Memo

To: Dustin Poppendieck

From: Andrew Spinardi

Date: 3/12/10

Re: Fern Lake water flow measurements from 2/25

Introduction

This week's lab was spent at Fern Lake measuring water flow. Josh Alexander, Valerie Budig-Markin and myself measured the water flow coming into and leaving Fern Lake. By measuring these flows, as well as taking into account rainfall and water being taken by the fish hatchery, we should be able to determine if Fern Lake is in steady state or not.

Materials and Methods

We used several methods to determine the flow amounts. At the top of Fern lake where the water enters, we used a FP101 flow probe (flow meter) and the ping pong ball method to determine flow. The flow meter measures the rate of the water in decimeters per second. By measuring the area of water where we used our flow meter, and multiplying that by the rate of the water (and doing all the proper unit conversions,) we are able to find flow rate in cubic meters per day. The ping pong ball method was similar. By finding the volume of a certain stretch of water, and then dividing that by how long it takes a ping pong ball to flow down this stretch, (and doing the proper unit conversions) we found flow in cubic meters per day.

For the outflow we used two different methods. For the first method, dubbed "The Bucket Scoop," we found a place in the creek below the overflow ramp where the water funneled into a narrow decline. We then situated the bucket at the bottom of the decline in a place where it seemed it would collect most of the water. Then we recorded how long it would take the water to fill the bucket to the point where it wasn't rushing in. That allowed us to calculate the volume per unit of time. For the second method, two of us tried to divert as much of the water from the bottom of the spillway into a bucket, while the third person used a stopwatch to tell us when 30 seconds had passed. Then, assuming the bucket was a perfect cylinder, we multiplied the surface area of the water in the bucket by the depth, which gave us volume. Then dividing this by time, (and converting units again) we can find flow in cubic meters per day.

Results

Method	Volume(m^3)	**Time (seconds)**	Flow (m^3/day)
Ping Pong Ball	0.0192	6.79	244.3
	Area (m^2)	**Rate (m/s)**	
Flow Meter	0.0101	0.25	218.2
	Area (m^2)	**Rate (cm/day)**	
Rainfall	2766.27	0.2	0.00055
		Total Inflow	**231.23**

Outflow			
Method	**Volume(cm^3)**	**Time (seconds)**	Flow (m^3/day)
Overflow Ramp	2127.12	30	6.13
"Bucket Scoop"	859.0	6.88	10.79
Fish Hatchery			50
		Total Outflow	**58.46**
Net Daily Water Budget	172.78 (m^3/day)		

Table 1: Results from measurements

	Width (m)	Volume(m ³)	Flow (m ³/day)
Ping Pong (orig)	=.==	=.===	===.==
Ping Pong (modified)	=.==	=.===	===.==
Flow Meter			===.==
Original Net Daily Water Budget			===.==
Modified Net Daily Water Budget			157 .54

Table =: Modified results

Discussion

The two methods used at the top of Fern Lake gave us two different, but fairly close measurements. Table 2 shows how if the width of the volume of water we measured during the ping pong trial was shortened by 3 centimeters, then the flow rates of the two methods would be less than a cubic meter in difference. It could be possible that the volume of water we measured did not have an even rate of flow throughout it. This makes sense, since the water around the shallow edges of the stream probably does not flow as fast as the water in the deeper center part of the stream. This may possibly explain why our modified measurement is more accurate when compared to our flow meter measurement. By taking 1.5 cm off each side of the stream, we may be closer to what the actual volume of water is at that rate.

The measurements we got for the outflow of Fern Lake were much smaller than the inflow. Even when the water taken for the Fish Hatchery is taken into account. This is understandable, as the methods we used to measure the water flow at the bottom of Fern Lake were not as accurate as the methods we used at the top. When we were trying to fill the bucket at the bottom of the spillway, there were large amounts of water spilling off the clipboards, as well as water going off other parts of the spillway we weren't able to divert into the bucket. If we take this water into account as well as any water that seeped through cracks in the ramp, and assume this water triples our original measurements, our outflow (averaged with the bucket scoop) would go from $58.46m^3$/day to $64.58m^3$/day, and our net daily water budget would lower from $172.78m^3$/day to $166.65m^3$/day.

