Aspen Planers Ltd.

THREE-YEAR (2000-2002) RESULTS OF CHANNEL MONITORING IN CHATAWAY CREEK

FINAL REPORT

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SUMMARY

Two channel monitoring stations – upstream and downstream – were installed in Chataway Creek in September 2000 and re-surveyed in 2001 and 2003. Sediment input to Chataway Creek was also surveyed each year.

The overall objective of the monitoring program is to identify changes in channel morphology related to proposed and ongoing forest development.

After three years of measurements, generally, both the Upper and Lower channel stations remained relatively stable throughout the monitoring program. Data collected suggests the channel may have been slightly scoured over the course of the study, however; the observed channel changes are likely within the error range of the methods used.

No forest development occurred during the project period, although the deactivation of a portion of the Chataway FSR occurred immediately above the Lower station. Therefore, the results of this three-year monitoring program can serve as baseline data for the watershed. Following any large-scale watershed disturbance, a re-survey of the monitoring stations can allow quantitative comparison of channel conditions following disturbance. Based on the current forest development plan, a suitable time frame for re-survey would be in the summer of either 2005 or 2006 when the ECA will double to over 35% at the Upper station and at the Lower station, the ECA will increase by 5% to 26%. Another disturbance type to re-survey is the summer after an unusually larger freshet when channel change is expected. Therefore, it is recommended to retain survey pins at the channel stations to be re-used in future surveys.

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1.0 Introduction

Chataway Creek is a small watershed that drains approximately 38 km^2 of the Thomson Plateau. The watershed has been developed for several purposes, including forestry, range and recreation. In 2000, approximately 640ha or 16.8% of the watershed was developed. At that time, it was anticipated that by 2002 Aspen Planers Ltd. would develop an additional 65ha or about 3% of the watershed area.

To evaluate the impact of forest development on channels, Aspen Planers Ltd. initiated a three-year channel monitoring program for Chataway Creek in 2000. This report summarizes results over the three years at two stations, a Lower and Upper (see Map).

The overall objective of the monitoring program is to identify changes in channel morphology related to proposed and ongoing forest development. A possible outcome of the monitoring program is to develop a bed-material sediment routing model of the drainage network and associate changes in channel morphology to sediment sources on the hillslope. These results may then be used in association with forest development and hydrologic indicators such as equivalent clearcut area (ECA) levels.

The specific objectives of the program are to:

1. Determine base-line channel conditions and characteristics (as they exist prior to any additional development in the watershed);
2. Determine if channel morphology has changed following forest development and/or restoration works;
3. Link any changes in channel morphology to specific areas of the watershed and to management activities (where appropriate); and,
4. Direct mitigative and/or restoration activities to specific areas of the watershed (if required).

In terms of RISC (formerly RIC) classifications, project monitoring type of this study falls under *Impact Assessment Monitoring*. In this case, baseline data is the first year data (2000) to which subsequent years of data (2001 and 2002) are compared. In addition, the Lower and Upper stations can be compared.

1.1 Previous Work

Annual interim reports (Henderson 2001, 2002) provide background information pertaining to watershed characteristics, and theoretical impacts of changes in hydrology and sediment transfer on channel stability.

Data collection involves surveys of sediment sources from roads and slopes, cross-sections of channels, surface sediment, and detailed channel mapping. The surveys are repeated annually at low flow when channel characteristics are visible.

1.2 ECA Update

The watershed area draining to the Upper and Lower monitoring stations are outlined on the map. Lakes in the Upper west portion of the watershed and Chataway Lake in the Lower east area of the watershed are a moderating influence to both peak flows and sediment transport (factors that directly affect channel conditions). The result is an 'effective' contributing drainage area below the lakes to the two channel stations. The effective area is applied in this study to isolate the watershed area that will possibly impact channel morphology above stations.

At project start, the ECA was projected to increase by close to three per cent at the Lower station and nearly five per cent at the Upper station (Henderson 2001). However, due to attention directed to beetle-salvage logging in other watersheds, no harvesting occurred in Chataway Creek over the project period. Therefore, the ECA actually dropped by about 0.8% from 19.5% in 2000 to 18.7% in 2002 in the Lower drainage area due to hydrologic recovery at older openings (Table 1). In the Upper drainage, there was no change in the ECA, constant at 12.8% between 2000 and 2002.

