An analysis of stream channel cross section technique as a means to determine anthropogenic change in second order streams at the Tenderfoot Creek Experimental Forest, Meagher County, Montana

Report for: RMRS RJVA-98541

By Jeff Boice for Dr. Andrew Marcus

Description of study area

Locational information for Reaches used in TCEF cross section study

All pin locations with azimuth and distance are readings were on the right side of the stream facing downstream

Stringer Creek Reach 1

Elevation at beginning of reach 2025 meters

Lat/Long location: 46°55.61' N 110° 54.11' W

Distance upstream from gauging station Approximately 56 meters

Location of selected pins relative to benchmarks and turning pts:
All turning point trees are marked with orange paint as BM or TP and have nails driven into the base of the tree. The stadia rod was placed on the nail for BS and FS readings.

1st pin Azimuth 222° distance 23.4 meters from BM 1 (Lodgepole pine marked with orange paint and nail at base of tree.

10th pin Azimuth 163° distance 21 meters from turning point #2 (nail at base of subalpine fir marked with a star)

28th pin azimuth 5° distance 1.57 meters (Turning point #5 marked with star on subalpine fir nail at base

survey error = 0.00

Bubbling Creek Reach 1

Elevation 2135 meters

Lat/Long location: 46° 55'09" N 110° 53.97' W

Distance upstream from gauging station approximately 230 meters

Location of selected pins relative to benchmarks and turning pts:

All turning point trees are marked with orange paint as BM or TP and have nails driven into the base of the tree. The stadia rod was placed on the nail for BS and FS readings.

1st pin location at azimuth 359°, 26.7 meters from 1st benchmark (Split Top Lodgepole marked with orange paint as BM 1)

16th pin azimuth 19° distance 8.61 meters from turning pt.#1

30th pin azimuth 1° 41.50 meters from benchmark
pin frequency is 2.5 meters

Survey arithmetic error =.010

Spring Park Creek Reach 1 (Lower)

Elevation unknown

Distance upstream from gauging station: Approximately 610 meters

Lat/Long location: 46° 55.62' N 110° 52.54' W

Reach length: 527 meters

Survey arithmetic error = 0.00

Location of selected pins relative to benchmarks and turning pts:

All turning point trees are marked with orange paint as BM or TP and have nails driven into the base of the tree. The stadia rod was placed on the nail for BS and FS readings.

1st pin Azimuth 226°distance 25.36 meters from benchmark (Lodgepole marked benchmark 1

30th pin Azimuth 64° distance 28.33 meters from turning point #4 (Lodgepole marked TP)

Spring Park Creek Reach 2 (Upper)

Elevation : Unknown:

Distance upstream from gauging station: Approximately 1020 meters

Lat/Long location: 46° 55.62'N 110°52.62'W

Reach length : 410 meters

No Azimuths or distances taken from Benchmark to pins

Sun Creek Reach 1

Elevation: Unknown

Lat/Long Location: 46°54.94' N 110° 52.64' W

Reach length 225.6 meters

Distance upstream from gauging station: approximately 550 meters

Location of selected pins relative to benchmarks and turning pts:

All BM or turning point trees are marked with orange paint as BM or TP and have nails driven into the base of the tree. The stadia rod was placed on the nail for BS and FS readings.

1st pin Azimuth 26° distance 18.3 meters to BM #1

9th pin Azimuth 16°distance .4 m to TP #1

13th pin Azimuth 66°distance 3.7m to TP #2

19th pin Azimuth 46° distance 6 m to TP #3

24th pin Azimuth 340°distance 4.05 m to TP #4

29th pin Azimuth 4° distance 4.8 m to TP #5

Survey arithmetic error= 0.00

Tenderfoot Creek Reach 1

Elevation. Unknown

Lat/Long Location: No information

Distance upstream from gauging station: approximately 520 meters

Reach length: 406 meters

Location of selected pins relative to benchmarks and turning pts

All BM or turning point trees are marked with orange paint as BM or TP and have nails driven into the base of the tree. The stadia rod was placed on the nail for BS and FS readings.

1st pin at azimuth 170° distance .8 meters from Bench Mark #1(Marked with orange paint and nail at base of tree)

11th pin at azimuth 205° distance 13.6 m from TP#1

12th pin at azimuth 181° distance 13.2 m from TP #1

20th pin at Azimuth 239° distance 3.2 m from TP # 2

21st pin at Azimuth 141° distance 4.2 m from TP #2

24th pin at Azimuth 251°distance 8 m from TP #3

30th pin at Azimuth 127°distance 26 m from TP #3

Relevant Stream Channel Characteristics used to establish reach breaks

Stream name	Km^2	Stream Classification.(Rosgen, 1995)	Valley Width (m)	Slope	Sinuosity
Sun Creek	3.47	A3	11-30	6.6%	1.1
Spring Park(1)	4.17	A3	10-17	5.5%	1.1
Spring Park(2)	4.04	C3	24-35	2%	1.8
Bubbling Ck	3.18	A3	24-29	10%	1.1
Stringer Ck	5.54	A2	12-33	7.7%	1.05
Upper Tend Ck	?	B3a	22-33	4.1%	1.2

Five second order tributaries to Tenderfoot Creek were investigated: Upper Tenderfoot Creek, Sun Creek, Spring Park Creek, Bubbling Creek, and Stringer Creek (Fig. 1). Second order reaches were initially located on 7.5 minute topographic maps using techniques first applied by **Strahler (1952)**. Reach breaks were determined in the field through visual inspection. Vegetation type (forested vs. non forested), channel slope, sinuosity, entrenchment ratio, and channel materials were used in the classification of stream reaches, using channel classification techniques developed by **Rosgen (1995)**.

Sun Creek and Stringer Creek were located entirely within mixed conifer stands of mature and overmature subalpine fir, Douglas fir *(Pseudotsuga menziesi)*, and lodgepole pine. Because of the overmature state of these stands, large woody material had commonly fallen across the channel and, in some cases, was actively affecting the hydraulics and sediment movement. Three reaches, Spring Park 1, Spring Park 2, and Bubbling Creek were each located on a non-forested, U shaped valley floor comprised of Grass and Grass-like species. No large woody material was present within these reaches. The sixth reach, Upper Tenderfoot Creek, was situated on a trough shaped valley floor. A patchy to continuous shrub willow species dominated the riparian margin throughout the reach..

Reach breaks were further defined by their stream channel type **(Rosgen, 1995; Warren and Buffington, 1992).** Stringer Creek, Bubbling Creek, Spring Park Creek(1), and Sun Creek were classified step-pool or "A" type streams, while Spring Park Creek(2) was classified as a "C" type stream because of its riffle-pool morphology, slope, and sinuosity.

Methodology

Cross section installation

Stream channel cross sections are frequently used in management and research to assess whether forest management has altered the hydraulic geometry of a stream. Based on a current literature review, I found very few studies that asked questions concerning how many cross sections might need to be installed in order to examine whether changes in hydraulic geometry are occurring.

On this basis, I chose methods described in the literature **(Harrelson, et al 1994).** The following list describe the steps I took to establish these cross sections in each of six reaches.

1) Reach break boundries were flagged and the total distance was paced.
2) A preliminary average bankfull width was determined so that the distance between cross sections could be determined
3) Reaches were segmented into 1 meter increments and a random start point for the first cross section was located based on these increments.
4) 30 Cross sections for each reach were placed systematically upstream from the initial start point based on a measurement of 2 times the wetted width of the stream.
5) 3/8" X 3 ft Rebar stakes were pounded into the stream bank perpendicular to the axis of flow.
6) A level line from stake to stake was determined with a carpenters string and line level. At level, a hacksaw was used so that level could be quickly located at a later data when field help

was available. Distance from stream bank was measured and recorded in the notes as a tecnique to minimize error in case the stake was moved.

7) Using a small crew at a later date, a measuring tape was strung between the rebar pins. Distance and depth measurements were taken at .1 meter increments from pin to pin starting on the right bank (facing downstream). Changes in slope, bankfull, and wetted width, were recorded in addition to the .1 meter increments
8) At each pin (left and right), characteristics of the stream bank were recorded in a 3X3 meter grid such as ground cover and rock type.
9) All right pin elevations (facing downstream) were surveyed relative to a permanent benchmark for future reference, although it is hoped that reusing exact cross section locations is unnecessary after sample size for various measures of precision is derived.
10) Selected pin locations are referenced from the benchmarks by azimuth and distance for future reference.