Even with the inaccuracies in our measurements, it is still likely that we'd be looking at a net daily water budget of at least $150m^3$/day. Which is only 12% lower than what our original measurements told us our water budget would be. $150m^3$/day is approximately a little larger than the computer lab in SCID15. So the volume of Fern Lake was changing by about that much on the day we took our measurements. That volume seems a little high to me. I think our measurements for the volume of water flowing out of Fern Lake were too low. It is possible that there was a large amount of water seeping out through the ground in Fern Lake that could not be measured by the methods available to us. If we were to measure the outflow more accurately I think the net daily water budget for that day would have been less than $50m^3$/day.

Conclusion

This Lab was a good exercise in visualizing how to take measurements of things that you can't measure directly with a tool. Being able to manipulate the data in a spreadsheet was useful in seeing how the smallest change in a measurement can have a big impact on the final result. Our measurements show that our daily water budget for that day was $172.78m^3$/day. A large number that possibly reflects the limitations of measurable water flow.

Appendices

Inflow — Creek In

	depth(cm)	depth(m)	width(cm)	width(m)	Length (cm)	length(m)	Area (m^2)	Volume (m^3)	Time (sec)	Time (/day)	Flow rate (dm/s)	Flow (m/s)	Flow (m^3/day)		Average Flow (m^3/day)
Trial 1 (flow meter)	6.00	0.06			12.00	0.12	0.0072				2.60	0.26	161.74		
trial 2 (flow meter)	10.00	0.10			13.00	0.13	0.0130				2.40	0.24	269.57		215.65
avg.		0.08			12.50		0.01					0.25			**218.16**
	depth(cm)	depth(m)	width(cm)	width(m)	Length (cm)	length(m)	volume (cm^3)	Volume (m^3)	Time (sec)	Time (/day)	Flow rate (dm/s)	Flow (m^3/s)	Flow (m^3/day)		
trial 3 (ping pong	3.86	0.04	27.20	0.27	183.00	1.83	19199.31	0.019	6.72	580608		0.00	246.85	Avg Flow (m^3/day)	230.56
trial 4 (ping pong)	3.86	0.04	27.20	0.27	183.00	1.83	19199.31	0.019	6.25	540000		0.00	265.41		
trial 5 (ping pong)	3.86	0.04	27.20	0.27	183.00	1.83	19199.31	0.019	7.40	639360		0.00	224.16		
														Average Flow (m^3/day)	245.47
trial average									6.79						

Total Flow Inn (m^3/day)	Fish Hatchery (m^3/day)	Total Flow Out (m^3/day)	Net Flow
230.57	50.00	6.13	174.44

	channel depth (cm)	width (cm)	length(cm)	volume (cm^3)	
	5.00	19.00	183.00	17385.00	0.0000174
	3.20	26.00	183.00	15225.60	0.0000152
	3.25	25.00	183.00	14868.75	0.0000149
	3.30	29.00	183.00	17513.10	0.0000175
	4.25	35.00	183.00	27221.25	0.0000272
	3.00	38.00	183.00	20862.00	0.0000209
	5.00	18.50	183.00	16927.50	0.0000169
avg.	3.86	27.21	183.00	19209.40	0.0000192

						rainfall (in)	(cm)	m
Surface Area	.68m/step					0.08	0.20	0.0000002
	length	width	area	area of triangle	total area (m^2)	amount rainfall (cm^3)	amount rainfall (m^3)	
	142.80	17.50	2499.00	267.27	2766.27	553.25	0.00055	

Outflow

bottom of overflow ramp

	time(s)	depth(cm)	radius(cm)	volume(cm^3)	flow(cm^3/s)	m^3/s	m^3/day
	30.00	4.00	12.50	1963.50	65.45	0.000065	5.65
	30.00	4.50	12.50	2208.93	73.63	0.000074	6.36
	30.00	4.50	12.50	2208.93	73.63	0.000074	6.36
average				2127.12			6.13

overflow (stream)

time(s)	depth(cm)	radius(cm)	volume(cm^3)	flow (cm^3/s)	m^3/s	m^3/day
6.88	1.75	12.50	859.03	124.86	0.00012	10.79