RUB wetted edge
	3.0	2.499	0.33	2.169	1195.340	1195.670	cobble
	4.0	2.531	0.41	2.121	1195.308	1195.718	cobble
	5.0	2.57	0.48	2.09	1195.269	1195.749	cobble
	6.0	2.574	0.47	2.104	1195.265	1195.735	cobble
	7.0	2.568	0.43	2.138	1195.271	1195.701	cobble
	8.0	2.36	0.235	2.125	1195.479	1195.714	cobble
	9.0	2.181	0.055	2.126	1195.658	1195.713	cobble
	9.5	2.129	0	2.129	1195.710	1195.710	gravel wetted edge
	10.0	2.057			1195.782		cobble
	11.0	1.963			1195.876		cobble mid channel bar
	12.0	1.986			1195.853		cobble
	13.0	1.981			1195.858		cobble
	14.0	2.034			1195.805		cobble
	15.0	2.041			1195.798		cobble
	16.0	2.055			1195.784		cobble
	17.0	2.133			1195.706		cobble
	17.8	2.148	0	2.148	1195.691	1195.691	gravel wetted edge
	18.0	2.168	0	2.168	1195.671	1195.671	gravel
	19.0	2.207	0.025	2.182	1195.632	1195.657	gravel
	20.0	2.271	0.1	2.171	1195.568	1195.668	cobble
	21.0	2.288	0.115	2.173	1195.551	1195.666	gravel
	22.0	2.165	0	2.165	1195.674	1195.674	cobble wetted edge
	23.0	1.926			1195.913		cobble
	24.0	1.729			1196.110		cobble
	25.0	1.609			1196.230		gravel
	26.0	1.598			1196.241		gravel

Reach 6, Site 2 Riffle X-Sxn

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	27.0	1.583			1196.256		gravel
	28.0	1.593			1196.246		gravel
	29.0	1.567			1196.272		gravel
	30.0	1.579			1196.260		gravel
	32.0	1.533			1196.306		gravel
	34.0	1.502			1196.337		gravel
	36.0	1.531			1196.308		gravel
	38.0	1.513			1196.326		gravel
	40.0	1.554			1196.285		gravel
	42.0	1.571			1196.268		gravel
	44.0	1.62			1196.219		gravel
	46.0	1.688			1196.151		gravel
	48.0	1.711			1196.128		gravel
	50.0	1.772			1196.067		gravel
	52.0	2.178			1195.661		gravel
	54.0	2.221			1195.618		gravel
	56.0	2.063			1195.776		gravel
	58.0	2.089			1195.750		gravel
	60.0	2.078			1195.761		cobble
	61.0	2.026			1195.813		cobble
	62.0	2.123			1195.716		cobble
	63.0	2.056			1195.783		cobble
	64.0	2.098			1195.741		gravel
	65.0	1.969			1195.870		gravel
	66.0	1.999			1195.840		gravel
	67.0	2.268			1195.571		gravel
	68.0	2.246			1195.593		gravel
	69.0	2.311			1195.528		gravel
	69.7	2.551	0	2.551	1195.288	1195.288	gravel wetted edge
	70.0	2.687	0.13	2.557	1195.152	1195.282	gravel
	71.0	2.709	0.105	2.604	1195.130	1195.235	gravel
	71.8	2.561	0	2.561	1195.278	1195.278	gravel wetted edge
	72.0	2.474			1195.365		gravel
	73.0	2.331			1195.508		gravel
	74.0	2.209			1195.630		gravel
	75.0	2.217			1195.622		gravel
	76.0	2.319			1195.520		gravel
	77.0	2.459			1195.380		gravel
	77.3	2.559	0	2.559	1195.280	1195.280	gravel side channel wetted edge

Reach 6, Site 2 Riffle X-Sxn

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	78.0	2.679	0.12	2.559	1195.160	1195.280	gravel
	79.0	2.667	0.115	2.552	1195.172	1195.287	gravel
	79.5	2.57	0	2.57	1195.269	1195.269	gravel
	79.8	2.008			1195.831		finer
	80.0	1.748			1196.091		vegetation
	81.0	1.442			1196.397		vegetation
	82.0	1.421			1196.418		vegetation
	83.0	1.432			1196.407		vegetation
	84.0	1.473			1196.366		vegetation
	85.0	1.23			1196.609		vegetation

* BM3 backsight = 1.659 m, height of instrument = 1197.839 m

R6,S2 Differential Level Loop

Differential Levelling Loop - Reach 6, Site 2

Date: 24/09/2001

Field (Arbitrary) Elevations (m)