Autocorrelation

A concern I had for this study was whether or not autocorrelation effects existed between adjacent cross sections due to their close proximity. Autocorrelated samples that show a high degree of relatedness suggest that there are systematic patterns to the data set that might indicate a lack of randomness, preventing the use of parametric tests at a later date (ie replication of this procedure to look at change) and reducing the effective sample size. I used standard time series autocorrelation technique to look at patterns from the first through the thirtieth cross section in each reach. I believe time series correlation could work because of the linear nature of the data set. These variables were included in analysis of autocorrelation using number cruncher statistical software (NCSS):

1) Bankfull Width
2) Bankfull Depth

3) Cross sectional area

4) Gini Coefficient

5) Width to Depth Ratio

Gini Coefficient and Width to Depth ratio are referenced in **Marlow (1992)** and are considered sensitive to changes in channel shape.

Descriptive Statistics

Descriptive statistics were calculated for each of the previously listed variables to determine the shape and characteristics of the sample distribution. I used NCSS software to assess whether the variables in question were normally distributed or skewed. Additionally I generated boxplots as a visual means of looking at outliers, skewedness, standard deviation, and various other features of a dataset that would indicate its relative value.

Statistical Questions

1) **Over what distances is there spatial autocorrelation between cross sections, if any?**

I examined the issue of spatial autocorrelation to determine whether I could discern a pattern in the sequence of cross sections that would indicate a lack of sample randomness and whether spatial patterns in the data set might indicate a systematic sequence of pool habitat types given the fact that I sampled the reach at 3 times wetted width. Pool sequencing at 3 times wetted width might have shown up as a pattern in a time series autocorrelation. **No indications of spatial autocorrelation except in bankfull depth**

2) Are there systematic downstream trends within each variable selected?

Scatter plots- Cross section sequence 1-30 (Independent axis) versus bank full width and other variables.

No systematic downstream trends to date

Regression plots-Indicate no linear, quadratic or reciprocal trend

Both techniques show random scatter of points but plots of 95% conf. Interval show tendency to remain within the interval except for a few outliers

3) What channel characteristics or types show these trends?

4) At what sample size does variance begin to stabilize (if at all with a sample size of 30 per each reach?)

5) Are there systematic downstream variations with each variable selected

6) How does confidence that you are within + or – 1%, 5%, and 10% of the population mean for each variable vary as a function of sample size?

7) How do questions 1, 2, and 3 above vary between streams if at all?

Use descriptive stats, boxplots,

Use one multiple regression

8) What are the implications for management in terms of sampling to characterize:

conditions at one time

changes over time

Sample Size Recommendation

I am currently still investigating whether the variables I've chosen to measure are appropriate to the task at hand; That is, providing recommendations on how many samples need to be taken in the future to assess actual channel change. Other researchers have found that approximately ten cross section samples need to be taken in order to assess change (Myers and Swanson, 1997). These authors found difficulty in assessing change in low order streams because of the stochastic

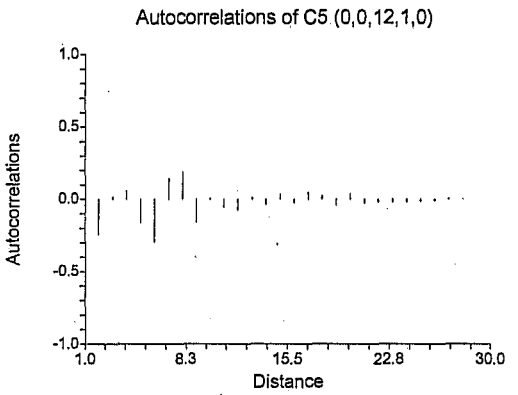
nature of boulder bedded step-pool systems. As a guess, I'd suggest a sample size between 10 and 15 with a 95% confidence level might be an appropriate.

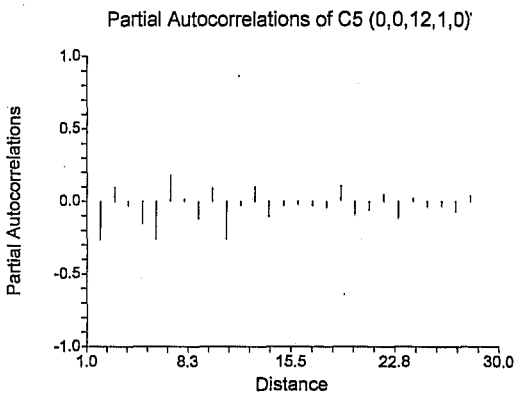
Appendix 1

This appendix is a sample of the statistical inquiry I've generated so far. More stats and interpretation will be forthcoming as I work my way through this process.

Autocorrelation Plots for Bankfull Width, X-sec Area

Stringer Creek bankfull width autocorrelation plot section

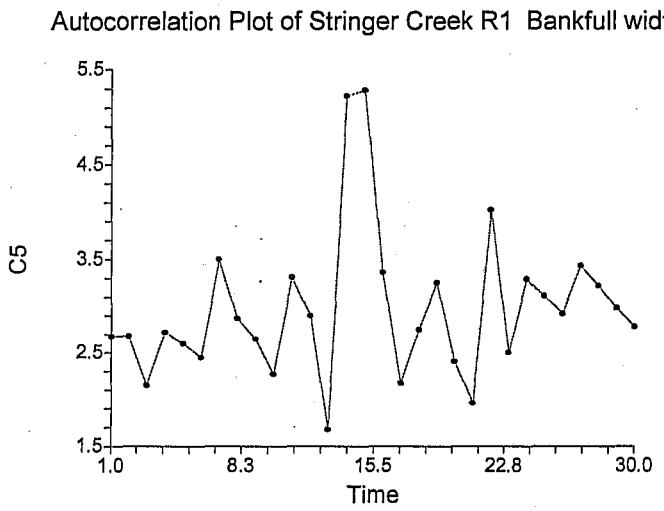




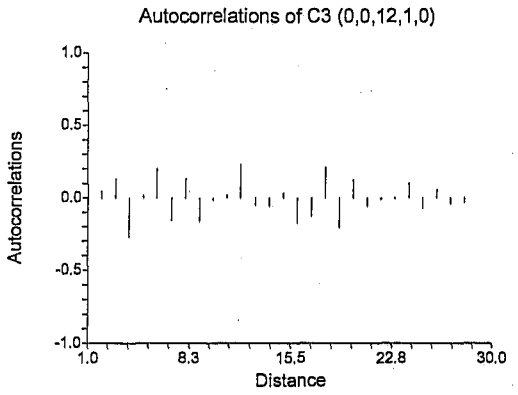
Autocorrelations stringer creek bankfull width (0,0,12,1,0)

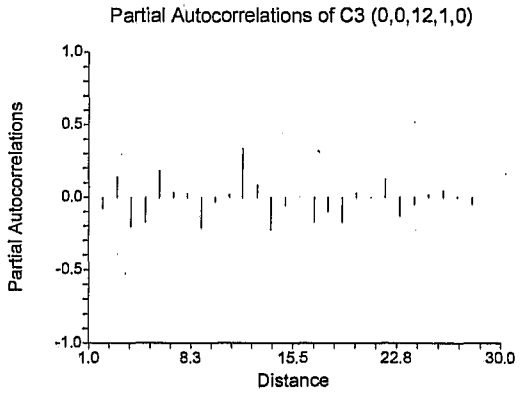
Lag	Correlation	Lag	Correlation	Lag	Correlation	Lag	Correlation
1	0.130323	8	0.186235	15	0.032564	22	-0.018890
2	-0.241006	9	-0.156797	16	-0.023906	23	-0.022225
3	0.015778	10	0.006259	17	0.046351	24	-0.018587
4	0.056503	11	-0.051257	18	0.020259	25	-0.015153
5	-0.160374	12	-0.072725	19	-0.038010	26	-0.009932
6	-0.294115	13	0.010870	20	0.034629	27	0.003825
7	0.141991	14	-0.036247	21	-0.028610	28	0.000743

Significant if |Correlation|> 0.359211


Autocorrelation Plot of Stringer Creek R1 Bankfull wid
C5
5.5
4.5
3.5
2.5
1.5
1.0
8.3
15.5
22.8
30.0
Time

