Conservation Name: _____
Fall 2011 Lab Day: Monday Wednesday

LABORATORY 6: PLU WATER BUDGET

Due next week in lab - October 24th or 26th

Purpose:

In recent years, the focus of resource management has been changing from conservation to sustainable use. The purpose of this lab is to calculate PLU's water budget and evaluate its sustainability. You will also assess a water budget using numerical and graphical methods.

The lab seeks to answer the following questions about visible and invisible water use. How much water do our basic daily activities use? How much water is available to PLU? Is our direct use of water sustainable? How much have renovations to buildings helped alter our water use? Are we sustainable in our use of off-site water that is used to provide us with goods?

Part I: Faucet Flow Rates and Personal Consumption

You will work with Ross Winters, PLU's plumber. Ross will help you measure the flow rate of various faucets in buildings on the PLU campus.

1. Measure the amount of time it takes to fill a ½ gallon container at 5 different faucets by following the steps below:
   - Time how long it takes to fill the large bowl to the top line with the faucet on fully. (If the larger bowl does not fit in the sink under the faucet, use the smaller bowl, fill it to the 4 cup mark, and multiply the time by 2 before entering it in the table). Make sure the faucet is fully open before putting the bowl under it to begin measuring.
   - In the table below, record the location of the faucets that you measured and the times for the three measurements for each faucet.

Table 1. Water flow rates of campus faucets

Faucet location	Test 1 (sec)	Test 2 (sec)	Test 3 (sec)	Average (sec)	Flow Rate (gal/min)
Rieke 109 lab sink					

- Determine the average of the three measurements for each faucet and fill in the table.
- You measured (in seconds) the length of time that it takes to fill your measuring container that holds ½ gallon. A far more common measurement of water flow is gallons per minute. Use the information you collected above to calculate flow rates in gallons per minute and fill in the table.

2. Why is the flow rate different at different faucets?

3. Determine your water usage by washing your hands each day:
   - The Health Department recommends that you wash your hands for the length of time that it takes you to sing the entire ABC song. Time how long it takes you to sing the ABC's. Your stopwatch will measure seconds – you will need to convert your time to minutes (divide by 60!). Enter it in the table below.

Table 2. Estimated water usage associated with hand-washing

	Time to sing ABC's (min)	**# Times per day**	**Flow rate* (gal/min)**	**Total water used per day (gals)**	**Total water used per year (gals)**	**Total water used per year (cubic feet)**
Faucet with lowest flow rate						
Faucet with highest flow rate						

* Use flow rates from Table 1

- Estimate the number of times that you wash your hands in a day, and record in table above.
- Calculate the total water you use each day (in gallons) for washing your hands at two faucets using the equation below. From Table 1, select the faucet with the highest flow rate and with the lowest flow rate. Enter your results in the table above.

4. As we examine the water usage on campus, we will do our calculations in hundreds of *cubic feet per year*.
   - Using information in the table above calculate how much water (in gallons) you would use in a year for washing your hands.
   - There are 7.48 gallons in a cubic foot. Calculate how much water (in cubic feet) you would use in a year for washing your hands.

5. What do these numbers suggest about the benefits to PLU of using foaming soap (rather than conventional soap)?

Part II: Water Availability and Use

In Table 3, PLU's monthly water availability is calculated using Botkin and Keller's evaporation rates (66% evaporates), and rule that only 50% of the remaining rainfall is available for human use.

Table 3: Monthly rainfall and available water on the PLU campus.

Month	Tacoma average rainfall, in	PLU water, acre-feet**	PLU rain, Hundreds of cubic feet	Available rainfall, hundreds of cubic feet
August	0.78	8.1	35347	**6009**
September	1.07	11.2	48604	**8263**
October	3.26	33.9	147788	**25124**
November	6.69	69.6	303522	**51599**
December	5.44	56.7	247108	**42008**
January	5.29	55.1	240070	**40812**
February	4.09	42.7	185904	**31604**
March	3.96	41.2	179661	**30542**
April	3.11	32.3	141000	**23970**
May	2.02	21.1	91896	**15622**
June	1.71	17.8	77413	**13160**
July	0.81	8.4	36618	**6225**
Total	38.07	396.6	1728575	**294,938**

***a unit defined by the amount of water it takes to cover one acre with a foot of water.*

6. What part of PLU's water budget does the total in Table 3 represent?

Table 4: Academic year water use 1998-99 through 2006-07 in hundreds of cubic feet.