Table 1

Chataway Creek 'Effective' ECA

Channel Station	Area	2000		2001		2002	
		ha	%	ha	%	ha	%
Lower	1922	374.4	19.5	374.4	19.5	360.23	18.7
Upper	697.5	89.2	12.8	89.2	12.8	89.2	12.8

1.3 Monitoring Status Update

This report summarizes results from three sediment source surveys, three data sets of channel geometry and surface sediment texture data, and two sets of sediment transport (note that sediment transport calculations require a survey before and after each freshet). Budget restraints prevented discharge calculations between years.

A qualitative and quantitative comparison of channel characteristics between 2000 and 2002 is presented in this report. A complete data summary, including planimetric maps and surveyed cross sections, is presented in the appendices.

Because there was no harvesting over the project period, the monitoring status has changed from *Impact Assessment* to *Baseline.*

2.0 METHODS

2.1 Sediment Survey

Sediment sources previously identified in a 1998 watershed report (Henderson 1998) were re-measured in October 2000, after the channel stations were installed. Any new sediment sources were identified and measured annually in surveys of roads and slopes in 2001 and 2002.

Sediment entering streams to either channel station were quantified by estimating the proportion of delivered sediment from the road surface and ditch, fillslope and cutbank. The volume of sediment entering streams in m^3 is multiplied by a factor of 1.6 tonnes/m^3 (bulk density) to produce sediment yield in tonnes. Proportions of bedload (>0.5mm diameter, i.e. coarse sand and larger), and suspended load (<0.5mm diameter, i.e. fine sand, silt and clay) was determined in a sample of eroded material by sieving by Griffin Laboratories Corporation, Kelowna.

2.2 Channel Stations

2.2.1 Channel survey

Each monitoring station consisted of seven surveyed cross sections spaced approximately one bankfull width apart. Each cross section was oriented perpendicular to the channel banks and fixed at each end by a permanent survey hub. The elevation of each survey hub was re-established in 2001 and 2002 relative to one of two benchmarks located at the site. Bed elevation was determined along the cross section with a Total Station.

A longitudinal profile was surveyed at each site to determine the length and relief of individual channel units (e.g., pool, riffles, and steps). Profiles were surveyed with a Total Station and established relative to the benchmarks. Thalweg and water elevations were measured at set intervals of one bankfull width along the channel. This approach enables objective analyses of channel characteristics. Other morphological features (e.g., breaks separating riffles and pools) were added as supplementary survey points. These were identified in the field by their topographical, sedimentological and hydraulic characteristics as defined by Keller and Melhorn (1973) and Sullivan (1986).

Surface sediment texture was determined by measuring the b-axis diameter of 300 stones distributed throughout each monitoring station. Relatively large blocks dropped from adjacent banks (lag material) were not included in the measurements.

2.3 Quality assurance and Quality Control

Key personnel are registered professionals in British Columbia, experienced and trained in the procedures selected for the project.

The sediment survey follows a procedure used in other parts of Interior BC (see Jordan and Commandeur 1998). Sediment hand texture estimates of eroded material were compared with lab results.

In the channel surveys, data accuracy was controlled by ensuring the survey was closed (closure errors were ± 0.016 and ± 0.018 m for Chataway Upper and Chataway Lower, respectively). Standard survey procedures were followed. Check points were used to quality control the planimetric mapping (check point root mean square errors were ± 0.033 and ± 0.051 m in the XY direction for Chataway Lower and Chataway Upper, respectively).

Quality assurance was maintained by ensuring that cross sections were spaced approximately one bankfull width apart and that cross sections encompassed at least one pool-riffle-bar sequence. This ensures that both local variability in channel morphometry and the assumed virtual travel length of an average particle on the bed is captured.

3.0 RESULTS

This section describes the results obtained from the 2000, 2001 and 2002 monitoring seasons. Detailed data for existing and proposed forest development is in the Appendix. Figures 1 through 3 present data for channel stations.

3.1 Sediment Survey

In 2000, sediment entering channels quantified above the Lower hydrometric station was nearly 4 tonnes (Table 2). Almost all (3.7 tonnes) sediment originated from dispersed fillslope erosion at the Chataway FSR onto the floodplain or directly into the channel. Very small amounts of sediment were delivered to the stream network at crossings or sumps to the Upper station (~ 0.013 tonnes) or other sites in the Lower drainage area such as Roscoe Creek (refer to map in Henderson 2001 for sediment site locations). At the Chataway FSR, approximately half of the sediment transported to the channel is bedload size and half is suspended sediment

A review of the watershed in the spring (2001) indicated that erosion conditions in 2001 remained relatively unchanged from 2000.