Station	Backsight	Height of Instrument	Foresight	Elevation
BM1	0.738	5.738		5.000
TP1	1.306	4.682	2.362	3.376
TP2	0.971	3.660	1.993	2.689
TP3	1.468	2.582	2.546	1.114
BM3	0.977	2.157	1.402	1.180
BM2		0.679	1.478	0.679
BM2	1.478	2.157		0.679
BM3	1.423	2.603	0.977	1.180
TP3	2.549	3.667	1.485	1.118
TP2	2.214	4.904	0.977	2.690
TP1	2.402	5.784	1.522	3.382
BM1			0.781	5.003
				error= +0.003

True Elevations (m)

Station	Backsight	Height of Instrument	Foresight	Elevation
BM1	0.738	1200.738		1200.000
TP1	1.306	1199.682	2.362	1198.376
TP2	0.971	1198.660	1.993	1197.689
TP3	1.468	1197.582	2.546	1196.114
BM3	0.977	1197.157	1.402	1196.180
BM2		1195.679	1.478	1195.679
BM2	1.478	1197.157		1195.679
BM3	1.423	1197.603	0.977	1196.180
TP3	2.549	1198.667	1.485	1196.118
TP2	2.214	1199.904	0.977	1197.690
TP1	2.402	1200.784	1.522	1198.382
BM1			0.781	1200.003
				error= +0.003

Benchmark Elevations (m)		
	2000	2001
BM1	1200.000	1200.000
BM2	1195.617	1195.679
BM3	1196.140	1196.180

Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 7, study site 3.
Channel was dry at time of survey

Reach 7, Site 3 Long Survey

Longitudinal Survey

Location: Wigwam River
Reach: 7
Site: 3

UTM: start 655471E, 5438625N
 end 654977E, 5439074N
Crew: KM/LC
Date: 25/09/2001

Benchmark UTM:

BM1: 655348E, 5438656N
 BM2: 655016E, 5439078N

Benchmark Elevations:

BM1: 1240.000 TP4: 1235.732
 TP1: 1237.545 BM2: 1237.721
 TP2: 1236.601
 TP3: 1236.113

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)		
BM1	0	2.665	channel is dry		1237.844		cobble	channel is dry
	10	2.719			1237.790		cobble	~habitat types
	20	2.676			1237.833		cobble	approximated
	30	2.730			1237.779		cobble	from 2000 data
	40	2.711			1237.798		cobble	
	50	2.791			1237.718		cobble	
TP1	60	2.929			1237.580		cobble	
	60	2.309			1237.491		cobble	
	70	2.534			1237.266		gravel	
	80	2.723			1237.077		gravel	
	90	2.715			1237.085		gravel	
	100	2.895			1236.905		cobble	glide
	110	2.832			1236.968		cobble	glide
	120	2.817			1236.983		cobble	glide
	130	2.737			1237.063		cobble	glide
	140	2.739			1237.061		cobble	glide
TP2	150	2.457			1237.343		gravel	riffle
	160	2.883			1236.917		gravel	pool
	170	3.550			1236.250		gravel	pool
	180	2.892			1236.908		gravel	riffle
	190	2.929			1236.871		gravel	riffle
	200	2.921			1236.879		gravel	pool
	210	2.870			1236.245		gravel	pool
	220	2.991			1236.124		boulder	glide
	230	2.768			1236.347		boulder	glide
	240	2.838			1236.277		boulder	glide
	250	2.906			1236.209		cobble	riffle
	260	2.746			1236.369		cobble	riffle
	270	2.792			1236.323		cobble	riffle

Reach 7, Site 3 Long Survey

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)		
TP3	280	2.841			1236.274		boulder	riffle
	290	2.889			1236.226		boulder	riffle
	300	2.977			1236.138		boulder	riffle
	300	2.980			1236.135		boulder	riffle
	310	3.031			1236.084		cobble	riffle
	320	3.339			1235.776		cobble	glide
	330	3.139			1235.976		cobble	glide
	340	1.632			1235.658		cobble	glide
	350	1.748			1235.542		cobble	glide
	360	1.703			1235.587		cobble	riffle
	370	1.691			1235.599		cobble	riffle
	380	1.732			1235.558		boulder	riffle
	390	1.901			1235.389		boulder	glide
	400	2.089			1235.201		boulder	glide
	410	2.076			1235.214		cobble	riffle
	420	2.122			1235.168		boulder	riffle
	430	2.111			1235.179		boulder	riffle
TP4	440	2.287			1235.003		boulder	riffle
	450	2.327			1234.963		boulder	riffle
	460	2.518			1234.772		boulder	riffle
	470	2.872			1234.418		boulder	riffle
	480	3.064			1234.408		boulder	glide
	490	3.229			1234.243		boulder	glide
	500	3.380			1234.092		boulder	glide
	500	3.358			1234.114		cobble	glide
	510	3.539			1233.933		cobble	glide
	520	3.513			1233.959		cobble	glide
	530	3.533			1233.939		cobble	glide
	540	3.552			1233.920		cobble	glide
	550	3.452			1234.020		cobble	riffle
	560	3.339			1234.133		cobble	riffle
	570	3.289			1234.183		cobble	riffle
	580	3.401			1234.071		cobble	riffle
	590	3.823			1233.649		cobble	riffle

Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 7, study site 3.
Channel was dry at time of survey.

Reach 7, Site 3 Pool X-Sxn

Pool Cross Sectional Survey

Location: Wigwam River

Reach: 7

Site: 3

UTM: 655250E, 5438840N

Crew: KM/LC

Date: 25/09/2001

Benchmark Elevation:

TP1: 1237.545 m

pool cross section located at 0+170 m of longitudinal profile

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
TP1*	5.0	1.192			1237.499		vegetation RUB start
	6.0	2.406	channel		1236.285	channel	finer
	7.0	2.323	is		1236.368	is	finer side channel
	8.0	2.034	dry		1236.657	dry	finer
	9.0	1.876			1236.815		vegetation
	10.0	1.741			1236.950		vegetation
	11.0	1.671			1237.020		vegetation
	12.0	1.837			1236.854		vegetation
	13.0	1.662			1237.029		vegetation
	14.0	1.577			1237.114		vegetation
	15.0	1.512			1237.179		vegetation
	16.0	1.573			1237.118		vegetation
	17.0	1.549			1237.142		vegetation
	18.0	1.579			1237.112		vegetation
	19.0	1.502			1237.189		vegetation
	20.0	1.499			1237.192		vegetation
	21.0	1.484			1237.207		vegetation
	22.0	1.512			1237.179		vegetation
	23.0	1.536			1237.155		vegetation
	24.0	1.592			1237.099		vegetation
	25.0	1.589			1237.102		vegetation
	26.0	1.563			1237.128		vegetation
	27.0	1.673			1237.018		gravel RUB bankfull 1237.018
	28.0	1.792			1236.899		gravel 1237.018
	29.0	1.991			1236.700		gravel 1237.018
	30.0	2.241			1236.450		gravel 1237.018
	31.0	2.283			1236.408		gravel 1237.018
	32.0	2.274			1236.417		finer 1237.018
	33.0	1.969			1236.722		finer 1237.018
	34.0	2.673			1236.018		finer 1237.018
	35.0	2.866			1235.825		finer 1237.018
	36.0	2.948			1235.743		cobble 1237.018

Reach 7, Site 3 Pool X-Sxn

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	37.0	3.186			1235.505		gravel 1237.018
	38.0	3.277			1235.414		gravel 1237.018
	39.0	3.092			1235.599		gravel 1237.018
	40.0	2.079			1236.612		cobble 1237.018
	41.0	2.424			1236.267		cobble 1237.018
	42.0	2.286			1236.405		cobble 1237.018
	43.0	2.264			1236.427		cobble 1237.018
	44.0	2.213			1236.478		cobble 1237.018
	45.0	2.181			1236.510		cobble 1237.018
	46.0	2.144			1236.547		cobble 1237.018
	47.0	2.084			1236.607		cobble 1237.018
	48.0	1.987			1236.704		cobble 1237.018
	49.0	1.972			1236.719		gravel 1237.018
	50.0	1.916			1236.775		gravel 1237.018
	51.0	1.797			1236.894		gravel 1237.018
	52.0	1.742			1236.949		gravel 1237.018
	53.0	1.687			1237.004		gravel 1237.018
	54.0	1.648			1237.043		gravel 1237.018
	55.0	1.597			1237.094		gravel 1237.018
	56.0	1.609			1237.082		gravel 1237.018
	57.0	1.618			1237.073		gravel 1237.018
	58.0	1.642			1237.049		gravel 1237.018
	59.0	1.667			1237.024		gravel 1237.018
	60.0	1.742			1236.949		gravel 1237.018
	61.0	1.797			1236.894		gravel bankfull heigh 1237.018
	62.0	1.822			1236.869		gravel vegetated bar 1237.018
	63.0	1.832			1236.859		gravel 1237.018
	64.0	1.889			1236.802		gravel 1237.018
	65.0	1.968			1236.723		gravel small cottonwc 1237.018
	66.0	2.058			1236.633		gravel 1237.018
	67.0	2.097			1236.594		cobble 1237.018
	68.0	2.029			1236.662		cobble 1237.018
	69.0	1.812			1236.879		vegetation 1237.018
	70.0	1.719			1236.972		vegetation grass 1237.018
	71.0	1.709			1236.982		vegetation 1237.018
	72.0	1.661			1237.030		vegetation 1237.018
	73.0	1.607			1237.084		vegetation sparse cottonw 1237.018
	74.0	1.462			1237.229		vegetation 1237.018
	75.0	1.38			1237.311		vegetation 1237.018
	76.0	1.373			1237.318		vegetation 1237.018