Bubbling Creek bankfull width Auto Correlation Plot

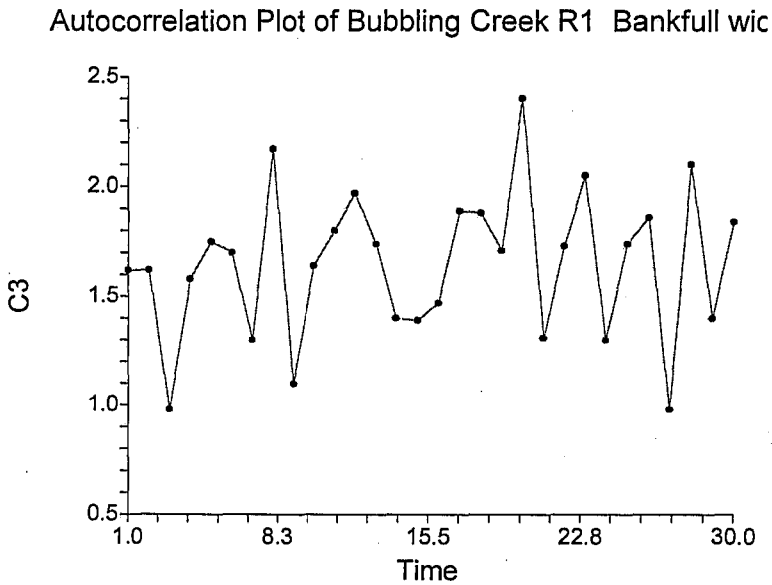




Autocorrelations of bubbling creek bankfull width (0,0,12,1,0)

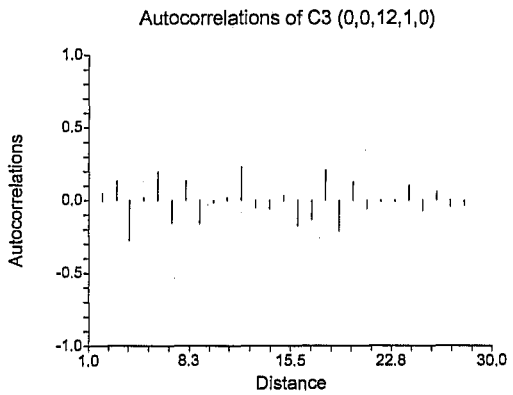
Lag	Correlation	Lag	Correlation	Lag	Correlation	Lag	Correlation
1	-0.340601	8	0.132720	15	0.032072	22	-0.009213
2	0.048439	9	-0.158197	16	-0.173196	23	-0.007197
3	0.131095	10	-0.015889	17	-0.130427	24	0.098550
4	-0.273644	11	0.016168	18	0.207648	25	-0.071239
5	0.016105	12	0.229280	19	-0.209106	26	0.053766
6	0.198452	13	-0.048578	20	0.123847	27	-0.043004
7	-0.154180	14	-0.057402	21	-0.056336	28	-0.034613

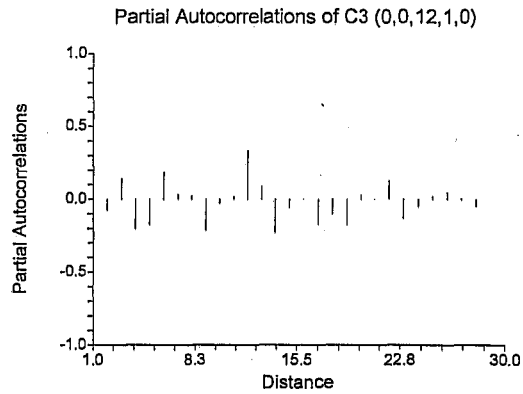
Significant if |Correlation|> 0.359211



Spring Park Reach 1 Bankfull Width Autocorrelation Plot Section

Autocorrelation Plot Section spring park creek bankfull width reach 1



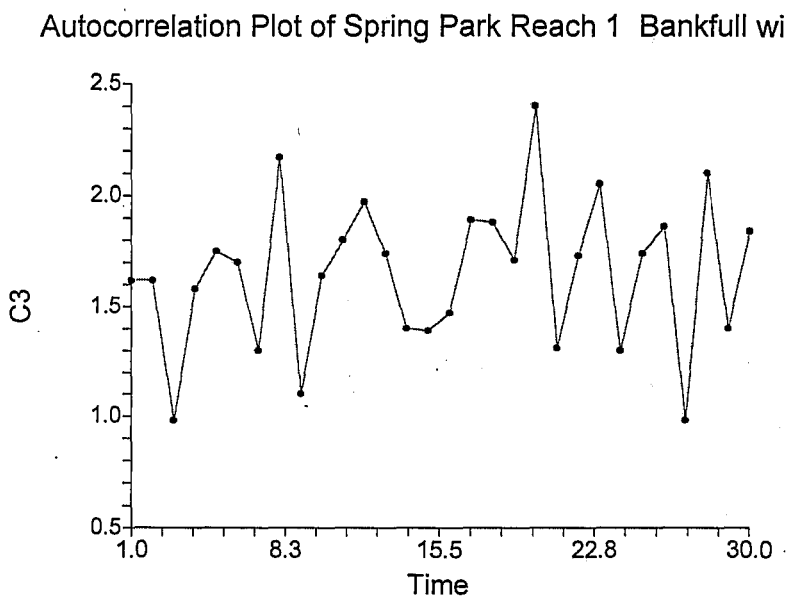


Autocorrelations of spring park creek bankfull width reach 1 (0,0,12,1,0)

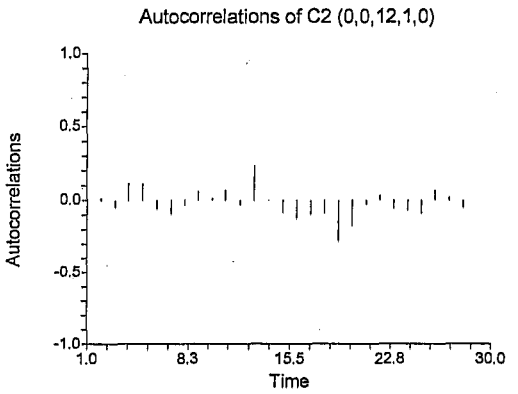
Lag	Correlation	Lag	Correlation	Lag	Correlation	Lag	Correlatic
1	-0.340601	8	0.132720	15	0.032072	22	-0.009213
2	0.048439	9	-0.158197	16	-0.173196	23	-0.007197
3	0.131095	10	-0.015889	17	-0.130427	24	0.098550
4	-0.273644	11	0.016168	18	0.207648	25	-0.071239
5	0.016105	12	0.229280	19	-0.209106	26	0.053766
6	0.198452	13	-0.048578	20	0.123847	27	-0.043004
7	-0.154180	14	-0.057402	21	-0.056336	28	-0.034613

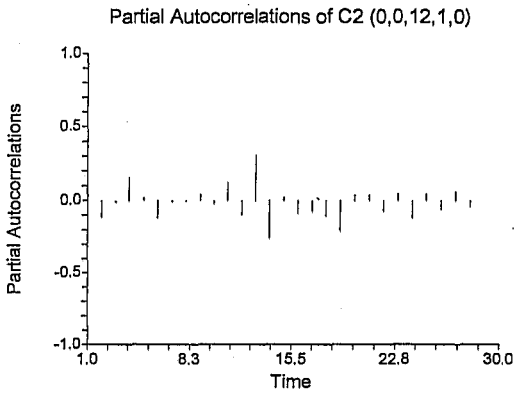
Significant if |Correlation|> 0.359211

Data Plot Section spring park creek bankfull width reach 1



Autocorrelation Report for spring park bankfull reach 2



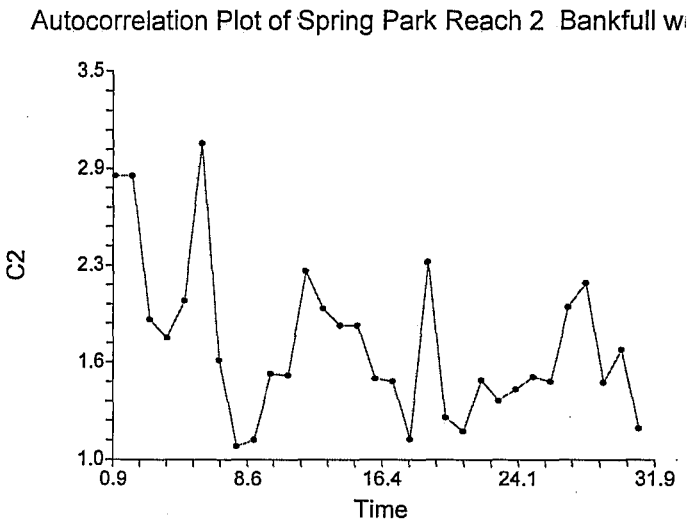


Autocorrelations of spring park bankfull width reach 2 (0,0,12,1,0)