Between 2001 and 2002, a portion of the Chataway FSR adjacent to Chataway Creek was deactivated (re-contoured) and re-located away from the creek. The deactivation effectively stopped sediment delivery to Chataway Creek, which previously accounted for most of the total sediment. Also, there was no sediment input at a crossing to Roscoe Creek. However, there was increased sediment delivery to the Upper Station (1.9 tonnes; all suspended sediment caliber) at the crossing immediately upstream of the station and at a crossing on 45-3.

Fine sediment (<0.5mm diameter) entering the channel is readily transported through the stream system as suspended sediment. Bedload sediment transports much slower, depending on diameter of materials, bed morphology and stream power.

Table 2
Sediment Delivery to Chataway Creek
(Tonnes)

Station	Year	Bedload (>0.5mm)	Suspended Sediment (<0.5mm)	Total
Lower*	2000	1.8	2.1	3.9
	2001	1.8	2.1	3.9
	2002	-	1.9	1.9
Upper	2000	-	0.2	0.2
	2001	-	0.2	0.2
	2002	-	1.9	1.9

*Lower station data includes sediment delivered to both stations.

3.2 Channel Stations

3.2.1 Channel Geometry

Changes and variability in the measured cross sections are summarized in Table 3. On average, the upstream site has a narrower bankfull width, bankfull depth and bankfull cross sectional area than the downstream site. Figure 1 illustrates that at both the Upper and Lower sites, the channel width at any single cross section may vary anywhere between 0.1 and 1.4 m between surveys (the relatively large change of 1.4 m depended, in part, on colonization of a gravel bar with pioneering plant species). In a similar manner, Figure 2 illustrates that at some cross-sections bankfull depths changed less than 0.02 m between surveys, while at other cross sections bankfull depths changed as much as
0.15 m between surveys.

Table 3 also illustrates that on average the channel cross sectional area appears to have increased during the study. To test if the changes in the channel cross section were statistically significant, a paired t-test approach that paired cross sections together was used. In general, significant increases in the channel cross sectional area were observed at the Upper site between 2000 and 2001, but not between 2001 and 2002. At the Lower site, the cross sectional area increased significantly from 2000 to 2002. At the Lower site, bankfull width increased significantly from 2000 to 2001 while bankfull depth increased significantly between 2001 and 2002.

These statistical tests were based only on the variability between cross sections and do not account directly for all the errors associated with the measurement of the cross-section. As the bankfull cross sectional is in part determined by estimating the bankfull waterline, the data depends on the accuracy and repeatability with which the bankfull waterline can be surveyed. Determining the bankfull waterline can depend on the magnitude of recent flows as leaf lines and small woody debris are often used to help identify the bankfull waterline. The position of leaf lines and small woody debris may vary if floods of different magnitudes occurred between each survey. Thus, while the discussed changes in the cross-sectional geometries are statically significant, it is possible that a systematic increase or decrease in the position of the bankfull waterline could be driving the “statistically significant” changes in the cross sectional geometry.

Scour and Fill

Figure 3 illustrates the total volumetric change at each site and the net scour or fill that occurred at individual cross sections between surveys. At most about 0.2 m^3 of sediment was deposited at any single cross-section. This corresponds to an average increase of about 0.08 m across the bankfull channel. Likewise at most about 0.15 m^3 of sediment was deposited at any one cross section. This corresponds to approximately 0.06 m of bed scour. At the Lower Chataway site, the data suggests that some sediment was on average scoured from the upstream cross sections and potentially deposited in the downstream cross sections. At the Upper Chataway site there is no obvious spatial pattern of scour and fill between successive surveys. For the upstream site, the cumulative net scour and fill (2000/2001 and 2001/2002) was negative (scour) at all seven cross sections. Statistically, based on the scour and fill that occurred there was no significant scour or fill at either site (one sample t-test; null hypothesis scour/fill= 0, $p>0.1$) between successive surveys. Likewise there was no significant cumulative scour or fill at the downstream site.