Year	Irrigation	Residence Halls	Student Life	Academic	Fitness	Total
1998-99	8,024	30,956	12,658	9,962	6,398	**67, 998**
1999-00	7,721	30,010	12,697	7,399	5,915	**63,742**
2000-01	21,718	36,404	12,200	6,762	5,590	**82, 674**
2001-02	19,105	36,604	10,710	7,582	5,481	**79, 482**
2002-03	17,849	36,724	13,961	8,800	5,619	**82, 953**
2003-04	8,059	32,038	13,689	8,262	6,723	**68, 771**
2004-05	9,791	27,020	13,787	6,581	4,281	**61, 460**
2005-06	11,660	30,692	11,141	7,660	3,712	**64, 865**
2006-07	9,458	23,670	15,184	7,814	3,788	**59, 914**

7. Using Table 4, explain how the total water use has changed at PLU from 1998-99 through 2006-07? Use the individual categories to hypothesize two possible reasons for that change.

8. Using the 2006-07 data, order the different categories of water use from highest usage to lowest usage.

9. How does the total water use number for the year compare to the total water available shown in Table 3? On an annual basis, is PLU's direct consumption of water sustainable? Explain.

10. What is a likely cause for the fluctuations in irrigation water used over these 9 years?

11. Retrofitting of residence halls with low flow fixtures started in the summer of 2003. What has happened to residence hall water use since that time?

12. Propose two other possible ways to reduce residence hall water usage.

Table 5: Monthly water use in 2006-07 in hundreds of cubic feet.

	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	TOTAL
Academic	2,051	1,688	274	25	306	22	27	43	30	111	635	1,216	**6,429**
Residential	1,787	2,883	4,254	2,102	1,416	959	2,097	2,336	1,938	2,290	3,171	1,029	**26,262**
Student Life	836	1,024	1,266	868	900	671	1,507	1,171	405	303	345	376	**9,672**
Fitness***	1,094	1,289	920	480	499	282	429	529	519	601	619	648	**7,906**
Irrigation	763	454	369	199	251	129	252	244	209	252	276	601	**3,999**
TOTAL	**6,531**	**7,338**	**7,083**	**3,674**	**3,372**	**2,063**	**4,312**	**4,323**	**3,101**	**3,557**	**5,046**	**3,870**	**54,268**

***includes pool

13. Use Table 3 and Table 5 to determine if PLU's visible water use is sustainable for each month of the year.

- Is PLU's water use sustainable each month of the year? In which month(s) is water use more than available water?

- Is(are) there a pattern(s) throughout the year in usage and availability? If so, what natural phenomenon might help produce this pattern? What unnatural causes might produce this pattern?

14. Plot water use for each category in Table 6 on the graph paper provided.

Table 6: Percent water use by category for 2006-07.

	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL
Student Life	12.8	14.0	17.9	23.6	26.7	32.5	35.0	27.1	13.1	8.5	6.8	9.7
Residence Halls	27.4	39.3	60.1	57.2	42.0	46.5	48.6	54.0	62.5	64.4	62.8	26.6
Irrigation	31.4	23.0	3.9	0.7	9.1	1.1	0.6	1.0	1.0	3.1	12.6	31.4