Lag	Correlation	Lag	Correlation	Lag	Correlation	Lag	Correlatic
1	0.335997	8	-0.033770	15	-0.081869	22	0.027060
2	0.009962	9	0.056627	16	-0.118878	23	-0.056361
3	-0.047740	10	0.010086	17	-0.094155	24	-0.065779
4	0.111107	11	0.068267	18	-0.085268	25	-0.087333
5	0.112789	12	-0.030466	19	-0.277160	26	0.065373
6	-0.058502	13	0.228116	20	-0.173739	27	0.017546
7	-0.090648	14	-0.001209	21	-0.027840	28	-0.051778

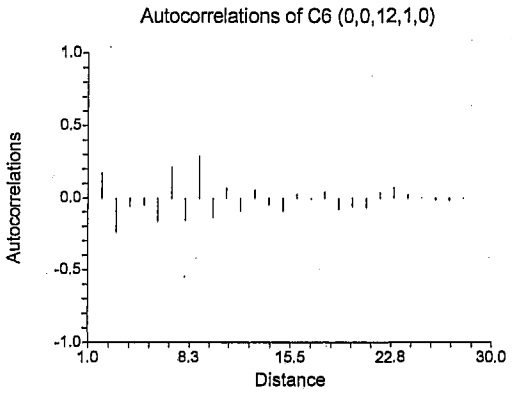
Significant if |Correlation|> 0.359211

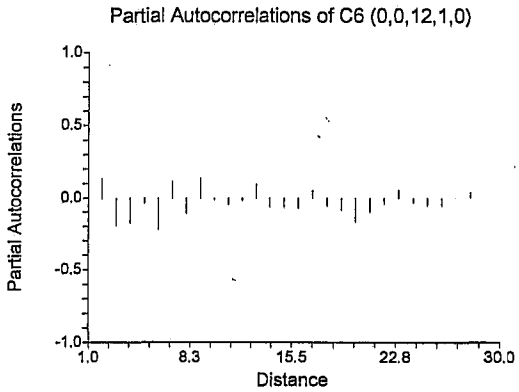
Data Plot of Spring Park Reach 2



Sun Creek Reach 1 bankfull width Autocorrelation Report

Autocorrelation Plot Section



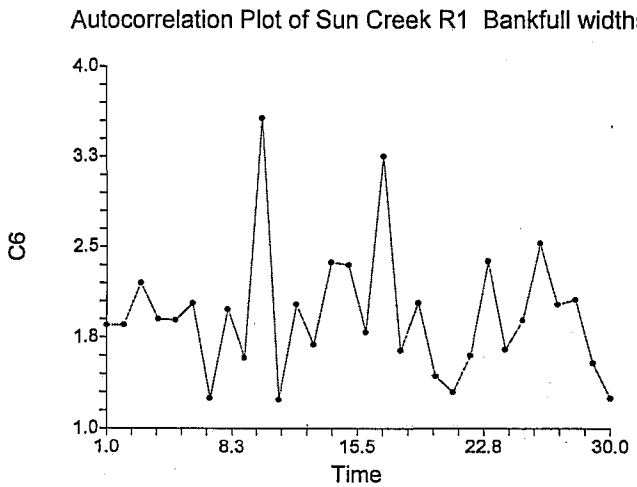


sun creek reach 1 bankfull width reach 1 (0,0,12,1,0)

Lag	Correlation	Lag	Correlation	Lag	Correlation	Lag	Correlatic
1	-0.215496	8	-0.158965	15	-0.094123	22	0.038700
2	0.174097	9	0.287320	16	0.026296	23	0.069531
3	-0.239275	10	-0.137120	17	-0.005852	24	0.020382
4	-0.061062	11	0.067799	18	0.042458	25	-0.002434
5	-0.048058	12	-0.094260	19	-0.079998	26	-0.011173
6	-0.161676	13	0.054001	20	-0.061996	27	-0.018897
7	0.210630	14	-0.041957	21	-0.069205	28	-0.002434

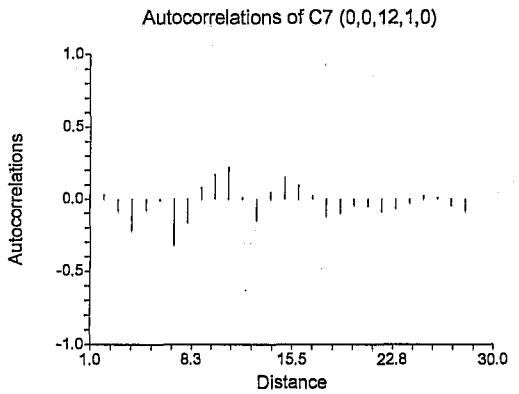
Significant if |Correlation|> 0.359211

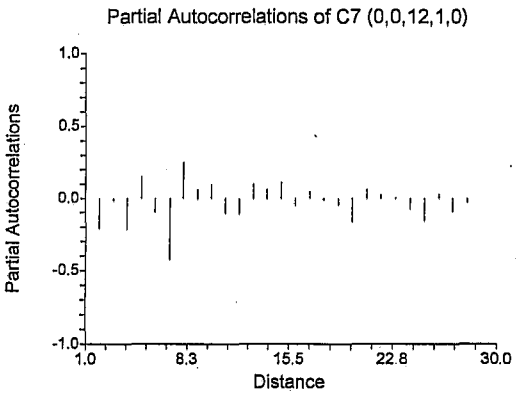
Data Plot Section for Sun Creek reach 1 bankfull width



Autocorrelation Report for Tenderfoot Creek bankfull width Reach 1

Autocorrelation Plot tenderfoot creek bankfull width reach 1



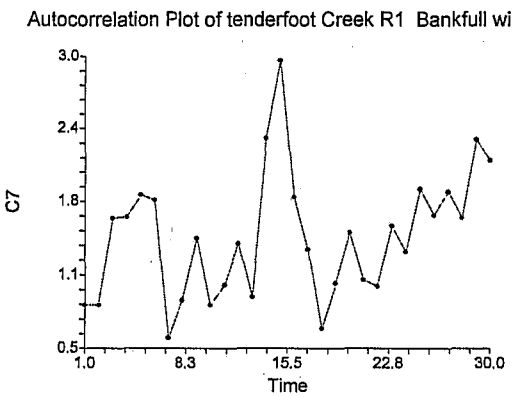


Autocorrelations of tenderfoot creek bankfull width reach 1 (0,0,12,1,0)

Lag	Correlation	Lag	Correlation	Lag	Correlation	Lag	Correlatic
1	0.446798	8	-0.164981	15	0.152209	22	-0.091384
2	0.031203	9	0.080031	16	0.096546	23	-0.071367
3	-0.085657	10	0.171726	17	0.023020	24	-0.028725
4	-0.222479	11	0.222966	18	-0.124659	25	0.021697
5	-0.080707	12	0.012616	19	-0.104104	26	0.008742
6	-0.010184	13	-0.155360	20	-0.041664	27	-0.046702
7	-0.325355	14	0.046088	21	-0.055778	28	-0.091052

Significant if |Correlation|> 0.359211

Data Plot Section for Tenderfoot Creek Reach 1



Descriptive statistics report representing cross section area for each of six streams

Summary Section of Stringer Creek Reach 1

		Standard	Standard			
Count	Mean	Deviation	Error	Minimum	Maximum	Range
30	0.3386667	0.1969375	0.0359557	0.05	0.8	0.75

Means Section of C14

				Geometric	Harmonic	
Parameter	Mean	Median	Mean	Mean	Sum	Mode
Value	0.3386667	0.275	0.2864373	0.2346088	10.16	0.2
Std Error	0.0359557				1.078671	
95% LCL	0.265129	0.2			7.95387	
95% UCL	0.4122043	0.4			12.36613	
T-Value	9.4190					
Prob Level	0.000000					
Count	30		30	30		3

Variation Section of C14

		Standard	Unbiased	Std Error	Interquartile	
Parameter	Variance	Deviation	Std Dev	of Mean	Range	Range
Value	3.878437E-02	0.1969375	0.1986422	0.0359557	0.2525	0.75
Std Error	9.304911E-03	3.340941E-02		6.099697E-03		
95% LCL	2.459953E-02	0.1568424		2.863537E-02		
95% UCL	7.009047E-02	0.264746		4.833579E-02		

Skewness and Kurtosis Section of C14

					Coefficient	Coefficient
Parameter	Skewness	Kurtosis	Fisher's g1	Fisher's g2	of Variation	of Dispersion
Value	0.8754777	2.726761	0.9222459	-9.476422E-02	0.5815083	0.5454546
Std Error	0.3249313	0.8174118			5.392997E-02	

