Assignment 1

Measuring River Characteristics- Vernon Creek

Applied Fluvial Geomorphology Field Techniques
EESc 435

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Introduction

River morphology is a dynamic process that shapes the channel with several natural factors governing the physical processes and discharge of the stream. Channel width, boundary roughness size, concentration and sediment load, along with depth and slope are independent variables that govern hydraulic systems in natural streams (Moriwasa, 1985). The vegetation and rate of plant growth and stability of the channel are key variables for fish habitat and spawning. For this assignment we are measuring river characteristics of Vernon Creek, which is a naturally meandering system.

The portion of the Vernon Creek that we used for surveying is located in Lake Country, BC with geographic coordinates of: 50° 01’ 43.13” N & 119° 24’ 05.31” W with an elevation of roughly 420m as retrieved from Google Earth on May 1, 2012. It is segmented into Upper, Middle and Lower Vernon Creek before it enters into Woods Lake, which is connected by a small canal to Kalamalka Lake to the north. Vernon Creek is a major spawning ground for Kokanee salmon in the Woods Lake and meanders through residential, agricultural and industrial areas in the district of Lake Country. It is highly vegetated with bush, trees and grass along the banks and flows through culverts under roads. The field site is situated in Swalwell Park just before the culvert that passes south of Bottom Wood Lake Road. The headwaters of Vernon Creek are located eleven miles southeast of Vernon, at an elevation of 4,900 feet. The natural watershed of Vernon Creek is roughly 150 km² and is dependent on upland storage.
reservoirs that rely on snowpack for annual water regeneration (Ecoscape, 2010). The purpose of this assignment is to survey the river morphology, estimate water velocity, and measure bed grain size.

**Qualitative Site Assessment**

The section of Vernon Creek that we surveyed had a natural, healthy look to it with a nice buffer of riparian vegetation that provided shade to the creek bed. There were no fine gravel and bars overwhelming the channel with only a small amount of sediment being deposited across from the cut bank. There was no visible degradation or aggradation to the channel with little sand being deposited. The channel is narrow and meandering with a fairly flat bed which is not that deep, which indicates no degradation and it is not wide and shallow which would indicate little aggradation. The bottom of the creek was fairly flat with gravel and boulder-sized rocks ranging in diameter from 0.5 cm to 29 cm. The channel section where we surveyed was quite narrow and shallow with an average water depth being 0.3181 m. There were trees that had appeared to fall into the channel but much of the large woody debris had been removed, presumably by human intervention.

**Methods**

The methods used to survey river morphology of Vernon Creek in both the cross-sectional and long profile sections were to collect precise measurements of the creek using data collection instruments. The bed grain size, velocity of water, channel slope, channel and bankfull width and depth were collected in increments that provide information on channel stability, hydraulic modeling and the variables for fish habitat.

**Grain Size**

Within the one cross-section of the stream channel, fifty randomly chosen clasts were measured along the B-axis. In an Excel spreadsheet, the results were entered and sorted from smallest to largest. The 8th size sample =D16, the 25th size sample =D50 and the 42nd size sample =D84. The D50 size is used to determine the n value in the Manning’s equation for estimated discharge.
**Measured Discharge**

Discharge was measured and calculated from data in 10 equidistant intervals of firstly, the stream’s wetted channel width, secondly, the depth of each cell (at midpoint), and thirdly, the velocity at 0.6 the depth at the midpoint of each cell (using a revolution metre). In summary, width x depth x velocity equals measured discharge \((Q_m)\) for each cell, which is then summed to calculate the total measured Discharge.

**Estimated Discharge**

In order to estimate the discharge, the formula \(Q_{bf} = vA\) (velocity x area) is used.

Velocity (m/s) is estimated using the Manning’s equation: 

\[
v = \frac{R^{2/3}}{n} S^{1/2}
\]

The R value is found by using Area and Wetted Perimeter: 

\[R = \frac{A}{P}\]

Wetted perimeter \((P)\) is wetted distance of the river: 

\[P = w + 2d\]

The n value is found by using the \(D_{50}\) measurement: 

\[n = 0.04(D_{50})^{1/6}\]

Cross-section Area \((m^2)\) from measurements: 

\[A = \text{(width x depth)}\]

**Surveying the Section of Vernon Creek**

In order to obtain elevation data to create the cross-section and the long profile, an engineer’s level was used. First a back-sight was measured in order to calculate the height of instrument followed by surveying foresight measurements across the cross-section of the channel and bankfull level. The foresight measurements were also collected by surveying thalweg points in increments from downstream, around the meander to upstream to provide a long profile slope.
Results

Cross-Section

**Figure 2: plot of cross-section**

The cross-section of the Vernon Creek channel shows the wetted perimeter as a fairly flat bed with an abrupt upwards slope to the bank.

Long Profile

**Figure 3: Long profile slope of Vernon Creek**
The slope of the analyzed section of Vernon Creek was calculated to be 0.0068 and the D_{16}, D_{50}, and D_{84} grain sizes were calculated to be 4cm, 9cm, and 12cm respectively. The long profile is not a perfect slope but varied with a general slope trend.

The cross-section and long profile figures show that the width of the creek stays the same and the slope is quite small so the velocity, although highest in the centre of the channel, does not normally go fast. This would probably mean that there is not much degradation or sediment transport downstream, as the stream bed is flat, not deep and narrow.