15. What are the reasons for the seasonal water use patterns at PLU?

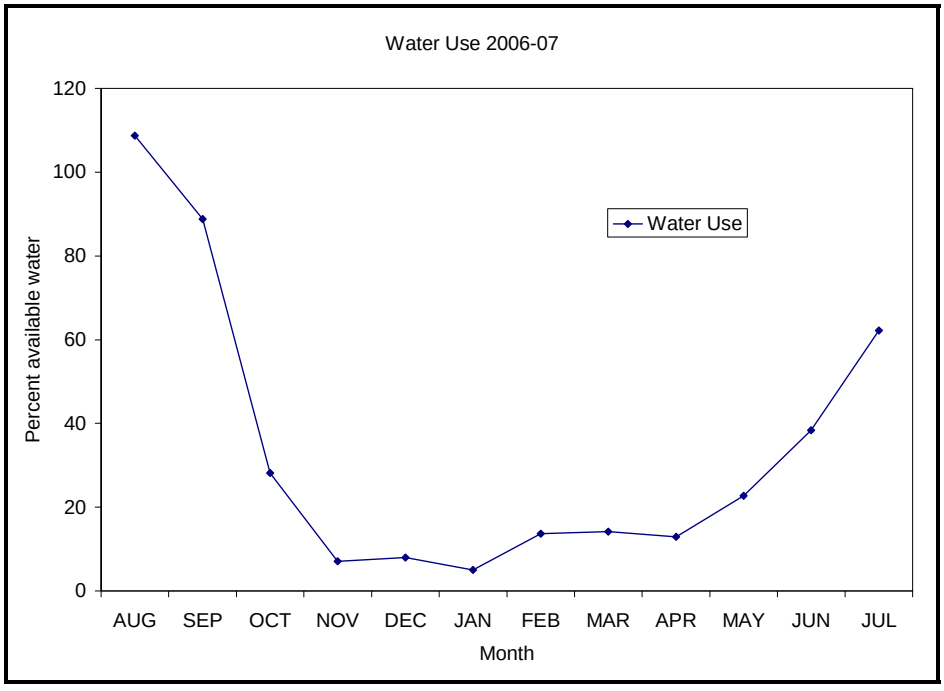

Figure 1. 2006-07 water usage at PLU.

16. On the graph above (Figure 1) add a line for 100% use across the graph.

17. What use causes PLU's use to exceed the available rainfall?

18. Do you think this purpose is important enough to justify unsustainable water use? Why or why not? (note: this question will be graded based on having and defending an opinion, not on any perceived 'correctness' of the opinion).

Part III: Renovations and Water Use

19. In Table 7, calculate the *percent change* in TOTAL water use in Stuen Hall. Show your calculation below.

Table 7: Stuen Hall water use, in hundreds of cubic feet, before and after summer 2003 renovation.

	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	TOTAL
2002/03-before renovation	274.9	403.3	226.7	206.7	176.8	71.8	180.3	216.4	135.3	210.8	31.5	36.4	**2170.9**
2003/04-after renovation	49.5	163.4	159.5	175.9	124.7	66.7	91.7	157.9	123.8	150.5	36.9	20.3	**1320.8**
Percent change	**-82**	**-59.5**	**-29.6**	**-14.9**	**-7.1**	**-49.1**	**-27**	**-8.5**	**-28.6**	**-28.6**	**17.1**	**-44.2**	

20. Have the Stuen renovations decreased water use each month? If not, in which months of the 2003-04 year does water use exceed the 2002-03 year water use? Hypothesize and explain a reason for the lack of reduction during some months.

21. If the **total** percent decrease experienced by Stuen Hall were applied to the total residence hall water usage in 2002-03 (see Table 4), how much water could PLU potentially save? Show your calculations.

Part IV: Paper and Water Use

A product that is used (and commonly wasted) on college campuses is paper. On average in 1995, US paper mills used 16,000 gallons (or 21.4 hundred cubic feet) of water per ton of paper produced (Bryant, 1995). Typical copy and printer paper used on the PLU campus is 20 pound paper; 40 cases (box that contains 10 reams or 5000 sheets of paper) weigh one ton.

22. In the library alone at PLU in 2003-2004 approximately 1280 reams of paper were used. How much water was required to produce this amount of paper? Remember to include your calculation and units!

23. Estimate how much copy and printer paper you use personally during one week (from class handouts, exams, finished work to turn in, paper that you throw away or recycle, etc – in your residence hall, at your house, or on campus). Report the value below.

24. If PLU has 3500 students who all use the same amount of paper per week as you do, calculate the amount of water that was used to produce the amount of paper used by all students for an entire year. Show your calculations.

25. What do the estimates and calculations in questions 22-24 indicate about the possibility of saving water by cutting back on paper usage at PLU?

26. Propose a water conservation idea that you think would be most promising and justify your proposal using information provided in this lab and in class.