Trimmed Section of C14

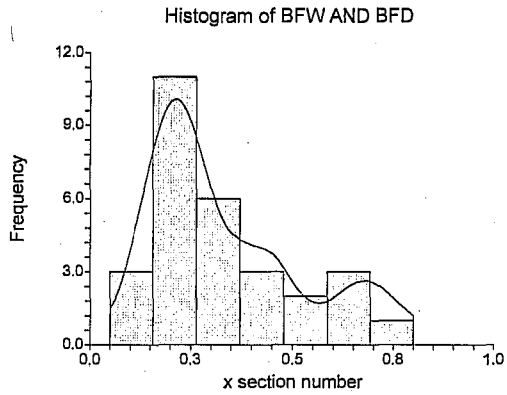
	5%	10%	15%	25%	35%	45%
Parameter	Trimmed	Trimmed	Trimmed	Trimmed	Trimmed	Trimmed
Trim-Mean	0.3288889	0.31875	0.305	0.2873333	0.2744444	0.2733333
Trim-Std Dev	0.1672937	0.1428076	0.1164742	8.119348E-02	5.077182E-02	9.128709E-03
Count	27	24	21	15	9	3

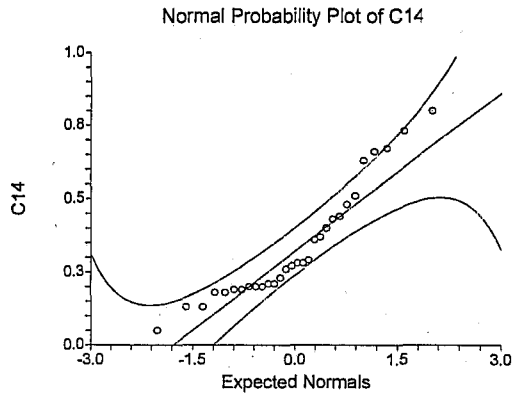
Descriptive Statistics Report

Normality Test Section of C14

Test NameValue	Test Level	Prob Value	10% Critical Value	5% Critical (5%)	Decision
Shapiro-Wilk W	0.8961647	0.006776			Reject Normality
Anderson-Darling	1.26909	0.002681			Reject Normality
Martinez-Iglewicz	1.197217		1.148522	1.228175	Accept Normality
Kolmogorov-Smirnov	0.1975913		0.146	0.159	Reject Normality
D'Agostino Skewness	2.1063	0.035175	1.645	1.960	Reject Normality
D'Agostino Kurtosis	0.1049	0.916465	1.645	1.960	Accept Normality
D'Agostino Omnibus	4.4477	0.108193	4.605	5.991	Accept Normality

Plots Section of C14





Descriptive Statistics Report

Descriptive Statistics Report

Summary Section of C15

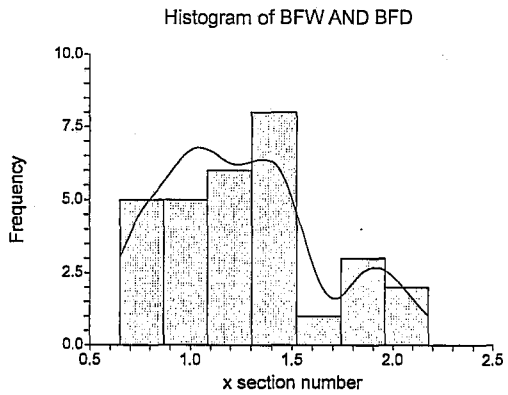
		Standard	Standard			
Count	Mean	Deviation	Error	Minimum	Maximum	Range
30	1.256	0.4043607	7.382583E-0	0.65	2.18	1.53

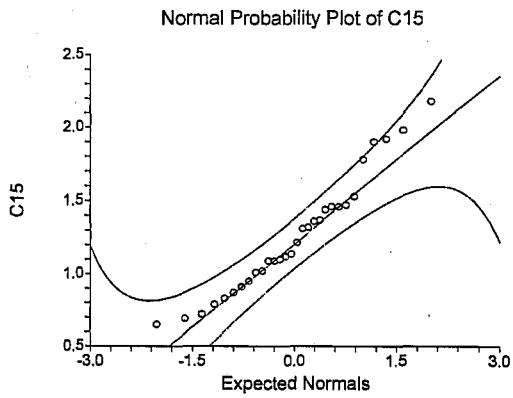
Means Section of C15

			Geometric	Harmonic		
Parameter	Mean	Median	Mean	Mean	Sum	Mode
Value	1.256	1.18	1.194768	1.135958	37.68	
Std Error	7.382583E-0				2.214775	
95% LCL	1.105009	1.01			33.15028	
95% UCL	1.406991	1.44			42.20972	
T-Value	17.0130					
Prob Level	0.000000					
Count	30		30	30		

Mean-Deviation Section of C15

Plots Section of C15





Descriptive Statistics Report

Summary Section of C16

		Standard	Standard			
Count	**Mean**	**Deviation**	**Error**	**Minimum**	**Maximum**	**Range**
30	0.9823334	0.1918276	3.502276E-0	0.53	1.28	0.75

Means Section of C16

Skewness and Kurtosis Section of C16

	Coefficient	Coefficient			
Parameter	**Skewness**	**Kurtosis**	**Fisher's g1**	**Fisher's g2**	**of**
Variation	**of Dispersion**				
Value	-0.4959981	2.846132	-0.5224944	4.718653E-02	
	0.1952775	0.1519459			
Std Error	0.267292	0.5008352			
	2.746929E-02				

Quartile Section of C16

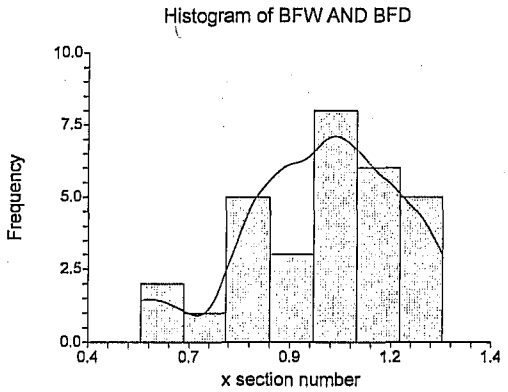
	10th	25th	50th	75th	90th
Parameter	**Percentile**	**Percentile**	**Percentile**	**Percentile**	**Percentile**
Value	0.711	0.8375	0.985	1.135	1.254
95% LCL	0.53	0.7	0.86	1.05	1.1
95% UCL	0.86	0.97	1.07	1.26	1.28

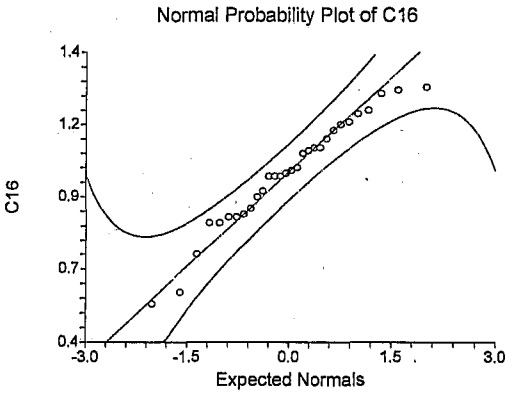
Normality Test Section of C16

	Test	Prob	10% Critica	5% Critical	Decision
Test Name	**Value**	**Level**	**Value**	**Value**	**(5%)**
Shapiro-Wilk W	0.9632844	0.374737			Accept Normality
Anderson-Darling	0.2830842	0.634453			Accept Normality
Martinez-Iglewicz	1.016691		1.148522	1.228175	Accept Normality
Kolmogorov-Smirnov	7.436813E-0		0.146	0.159	Accept Normality
D'Agostino Skewness	-1.2597	0.207793	1.645	1.960	Accept Normality
D'Agostino Kurtosis	0.2931	0.769483	1.645	1.960	Accept Normality
D'Agostino Omnibus	1.6726	0.433307	4.605	5.991	Accept Norm

ality

Plots Section of C16





Descriptive Statistics Report

Summary Section of C17

		Standard	Standard			
Count	Mean	Deviation	Error	Minimum	Maximum	Range
30	0.991	0.3319052	6.059732E-0	0.57	2.1	1.53

Means Section of C17

			Geometric	Harmonic		
Parameter	Mean	Median	Mean	Mean	Sum	Mode
Value	0.991	0.93	0.9463401	0.9084201	29.73	
Std Error	6.059732E-0				1.817919	
95% LCL	0.8670646	0.8			26.01194	
95% UCL	1.114935	1.01			33.44806	
T-Value	16.3539					
Prob Level	0.000000					
Count	30		30	30		