**Cross-Section Data Table:**

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<th>Station</th>
<th>Elevation (m)</th>
<th>Distance (m)</th>
<th>Rev. (R)</th>
<th>Rev./s</th>
<th>Channel Width (m)</th>
<th>Panel Width (m)</th>
<th>Channel Area (m²)</th>
<th>Channel Width (m)</th>
<th>Bankfull Depth (m)</th>
<th>Bankfull Velocity (m²/s)</th>
<th>Avg. Discharge (m³/s)</th>
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**Table 1:** Cross-sectional data for Vernon Creek

Velocity formula to convert from revolutions: \( v = 0.9604R + 0.0312 \) (m/s)

- Depth average (D): 0.3181 m
- Area Total (A): 4.3341 m²
- Wetted Perimeter (P): 7.1362 m
- Hydraulic Radius (R): 0.60734 m
- Slope (S): 0.0068 m/m
- Manning’s n value (n): 0.02809
- Estimated Discharge (Qe): 4.278 m³/s

\( P = w + 2d \)

\( R = \frac{A}{P} \)

\( n = 0.04 \left( D_{50} \right)^{1/6} \)
Long Profile Data Table:

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Table 2: Long profile survey data table

Average depth in the long profile: 1.135 m
Total area: 6.244 m²
Total width: 5.50 m
Wetted Perimeter (P): 7.771 m
Revolutions (R): 0.8035 rev
Slope (S): 0.0068 m/m
n value: 0.028092
Velocity average (v): 2.537153 m/s
Bankfull Discharge (Q₉₅₅): 15.84262 m³/s
Shear Stress (τ): 53.5499 τ = γRS
Specific Stream Power (ω): 191.9549 ω = γQS / w
Mobility Ratio (MR): 446.2492 MR = τ/D₅₀
Width-Depth Ratio (W/D): 4.844457
Measured Discharge (Qm): 4.052 m³/s
Estimated Discharge (Qe): 4.278 m³/s

Discussion

Measured vs. Estimated Discharge

The measured discharge from our work in the creek gave a result of 4.052 m³/s, whereas the estimated discharge using Manning’s equation was 4.278 m³/s. Although the estimated discharge is a little higher (0.226 m³/s), it is very close. The variables in the Manning’s equation, R (hydraulic radius), S (slope) and n value, are dependent on accuracy in measurements of area, wetted perimeter (width, depth), slope and 50th
percentile of grain size. The measured discharge, on the other hand, relies on wetted width, depth and velocity. There is room for error in using survey equipment and variances in measurements could have influenced the difference between measured and estimated discharge. This exercise, though, proves that the Manning’s equation is quite reliable in estimated discharge and would be a useful tool.

Bankfull discharge was measured to be 15.84 m$^3$/s, which seems somewhat high during peak flows, as it is almost four times (3.91 times) the discharge measured on the day we surveyed the site. It would be interesting to return to the site during peak flows in order to compare bankfull discharge rates with measurements then. Error in bankfull discharge may have occurred due to estimating the level of bankfull depth too high, when we relied on the vegetation and trees on the bank to indicate an appropriate level.

The flow of the creek is probably usually not a fast-flowing river with no waterfalls, very little to no hydraulic jumps yet some pools and riffles helpful for spawning of local Kokanee salmon. The specific stream power takes into account the specific weight of water at 9800 N/m$^3$ and calculated to be 191.95 which is significant power for a creek.

In a broader perspective, there are a couple of stormwater detention ponds that flow into Vernon Creek, one just downstream of Beaver Lake Road and another near Swalwell Park where our analysis site was. The ponds keep out sand. The Middle Vernon Creek (MVC) area of our analysis is rich kokanee spawning habitat throughout its length. Unfortunately, the big challenge is that in recent years, flow stops in MVC by July and efforts are made to have sufficient water for spawning in the fall (Neumann, 2012).

The shape of the long profile is of a narrow meandering stream with a slight downward slope. It is a meandering river with no waterfalls or rapids situated in an urban and agricultural setting. Areas of deposition or erosion in the profile would be expected on the inside of the curves in the profile. The long profile and slope may inform changes in the channel pattern as a result of gradual or steep elevation.
differences which would increase velocity, erosion and sediment movement. The channel pattern changes when the long profile and slope change. The Okanagan Valley and, specifically the Lake country area, is a basin with water heavily reliant on snow melt and to a lesser extent, groundwater recharge. The river valley is not very narrow, resulting in numerous lakes on a former glacier bed that has a high percentage of sand. The specific stream power was probably higher than usual due to the timing of spring season snow melt, which will decrease through the summer dry periods. It would be important to control water extraction from the creek so that Kokanee salmon can successfully spawn in the creek and the salmon fry have enough water and grain size to support their development. Homes, agricultural land with irrigation needs and the urban setting of the Vernon Creek require monitoring for appropriate quality and quantity of water.

**Conclusion**

The Vernon Creek situated in the district of Lake Country, BC, is a meandering river through an urban, residential and agricultural setting. The creek bed and riparian zone were observed as natural and healthy. The measured discharge rate from survey results was very close to the estimated discharge rate using Manning’s equation concluding that Manning’s equation is a reliable tool in determining discharge rates of rivers and creeks.
References