Reach 7, Site 3 Pool X-Sxn

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments	
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
	77.0	1.561			1237.130		vegetation	1237.018
	78.0	1.388			1237.303		vegetation	1237.018
	79.0	1.334			1237.357		vegetation	1237.018
	80.0	1.319			1237.372		vegetation	1237.018
	81.0	1.463			1237.228		vegetation	1237.018
	85.0	1.776			1236.915		vegetation	side channel 1237.018
	90.0	1.389			1237.302		gravel	1237.018
	95.0	1.181			1237.510		gravel	1237.018
	100.0	1.291			1237.400		gravel	1237.018
	105.0	1.421			1237.270		gravel	1237.018
	108.0	1.62			1237.071		gravel	bankfull 1237.018
	109.0	1.825			1236.866		finer	1237.018
	110.0	2.136			1236.555		finer	1237.018
	111.0	2.281			1236.410		gravel	1237.018
	112.0	2.409			1236.282		gravel	1237.018
	113.0	2.48			1236.211		gravel	LUB bankfull h 1237.018
	114.0	2.576			1236.115		gravel	1237.018
	115.0	1.986			1236.705		boulder	1237.018
	116.0	2.453			1236.238		gravel	1237.018
	117.0	2.175			1236.516		gravel	bankfull 1237.018
	118.0	1.848			1236.843		gravel	
	119.0	1.369			1237.322		finer	
	120.0	0.974			1237.717		finer	

* TP1 backsight=2.189 m, height of instrument = 1239.691 m

Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 7, study site 3.
Channel was dry at time of survey.

Reach 7, Site 3 Riffle X-Sxn

Riffle Cross Sectional Survey

Location: Wigwam River

Reach: 7

Site: 3

UTM: 655186E, 5438950N

Crew: KM/LC

Date: 25/09/2001

Benchmark Elevation:

TP2: 1236.601 m

riffle cross section located at 0+285m of longitudinal profile

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
TP2*	4.0	0.112			1237.341		vegetation	RUB start
	5.0	0.452	channel		1237.001			
	6.0	0.802	is		1236.651			
	7.0	1.242	dry		1236.211			RUB bankfull height
	8.0	1.813			1235.640		boulder	side channel outlet
	9.0	1.642			1235.811		gravel	
	10.0	1.598			1235.855		gravel	
	11.0	1.547			1235.906		sand	
	12.0	1.877			1235.576		sand	
	13.0	2.105			1235.348		sand	
	14.0	2.196			1235.257		gravel	
	15.0	1.853			1235.600		gravel	
	16.0	1.711			1235.742		cobble	
	17.0	1.618			1235.835		gravel	
	18.0	1.617			1235.836		gravel	
	19.0	1.584			1235.869		gravel	
	20.0	1.723			1235.730		gravel	
	21.0	1.692			1235.761		gravel	
	22.0	1.738			1235.715		gravel	
	23.0	1.782			1235.671		gravel	
	24.0	1.857			1235.596		cobble	
	25.0	2.018			1235.435		cobble	
	26.0	2.128			1235.325		cobble	
	27.0	2.194			1235.259		cobble	
	28.0	2.178			1235.275		cobble	
	29.0	2.119			1235.334		cobble	
	30.0	2.049			1235.404		cobble	
	31.0	2.071			1235.382		cobble	
	32.0	2.041			1235.412		cobble	
	33.0	2.032			1235.421		cobble	
	34.0	2.172			1235.281		boulder	main channel
	35.0	2.178			1235.275		boulder	
	36.0	2.313			1235.140		boulder	