Skewness and Kurtosis Section of C17

					Coefficient	Coefficient
Parameter	Skewness	Kurtosis	Fisher's g1	Fisher's g2	of Variation	of Dispersio
Value	1.511216	5.544039	1.591945	3.255411	0.3349194	0.2405018
Std Error	0.4186303	1.797642			5.284279E-0	

Mean-Deviation Section of C17

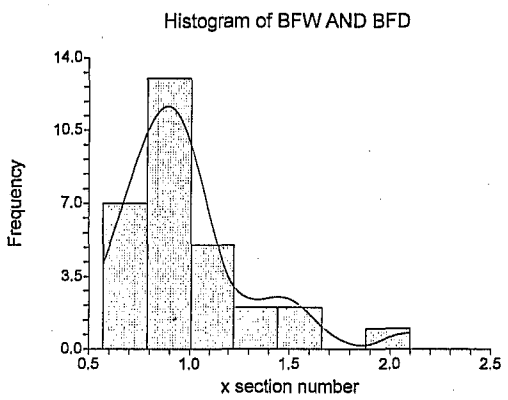
Quartile Section of C17

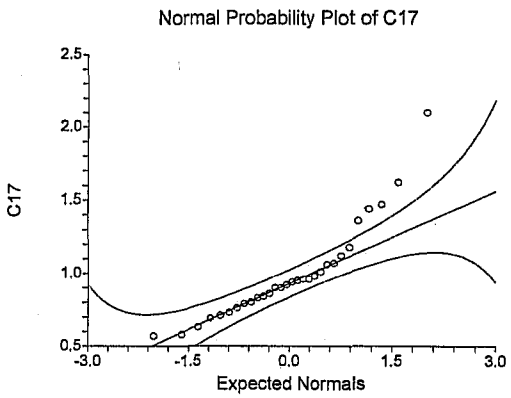
	10th	25th	50th	75th	90th
Parameter	Percentile	Percentile	Percentile	Percentile	Percentile
Value	0.636	0.7825	0.93	1.0825	1.467
95% LCL	0.57	0.63	0.8	0.96	1.06
95% UCL	0.8	0.9	1.01	1.47	2.1

Normality Test Section of C17

	Test	Prob	10% Critical	5% Critical	Decision
Test Name	Value	Level	Value	Value	(5%)
Shapiro-Wilk W Normality	0.8696207	0.001643			Reject
Anderson-Darling Normality	1.200807	0.003947			Reject
Martinez-Iglewicz Normality	1.721393		1.148522	1.228175	Reject
Kolmogorov-Smirnov Normality	0.179886		0.146	0.159	Reject
D'Agostino Skewness Normality	3.2491	0.001158	1.645	1.960	Reject
D'Agostino Kurtosis Normality	2.5003	0.012408	1.645	1.960	Reject
D'Agostino Omnibus Normality	16.8084	0.000224	4.605	5.991	Reject

Plots Section of C17





Descriptive Statistics Report

Summary Section of C18

Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum
		Range			
30	1.346	0.3641201	6.647893E-02	0.71	2.46

Skewness and Kurtosis Section of C18

Parameter	Skewness	Kurtosis	Fisher's g1	Fisher's g2	Coefficient of Variation	Coefficient of Dispersio
Value	0.9081728	4.737498	0.9566875	2.296311	0.2705201	0.1887641
Std Error	0.3901371	1.210775			4.315811E-0	

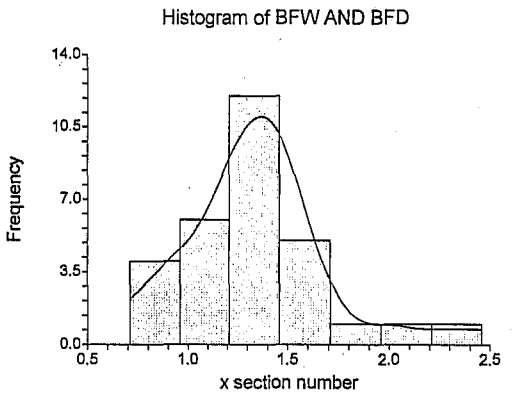
Descriptive Statistics Report

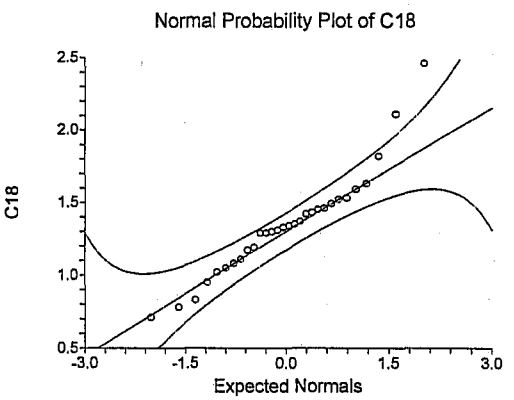
Normality Test Section of C18

Test Name	Test Value	Prob Level	10% Critica Value	5% Critical Value	Decision (5%)
Shapiro-Wilk W	0.932325	0.056623			Accept Normality
Anderson-Darling	0.635307	0.097709			Accept Normality
Martinez-Iglewicz	1.35583		1.148522	1.228175	Reject Normality
Kolmogorov-Smirnov	0.1399976		0.146	0.159	Accept Normality
D'Agostino Skewness	2.1733	0.029758	1.645	1.960	Reject Normality
D'Agostino Kurtosis	2.0711	0.038353	1.645	1.960	Reject Normality
D'Agostino Omnibus	9.0125	0.011040	4.605	5.991	Reject Norma

lity

Plots Section of C18





Summary Section of C19

		Standard	Standard			
Count	Mean	Deviation	Error	Minimum	Maximum	Range
30	0.8933333	0.2777289	5.070613E-0	0.35	1.45	1.1

Means Section of C19

			Geometric	Harmonic		
Parameter	Mean	Median	Mean	Mean	Sum	Mode
Value	0.8933333	0.93	0.8440675	0.786656	26.8	0.65
Std Error	5.070613E-0				1.521184	
95% LCL	0.7896277	0.71			23.68883	
95% UCL	0.997039	1.08			29.91117	
T-Value	17.6179					
Prob Level	0.000000					
Count	30		30	30		3

Skewness and Kurtosis Section of C19

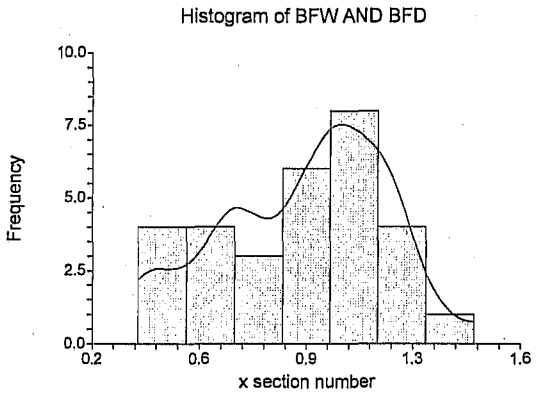
					Coefficient	Coefficient
Parameter	Skewness	Kurtosis	Fisher's g1	Fisher's g2	of Variation	of Dispersio
Value	-0.2899076	2.357449	-0.3053945	-0.5339326	0.3108906	0.2387097
Std Error	0.2947332	0.4058607			4.098602E-0	

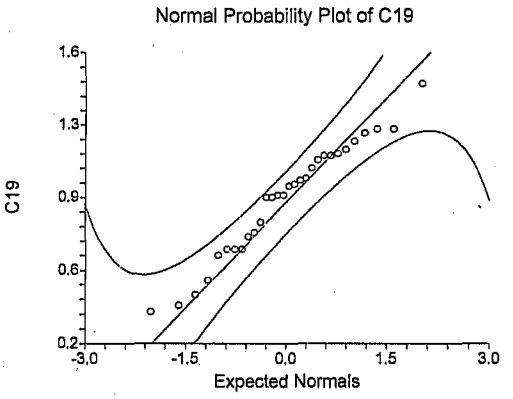
Normality Test Section of C19

	Test	Prob	10% Critica	5% Critical	Decision
Test Name	Value	Level	Value	Value	(5%)
Shapiro-Wilk W	0.9664851	0.447995			Accept Normality
Anderson-Darling	0.400608	0.361326			Accept Normality
Martinez-Iglewicz	0.9835051		1.148522	1.228175	Accept Normality
Kolmogorov-Smirnov	0.1095754		0.146	0.159	Accept Normality
D'Agostino Skewness	-0.7509	0.452708	1.645	1.960	Accept Normality
D'Agostino Kurtosis	-0.6018	0.547290	1.645	1.960	Accept Normality
D'Agostino Omnibus	0.9261	0.629375	4.605	5.991	Accept Norm

ality

Plots Section of C19





Descriptive Statistics Report for Bankfull Width on six reaches

Summary Section of Spring Park Reach 2

Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum
		Range			
30	1.7054	0.468569	8.554859E-02	1.085	3.038