While examining the scour and fill data it is important to consider the resolution of the surveys. It is estimated that the Total Station survey of bed topography may have a vertical resolution of approximately +/- 0.03 m. Considering this and an average channel width of about 2.5 m (Table 1), it is estimated that scour and fill along a cross section can at best be resolved to +/- 0.075 m^3. When this error is applied across the length of a survey (13-19 m) the total volumetric change is estimated to have a resolution of approximately +/- 1 m^3. This approximate error analysis suggests that at least some of the scour and fill observed at the cross-sections is simply error associated with the measurement of the cross sections. Furthermore, the net volumetric change observed at both sites is less than the resolution of the technique and may not have actually occurred. In summary, relatively small amounts of scour and fill may have occurred at the two sites, but overall channel changes were not documented.

Comparing scour and fill and changes in channel geometry

In general, if scour or fill is observed to occur at a cross section the change would be expected to effect the channel cross sectional geometry as well (i.e., net scour or fill at a cross section will alter the cross sectional geometry of the channel). Table 4 describes the results from analysis that tested whether or not the recorded scour or fill at each cross section coincided with an increase or decrease in the bankfull width, bankfull depth or cross sectional area. For for our analysis, localized scour at a cross section is expected to increase channel width, depth and area, while localized fill is expected to decrease these same variables. (Note that we assume localized scour will increase channel width as bank material is removed from a cross section, while fill will reduce channel width and depth as fresh deposits are colonized by riparian vegetation.)

For the Upper site between the 2000 and 2002 surveys the channel was scoured at every cross section and the bankfull depth, width and bankfull area all increased. At the Lower site between 2000 and 2002 a channel change of the same type (e.g., scouring/widening/deepening or deposition/narrowing/shallowing) occurred at five of seven cross-sections. Between individual survey years (i.e., 2000/2001 and 2001/2002) on average 56 % of the changes observed at a cross section between surveys were of the same type. This is surprisingly low[1] suggesting that between successive surveys there is little evidence that scour or fill at a cross sectional will cause a corresponding change in the bankfull geometry. This suggests there is no trend between changes in scour/fill and channel geometry.

4.0 Discussion

In general, the bankfull geometry data suggests that at both sites the stream channel may have become larger during the study. This was not generally supported by the scour and fill data. Cumulative net scour was only observed at the Upper site. The surface sediment grain size data suggests the channel may have been scoured between 2000 and 2001 as the sediment became coarser. In summary, while the data suggests the channel may have been slightly scoured over the course of the study, the observed channel changes are likely within the error range of the methods and should not be considered significant. In addition to variability introduced by the survey methods, detected channel changes likely represent the level of natural variability expected in a channel similar to Chataway Creek.

Bed material transport rates were estimated in the 2000/2001 monitoring season (Henderson 2002). Transport rates are relatively low in both reaches--1.5 tonnes/yr at Lower and 0.48 tonnes/yr at Upper--likely reflecting the generally low rates of bedload-sediment delivered to the stream.

Given the relative volume of sediment yield to the stream and the capacity of the channel to transport sediment, the channel can be considered “supply limited”. In years of relatively high flow (excess stream power) and low sediment yield to the stream, the channel can be expected to scour the streambed and transport sediments within the size fractions shown in Figure A3-1 in Henderson (2002). The channel depth is expected to increase and surface sediments to coarsen. These conditions were observed to some extent at both monitoring stations.

Table 5 illustrates that the surface sediment at both sites coarsened from 2000 to 2001. (No data for 2002). The D_{50} increased from 57 to 66 mm at the Upper site and 64.5 to 90 mm at the Lower site. The D_{84} and D_{95} also increased between surveys. At both sites a couple of percent of all stones were boulders while most of the bed is covered with approximately equal amounts of gravel and cobble. The grain size data also indicates that the Lower monitoring site is coarser than the Upper monitoring site.

5.0 Conclusions

The overall objective of the monitoring program was to identify changes in channel morphology related to proposed and ongoing forest development that might in turn degrade channel conditions. Generally, both the Upper and Lower channel stations remained relatively stable throughout the monitoring program. Data collected suggests

[1] If scour/fill and bankfull geometry are independent of each other, the probability of both variables changing in the same manner is 50%

the channel may have been slightly scoured over the course of the study, however; the observed channel changes are likely within the error range of the methods used to document the channel.