Reach 7, Site 3 Riffle X-Sxn

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
	37.0	2.211			1235.242		boulder
	38.0	2.260			1235.193		boulder
	39.0	2.172			1235.281		gravel
	40.0	1.446			1236.007		gravel
	40.2	0.964			1236.489		gravel
	41.0	0.478			1236.975		gravel
	42.0	0.432			1237.021		gravel
	43.0	0.335			1237.118		gravel
	44.0	0.338			1237.115		gravel
	45.0	0.413			1237.040		gravel
	46.0	0.398			1237.055		gravel
	47.0	0.574			1236.879		gravel
	48.0	0.697			1236.756		gravel
	49.0	0.75			1236.703		gravel
	50.0	0.757			1236.696		gravel

TP2* backsight = 1.852 m, height of instrument = 1237.453 m

R7,S3 Differential Level Loop

Differential Levelling Loop - Reach 7, Site 3

Date: 27/09/2001

Field (Arbitrary) Elevations (m)

Station	Backsight	Height of Instrument	Foresight	Elevation
BM1	0.509	5.509		5.000
TP1	2.212	4.800	2.921	2.588
TP2	2.519	4.115	3.204	1.596
TP3	2.178	3.290	3.003	1.112
TP4	2.741	3.472	2.559	0.731
BM2		2.721	0.751	2.721
BM2	0.751	3.472		2.721
TP4	2.571	3.304	2.739	0.733
TP3	3.051	4.165	2.190	1.114
TP2	3.213	4.819	2.559	1.606
TP1	3.010	5.512	2.317	2.502
BM1			0.516	4.996
				error=-0.004

True Elevations (m)

Station	Backsight	Height of Instrument	Foresight	Elevation
BM1	0.509	1240.509		1240.000
TP1	2.212	1239.800	2.921	1237.588
TP2	2.519	1239.115	3.204	1236.596
TP3	2.178	1238.290	3.003	1236.112
TP4	2.741	1238.472	2.559	1235.731
BM2		1237.721	0.751	1237.721
BM2	0.751	1238.472		1237.721
TP4	2.571	1238.304	2.739	1235.733
TP3	3.051	1239.165	2.190	1236.114
TP2	3.213	1239.819	2.559	1236.606
TP1	3.010	1240.512	2.317	1237.502
BM1			0.516	1239.996
				error=-0.004

Benchmark Elevations (m)		
	2000	2001
BM1	1240.000	1240.000
BM2	1237.712	1237.721

Longitudinal profile of a representative two meander lengths of the Wigwam River in reach 9, study site 4.

Reach 9, Site 4 Long Survey

Longitudinal Survey

Location: Wigwam River

Reach: 9

Site: 4

UTM: start 661031E, 5432738N

end 654977E, 5439074N

Crew: KM/LC

Date: 26/09/2001

Benchmark UTM:

BM1: 661028E, 5432729N

Benchmark Elevations:

BM1: 1330.000

BM2: 1327.388

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Habitat Type	Comments
		Thalweg Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Thalweg Elevation (m)	Water Surface Elevation (m)			
BM1	0	1.476	0.295	1.181	1328.561	1328.856	boulder	glide	
	10	1.668	0.420	1.248	1328.369	1328.789	boulder	glide	
	20	1.759	0.505	1.254	1328.278	1328.783	boulder	glide	
	30	2.006	0.470	1.536	1328.031	1328.501	boulder	riffle	
	40	2.296	0.470	1.826	1327.741	1328.211	boulder	riffle	
	50	2.511	0.450	2.061	1327.526	1327.976	boulder	riffle	
	60	2.779	0.505	2.274	1327.258	1327.763	boulder	riffle	
	70	3.038	0.510	2.528	1326.999	1327.509	boulder	riffle	
	80	3.248	0.390	2.858	1326.789	1327.179	cobble	pool	
TP1	90	3.557	0.460	3.097	1326.480	1326.940	boulder	riffle	
	100	1.517	0.460	1.057	1326.272	1326.732	boulder	riffle	
	110	1.648	0.425	1.223	1326.141	1326.566	boulder	riffle	
	120	1.847	0.420	1.427	1325.942	1326.362	boulder	riffle	
	130	2.159	0.480	1.679	1325.630	1326.110	boulder	riffle	
	140	2.384	0.545	1.839	1325.405	1325.950	boulder	riffle	
	150	2.361	0.395	1.966	1325.428	1325.823	boulder	riffle	
	160	2.489	0.430	2.059	1325.300	1325.730	boulder	riffle	
	170	2.747	0.470	2.277	1325.042	1325.512	boulder	riffle	
TP2	180	2.976	0.450	2.526	1324.813	1325.263	boulder	riffle	
	190	3.298	0.550	2.748	1324.491	1325.041	cobble	glide	Rabbit Creek
	200	2.083	0.545	1.538	1324.397	1324.942	cobble	glide	
	210	2.125	0.560	1.565	1324.355	1324.915	cobble	glide	
	220	1.991	0.395	1.596	1324.489	1324.884	cobble	glide	
	230	1.958	0.305	1.653	1324.522	1324.827	cobble	glide	
	240	2.244	0.515	1.729	1324.236	1324.751	boulder	riffle	
	250	2.167	0.430	1.737	1324.313	1324.743	boulder	riffle	
	260	2.348	0.495	1.853	1324.132	1324.627	cobble	riffle	
	270	2.296	0.360	1.936	1324.184	1324.544	cobble	riffle	
	280	2.395	0.310	2.085	1324.085	1324.395	boulder	cascade	
	290	3.089	0.500	2.589	1323.391	1323.891	boulder	cascade	end of reach