Variation Section of Spring Park Reach 2

Parameter	Variance	Standard Deviation	Unbiased Std Dev	Std Error of Mean	Interquartile Range	Range
Value	0.2195569	0.468569	0.472625	8.554859E-0	0.54	1.953
Std Error	7.066669E-0	0.1066415		1.946999E-0		
95% LCL	0.139257	0.3731716		6.813149E-0		
95% UCL	0.3967795	0.6299044		0.1150043		

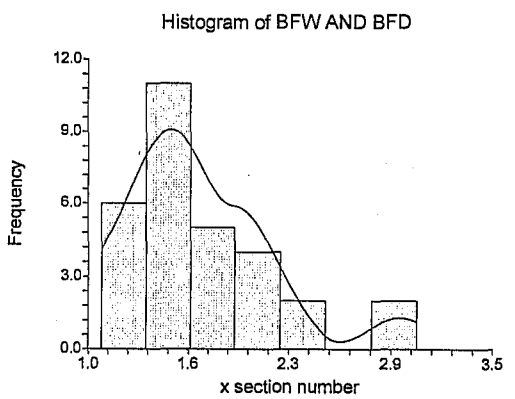
Skewness and Kurtosis Section of Spring Park Reach 2

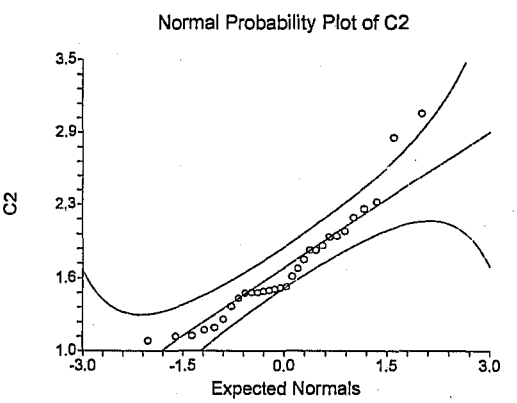
Parameter	Skewness	Kurtosis	Fisher's g1	Fisher's g2	Coefficient of Variation	Coefficient of Dispersio
Value	1.0824	4.107826	1.140222	1.547534	0.274756	0.2229126
Std Error	0.2943546	1.03212			3.745607E-0	

Normality Test Section of Spring Park Reach 2

Test Name	Test Value	Prob Level	10% Critical Value	5% Critical Value
Shapiro-Wilk W	0.909903	0.014797		
Anderson-Darling	0.7577834	0.048713		
Martinez-Iglewicz	1.282096	1.148522	1.228175	
Kolmogorov-Smirnov	0.1632558	0.146	0.159	
D'Agostino Skewness	2.5142	0.011929	1.645	1.960
D'Agostino Kurtosis	1.6414	0.100707	1.645	1.960
D'Agostino Omnibus	9.0157	0.011022	4.605	5.991

Plots Section of Spring Park Reach 2





Summary Section of Spring Park Reach 1

		Standard	Standard			
Count	Mean	Deviation	Error	Minimum	Maximum	Range
30	1.654333	0.34106	6.226876E-0	0.98	2.4	1.42

Skewness and Kurtosis Section of Spring Park Reach 1

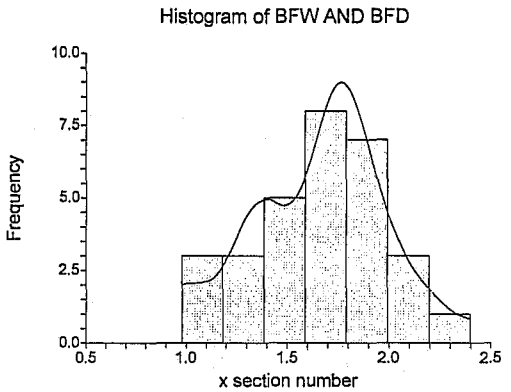
					Coefficient	Coefficient
Parameter	Skewness	Kurtosis	Fisher's g1	Fisher's g2	of Variation	of Dispersio
Value	-0.1651691	2.720826	-0.1739925	-0.1018214	0.2061616	0.1525194
Std Error	0.3110435	0.4648122			2.674205E-0	

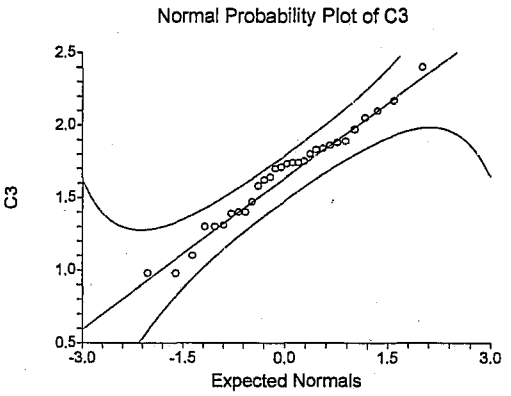
Descriptive Statistics Report

Normality Test Spring Park Reach 1

	Test	Prob	10% Critic	5% Critica	Decision
Test Name	**Value**	**Level**	**Value**	**Value**	**(5%)**
Shapiro-Wilk W	0.9765111	0.727166			Accept Normality
Anderson-Darling	0.3166765	0.539911			Accept Normality
Martinez-Iglewicz	1.006731		1.148522	1.228175	Accept Normality
Kolmogorov-Smirnov	8.659104E-		0.146	0.159	Accept Normality
D'Agostino Skewness	-0.4310	0.666499	1.645	1.960	Accept Normality
D'Agostino Kurtosis	0.0951	0.924235	1.645	1.960	Accept Normality
D'Agostino Omnibus	0.1948	0.907207	4.605	5.991	Accept Normality

Plots Section of Spring Park Reach 1





Descriptive Statistics Report

Summary Section of Bubbling Creek Reach 1 Bank Full Width

		Standard	Standard			
Count	Mean	Deviation	Error	Minimum	Maximum	Range
30	2.147	0.7381251	0.1347626	0.92	3.72	2.8

Means Section of Bubbling Creek Reach 1 Bank Full Width

			Geometric	Harmonic		
Parameter	Mean	Median	Mean	Mean	Sum	Mode
Value	2.147	2.05	2.019634	1.889678	64.41	1.62
Std Error	0.1347626				4.042878	
95% LCL	1.87138	1.62			56.14139	
95% UCL	2.422621	2.55			72.67861	
T-Value	15.9317					
Prob Level	0.000000					
Count	30		30	30		3

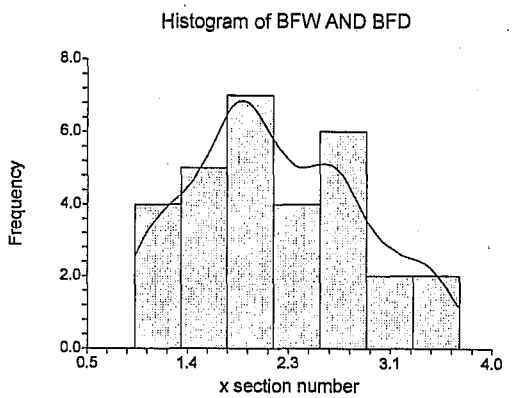
Variation Section of Bubbling Creek Reach 1 Bank Full Width

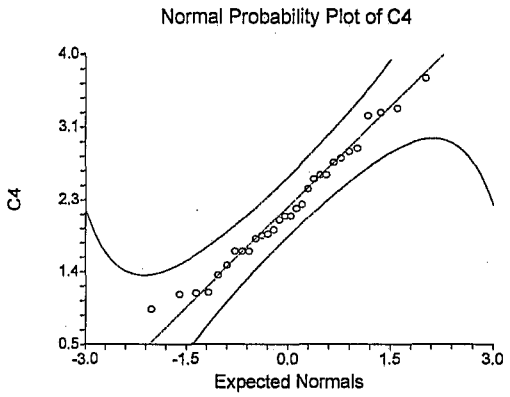
		Standard	Unbiased	Std Error	Interquartile	
Parameter	Variance	Deviation	Std Dev	of Mean	Range	Range
Value	0.5448286	0.7381251	0.7445145	0.1347626	1.0925	2.8
Std Error	0.1122541	0.1075368		1.963345E-0		
95% LCL	0.3455652	0.5878479		0.1073259		
95% UCL	0.9846052	0.9922727		0.1811634		