The results of this three-year monitoring program can serve as baseline data for the watershed. Following any large-scale watershed disturbance, a re-survey of the monitoring stations can allow quantitative comparison of channel conditions following disturbance. Based on the current forest development plan, a suitable time frame for re-survey would be in the summer of either 2005 or 2006 when the ECA will double to over 35% at the Upper station and at the Lower station, the ECA will increase by 5% to 26%. Another disturbance type to re-survey channel conditions is the summer after an unusually larger freshet, when channel change is expected. Therefore, it is recommended to retain survey pins at the channel stations, to be re-used in future surveys.

Table 3. Cross sectional geometry of Upper and Lower Chataway Creek monitoring sites based on 2000, 2001 and 2002 surveys. The cross sectional geometry was described by the bankfull width (Wb), the bankfull depth (Db) and the bankfull cross sectional area (Ab). P values of paired t-tests that tested whether the cross sectional geometry changed significantly between surveys are also given. Bold values indicate a significant change in the cross sectional geometry at the p< 0.05 level.

Site	Wb (m)	Db (m)	Ab (m^2)	Paired t-test p value	Wb	Db	Ab
Lower 2000	2.71	0.39	1.04	Change 00-01	**0.012**	0.213	0.054
Lower 2001	3.13	0.43	1.34	Change 01-02	0.583	**0.038**	0.233
Lower 2002	3.24	0.48	1.53	Change 00-02	**0.042**	**0.006**	**0.01**
Average Lower	**3.02**	**0.43**	**1.30**				
Upper 2000	2.06	0.27	0.57	Change 00-01	**0.002**	**0.039**	**0.013**
Upper 2001	2.25	0.32	0.73	Change 01-02	0.942	0.751	0.742
Upper 2002	2.26	0.33	0.75	Change 00-02	**0.014**	**0.014**	**0.007**
Average Upper	**2.19**	**0.31**	**0.69**				

Table 4: Sign test examining if scour or fill was accompanied by an equal change in the cross sectional geometry. The cross sectional geometry was described by the bankfull width (Wb), the bankfull depth (Db) and the bankfull cross sectional area (Ab). A "1" implies that the changes observed at a cross section were of the same type (i.e. if scour was observed then the channel cross section geometry increased (Wb, Db or Ab increased). We assume localized scour will increase channel width as bank material is removed from the cross section, while fill will reduce channel width as fresh deposits are colonized by riparian vegetation.

					Lower Chataway				
	Change 2000 to 2001			Change 2001 to 2002			Change 2000 to 2002		
	Wb	Db	Ab	Wb	Db	Ab	Wb	Db	Ab
Xs 1				1		1			
Xs 2		1	1						
Xs 3					1	1	1	1	1
Xs 4	1	1	1		1		1	1	1
Xs 5	1		1	1	1	1	1	1	1
Xs 6	1	1	1	1	1	1	1	1	1
Xs 7	1	1	1	1	1	1	1	1	1
					Upper Chataway				
	Change 2000 to 2001			Change 2001 to 2002			Change 2000 to 2002		
	Wb	Db	Ab	Wb	Db	Ab	Wb	Db	Ab
Xs-1		1	1	1	1	1	1	1	1
Xs 1							1	1	1
Xs 2							1	1	1
Xs 3					1	1	1	1	1
Xs 4	1	1	1	1	1	1	1	1	1
Xs 5	1	1	1	1	1	1	1	1	1
Xs 6				1			1	1	1

Table 5. Surface grain sizes at Upper and Lower Chataway monitoring sites during 2000 and 2001. 300 stones were measured at each site (see Henderson 2002 for detailed results).

	Upper 2000	Upper 2001	Lower 2000	Lower 2001
D50 (mm)	57	66	65	90
D84 (mm)	114	120	137	173
D95 (mm)	165	196	235	240
Proportion of sediment in each class				
Boulder (≥256 mm)	0.01	0.03	0.04	0.03
Cobble (64-256 mm)	0.43	0.48	0.48	0.62
Gravel (< 64 mm)	0.55	0.49	0.48	0.35

6.0 REFERENCES

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Figure Captions

Figure 1: Cross-sectional channel change at Chataway Lower 2000-2002.

Figure 2: Cross-sectional channel change at Chataway Upper 2000-2002.

Figure 3: Scour and fill recorded along each cross section between survey years and cumulative scour and fill at each cross section from 2000 to 2002. The net volumetric change between surveys is also illustrated. See methods for details.

Appendix

ECA at Chataway Lower and Upper