Cross sectional profile of a representative pool habitat unit of the Wigwam River in reach 9, study site 4.

Reach 9, Site 4 Pool X-Sxn

Pool Cross Sectional Survey

Location: Wigwam River

Reach: 9

Site: 4

pool cross section at 0+26m of longitudinal survey

UTM: 661005E, 5432852N

Crew: KM/LC

Date: 26/09/2001

Benchmark UTM:

BM1: 661028E, 5432729N

Benchmark Elevation:

BM1: 1330.000 m

Ground Station No.	Distance from Start (m)	Uncorrected Data			Corrected Data		Dominant Substrate	Comments
		Ground Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)		
BM1*	3.8	0.151			1330.518		vegetation	RUB start
	4.0	0.899			1329.770		finer	
	5.0	1.509			1329.160		finer	RUB bankfull
	6.0	1.813			1328.856		vegetation	
	6.4	1.989	0.08	1.909	1328.710	1328.790	boulder	RUB wetted edge
	7.0	2.343	0.435	1.908	1328.356	1328.791	boulder	
	8.0	2.522	0.615	1.907	1328.177	1328.792	boulder	
	9.0	2.421	0.51	1.911	1328.278	1328.788	cobble	
	10.0	2.532	0.62	1.912	1328.167	1328.787	cobble	
	11.0	2.522	0.615	1.907	1328.177	1328.792	cobble	
	12.0	2.342	0.44	1.902	1328.357	1328.797	gravel	
	13.0	2.193	0.295	1.898	1328.506	1328.801	gravel	
	14.0	2.183	0.28	1.903	1328.516	1328.796	gravel	
	15.0	2.162	0.26	1.902	1328.537	1328.797	gravel	
	16.0	2.178	0.275	1.903	1328.521	1328.796	gravel	
	17.0	2.174	0.26	1.914	1328.525	1328.785	gravel	
	18.0	2.169	0.21	1.959	1328.530	1328.740	gravel	
	18.7	1.79	0	1.79	1328.909	1328.909	gravel	LUB wetted edge
	19.0	1.652			1329.047		boulder	
	20.0	1.564			1329.135		vegetation	LUB bankfull
	21.0	1.229			1329.470		vegetation	
	22.0	0.272			1330.427		vegetation	
	23.0	1.203			1329.496		vegetation	
	24.8	0.659			1330.040		vegetation	

* BM1 backsight = 0.699 m, height of instrument = 1330.699 m

Cross sectional profile of a representative riffle habitat unit of the Wigwam River in reach 9, study site 4.