Skewness and Kurtosis Section of Bubbling Creek Reach 1 Bank Full Width

					Coefficient	Coefficient
Parameter	Skewness	Kurtosis	Fisher's g1	Fisher's g2	of Variation	of Dispersio
Value	0.2805066	2.27352	0.2954912	-0.633737	0.3437937	0.2912195
Std Error	0.260394	0.3761337			3.648205E-0	

Normality Test Section of Bubbling Creek Reach 1 Bank Full Width
Section of Bubbling Creek Reach 1 Bank Full Width





Descriptive Statistics Report

Summary Section of Stringer Creek Reach 1 Bankfull Width

Count	Mean	Standard Deviation	Standard Error	Minimum	Maximum
		Range			
30	2.981333	0.7946708	0.1450864	1.68	5.28

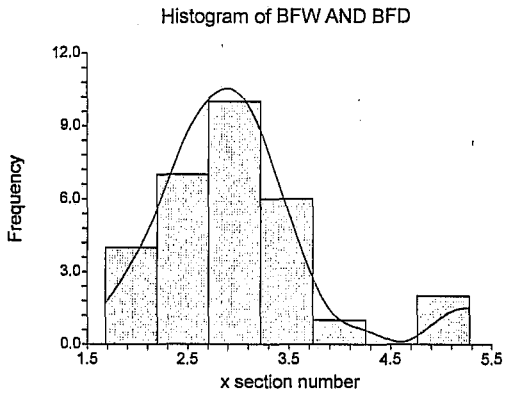
Means Section of Stringer Creek Reach 1 Bankfull Width

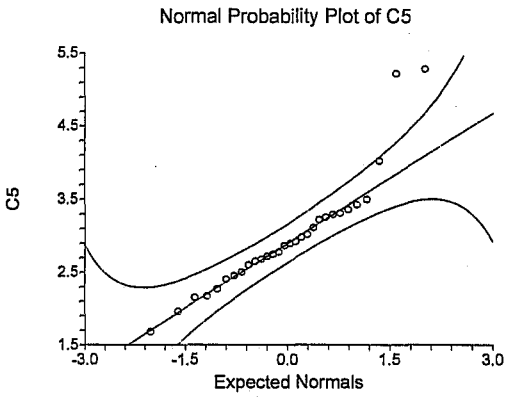
Parameter	Mean	Median	Geometric Mean	Harmonic Mean	Sum	Mode
Value	2.981333	2.885	2.891512	2.810112	89.44	
Std Error	0.1450864				4.352591	
95% LCL	2.684598	2.6			80.53795	
95% UCL	3.278068	3.22			98.34205	
T-Value	20.5487					
Prob Level	0.000000					
Count	30		30	30		

Skewness and Kurtosis Section of Stringer Creek Reach 1 Bankfull Width

Parameter	Skewness	Kurtosis	Fisher's g1	Fisher's g2	Coefficient of Variation	Coefficient of Dispersio
Value	1.363834	5.347613	1.43669	3.021831	0.2665488	0.186944
Std Error	0.2940508	1.696393			4.347729E-0	

Plots Section of Stringer Creek Reach 1 Bankfull Width





Summary Section of Sun Creek Reach 1 Bankfull Width

		Standard	Standard			
Count	Mean	Deviation	Error	Minimum	Maximum	Range
30	1.928	0.5353465	9.774045E-0	1.24	3.57	2.33

Means Section of Sun Creek Reach 1 Bankfull Width

			Geometric	Harmonic		
Parameter	Mean	Median	Mean	Mean	Sum	Mode
Value	1.928	1.89	1.86503	1.808801	57.84	
Std Error	9.774045E-0				2.932214	
95% LCL	1.728098	1.6			51.84295	
95% UCL	2.127902	2.03			63.83705	
T-Value	19.7257					
Prob Level	0.000000					
Count	30		30	30		

Variation Section of Sun Creek Reach 1 Bankfull Width

		Standard	Unbiased	Std Error	Interquartile	
Parameter	Variance	Deviation	Std Dev	of Mean	Range	Range
Value	0.2865959	0.5353465	0.5399806	9.774045E-0	0.52	2.33
Std Error	0.1046917	0.1382809		2.524652E-0		
95% LCL	0.1817774	0.4263537		7.784117E-0		
95% UCL	0.5179313	0.7196744		0.131394		

Skewness and Kurtosis Section of Sun Creek Reach 1 Bankfull Width

					Coefficient	Coefficient
Parameter	Skewness	Kurtosis	Fisher's g1	Fisher's g2	of Variation	of Dispersio
Value	1.295621	5.003185	1.364833	2.612253	0.2776693	0.1996473
Std Error	0.296906	1.423021			4.306469E-0	

Normality Test Section of Sun Creek Reach 1 Bankfull Width

	Test	Prob	10% Critic	5% Critica	Decision
Test Name	Value	Level	Value	Value	(5%)
Shapiro-Wilk W	0.8888993	0.004543			Reject Normality
Anderson-Darling	0.865706	0.026392			Reject Normality
Martinez-Iglewicz	1.379192		1.148522	1.228175	Reject Normality
Kolmogorov-Smirnov	0.1692875		0.146	0.159	Reject Normality
D'Agostino Skewness	2.8970	0.003767	1.645	1.960	Reject Normality
D'Agostino Kurtosis	2.2249	0.026089	1.645	1.960	Reject Normality
D'Agostino Omnibus	13.3429	0.001267	4.605	5.991	Reject Normal

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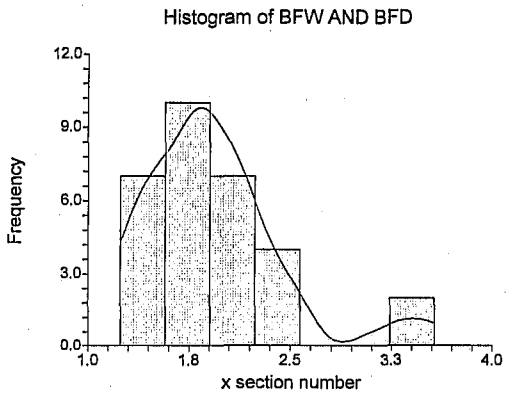
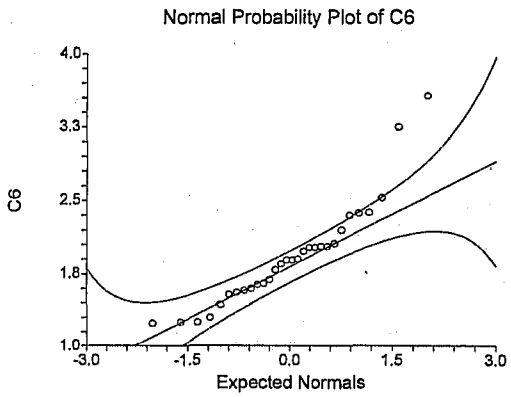
Plots Section of C6


Histogram of BFW AND BFD
Frequency
12.0
9.0
6.0
3.0
0.0
1.0
1.8
2.5
3.3
4.0
x section number


Normal Probability Plot of C6
C6
4.0
3.3
2.5
1.8
1.0
-3.0
-1.5
0.0
1.5
3.0
Expected Normals

Summary Section of Tenderfoot Creek Reach 1 Bankfull Width

		Standard	Standard			
Count	Mean	Deviation	Error	Minimum	Maximum	Range
30	1.489133	0.5367133	9.798999E-0	0.59	2.965	2.375

Means Section of Tenderfoot Creek Reach 1 Bankfull Width

			Geometric	Harmonic		
Parameter	Mean	Median	Mean	Mean	Sum	Mode
Value	1.489133	1.51	1.393867	1.296553	44.674	0.87
Std Error	9.798999E-0				2.9397	
95% LCL	1.288721	1.05			38.66164	
95% UCL	1.689545	1.76			50.68636	
T-Value	15.1968					
Prob Level	0.000000					
Count	30		30	30		2

Variation Section of Tenderfoot Creek Reach 1 Bankfull Width

	Interquartile	Standard	Unbiased	Std Error	
Parameter	Variance	Deviation	Std Dev	of Mean	Range
Value	0.2880611	0.5367133	0.5413592	9.798999E-02	0.774
Std Error	7.882596E-02	0.1038513		1.896057E-02	
95% LCL	0.1827068	0.4274422		7.803991E-02	
95% UCL	0.5205793	0.7215118		0.1317294	

Plots Section of C7