Reach 9, Site 4 Riffle X-Sxn

Riffle Cross Sectional Survey

Location: Wigwam River

Reach: 9

Site: 4

cross section located at 0+141m of longitudinal survey

UTM: 660942E, 5432911N

Crew: KM/LC

Date: 26/09/2001

Benchmark UTM

BM1: 661028E, 5432729N

Benchmark Elevation

BM1: 1330.000 m

TP1: 1327.436 m

Ground Station No.	Distance from Start (m)	Uncorrected Data		Corrected Data		Dominant Substrate	Comments
		Elevation (m)	Water Level (m)	Water Surface Elevation (m)	Ground Elevation (m)	Water Surface Elevation (m)	
TP1	0.5	0.015			1327.774		vegetation RUB start
	2.0				1327.789		vegetation
	3.0	0.943			1326.846		vegetation
	4.5	0.866			1326.923		vegetation
	6.0	1.023			1326.766		vegetation
	6.3	1.194			1326.595		vegetation RUB bankfull height
	7.4	1.973	0	1.973	1325.816	1325.816	boulder RUB wetted edge
	8.0	2.223	0.265	1.958	1325.566	1325.831	gravel
	9.0	2.291	0.34	1.951	1325.498	1325.838	boulder
	10.0	2.355	0.395	1.96	1325.434	1325.829	cobble
	11.0	2.271	0.325	1.946	1325.518	1325.843	cobble
	12.0	2.394	0.46	1.934	1325.395	1325.855	boulder
	13.0	2.439	0.49	1.949	1325.350	1325.840	boulder
	14.0	2.278	0.315	1.963	1325.511	1325.826	boulder
	15.0	2.265	0.31	1.955	1325.524	1325.834	boulder
	16.0	2.264	0.3	1.964	1325.525	1325.825	boulder
	17.0	2.181	0.195	1.986	1325.608	1325.803	boulder
	17.7	1.972	0	1.972	1325.817	1325.817	boulder LUB wetted edge
	18.0	1.493			1326.296		boulder
	19.0	1.361			1326.428		boulder
	19.2	1.201			1326.588		cobble LUB bankfull height
	20.0	0.799			1326.990		cobble
	21.0	0.468			1327.321		vegetation

R9, S4 Differential Level Loop

Differential Levelling Loop - Reach 9, Site 4

Date: 26/09/2001

Field (Arbitrary) Elevations (m)

Station	Backsight	Height of Instrument	Foresight	Elevation
BM1	0.037	10.037		10.000
TP1	0.353	7.789	2.601	7.436
TP2	1.141	6.480	2.45	5.339
BM3		4.464	2.016	4.464
BM3	2.016	6.480		4.464
TP2	2.457	7.796	1.141	5.339
TP1	2.754	10.190	0.36	7.436
BM1		10.001	0.189	10.001
				error = +0.001

True Elevations (m)

Station	Backsight	Height of Instrument	Foresight	Elevation
BM1	0.037	1330.037		1330.000
TP1	0.353	1327.789	2.601	1327.436
TP2	1.141	1326.480	2.45	1325.339
BM3		1324.464	2.016	1324.464
BM3	2.016	1326.480		1324.464
TP2	2.457	1327.796	1.141	1325.339
TP1	2.754	1330.190	0.36	1327.436
BM1		1330.001	0.189	1330.001
				error = +0.001

Benchmark Elevations (m)		
	2000	2001
BM1	1330.000	1330.000
BM2	1327.573	1327.388
BM3	1324.374	1324.464

Appendix E

Pebble Count Data

Bighorn Creek, Reach 1 Pebble Count

Station:	Reach 1
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Particle Class	Particle Size (mm)	Number	Total %	Cumulative %
Silt/Clay	< .062	11	11.00	11.00
VFS	.062-.125	1	1.00	12.00
FS	.125-.25	4	4.00	16.00
MS	.25-.50	1	1.00	17.00
CS	.50-1.0	5	5.00	22.00
VCS	1.0-2.0		0.00	22.00
VFG	2-4	3	3.00	25.00
FG	4-6	1	1.00	26.00
FG	6-8	3	3.00	29.00
MG	8-12	2	2.00	31.00
MG	12-16	4	4.00	35.00
CG	16-24	3	3.00	38.00
CG	24-32	11	11.00	49.00
VCG	32-48	14	14.00	63.00
VCG	48-64	14	14.00	77.00
SC	64-96	11	11.00	88.00
SC	96-128	6	6.00	94.00
LC	128-192	5	5.00	99.00
LC	192-256		0.00	99.00
SB	256-384	1	1.00	100.00
SB	384-512		0.00	
MB	512-1024		0.00	
LB	1024-2048		0.00	
VLB	2048-4096		0.00	
VLB	> 4096		0.00	
	BEDROCK		0.00	

Bighorn Creek Chart 1

Wigwam River, Reach 5 Pebble Count

Station:	Reach 5
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Particle Class	Particle Size (mm)	Number	Total %	Cumulative %
Silt/Clay	< .062	2	2.00	2.00
VFS	.062-.125		0.00	2.00
FS	.125-.25	2	2.00	4.00
MS	.25-.50		0.00	4.00
CS	.50-1.0	1	1.00	5.00
VCS	1.0-2.0	2	2.00	7.00
VFG	2-4	2	2.00	9.00
FG	4-6	1	1.00	10.00
FG	6-8	1	1.00	11.00
MG	8-12	3	3.00	14.00
MG	12-16		0.00	14.00
CG	16-24	5	5.00	19.00
CG	24-32	5	5.00	24.00
VCG	32-48	10	10.00	34.00
VCG	48-64	4	4.00	38.00
SC	64-96	13	13.00	51.00
SC	96-128	17	17.00	68.00
LC	128-192	15	15.00	83.00
LC	192-256	8	8.00	91.00
SB	256-384	6	6.00	97.00
SB	384-512	2	2.00	99.00
MB	512-1024	1	1.00	100.00
LB	1024-2048		0.00	
VLB	2048-4096		0.00	
VLB	> 4096		0.00	
	BEDROCK		0.00	

Reach 5, Site 1 Chart 1

Wigwam River Reach 6, Site 2 Pebble Count

Station:	Reach 6
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Particle Class	Particle Size (mm)	Number	Total %	Cumulative %
Silt/Clay	< .062		0.00	0.00
VFS	.062-.125		0.00	0.00
FS	.125-.25	1	1.00	1.00
MS	.25-.50	2	2.00	3.00
CS	.50-1.0	5	5.00	8.00
VCS	1.0-2.0	2	2.00	10.00
VFG	2-4	5	5.00	15.00
FG	4-6		0.00	15.00
FG	6-8	1	1.00	16.00
MG	8-12	4	4.00	20.00
MG	12-16	4	4.00	24.00
CG	16-24	8	8.00	32.00
CG	24-32	5	5.00	37.00
VCG	32-48	11	11.00	48.00
VCG	48-64	8	8.00	56.00
SC	64-96	19	19.00	75.00
SC	96-128	14	14.00	89.00
LC	128-192	11	11.00	100.00
LC	192-256		0.00	
SB	256-384		0.00	
SB	384-512		0.00	
MB	512-1024		0.00	
LB	1024-2048		0.00	
VLB	2048-4096		0.00	
VLB	> 4096		0.00	
	BEDROCK		0.00	

Reach 6, Site 2 Chart 1

Wigwam River, Reach 7 Pebble Count

Station:	Reach 7
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Particle Class	Particle Size (mm)	Number	Total %	Cumulative %
Silt/Clay	< .062		0.00	0.00
VFS	.062-.125		0.00	0.00
FS	.125-.25		0.00	0.00
MS	.25-.50		0.00	0.00
CS	.50-1.0	2	2.00	2.00
VCS	1.0-2.0		0.00	2.00
VFG	2-4		0.00	2.00
FG	4-6	2	2.00	4.00
FG	6-8	3	3.00	7.00
MG	8-12	3	3.00	10.00
MG	12-16	3	3.00	13.00
CG	16-24	7	7.00	20.00
CG	24-32	3	3.00	23.00
VCG	32-48	8	8.00	31.00
VCG	48-64	9	9.00	40.00
SC	64-96	21	21.00	61.00
SC	96-128	12	12.00	73.00
LC	128-192	11	11.00	84.00
LC	192-256	6	6.00	90.00
SB	256-384	9	9.00	99.00
SB	384-512	1	1.00	100.00
MB	512-1024		0.00	
LB	1024-2048		0.00	
VLB	2048-4096		0.00	
VLB	> 4096		0.00	
	BEDROCK		0.00	

Reach 7, Site 3 Chart 1

Wigwam River, Reach 9 Pebble Count

Station:	Site 4
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Particle Class	Particle Size (mm)	Number	Total %	Cumulative %
Silt/Clay	< .062		0.00	0.00
VFS	.062-.125		0.00	0.00
FS	.125-.25		0.00	0.00
MS	.25-.50		0.00	0.00
CS	.50-1.0	1	1.00	1.00
VCS	1.0-2.0	1	1.00	2.00
VFG	2-4	1	1.00	3.00
FG	4-6	1	1.00	4.00
FG	6-8		0.00	4.00
MG	8-12	1	1.00	5.00
MG	12-16	1	1.00	6.00
CG	16-24	2	2.00	8.00
CG	24-32	3	3.00	11.00
VCG	32-48	4	4.00	15.00
VCG	48-64	4	4.00	19.00
SC	64-96	8	8.00	27.00
SC	96-128	5	5.00	32.00
LC	128-192	20	20.00	52.00
LC	192-256	5	5.00	57.00
SB	256-384	11	11.00	68.00
SB	384-512	12	12.00	80.00
MB	512-1024	15	15.00	95.00
LB	1024-2048	5	5.00	100.00
VLB	2048-4096		0.00	
VLB	> 4096		0.00	
	BEDROCK		0.00	

Reach 9, Site 4 Chart 1