KEY

G322 Geomorphology / Aerial Photography

Lab Exercise: Fluvial Hydrology of Luckiamute River (Fluvial Field Part 2)

c:\wou\fluvlab.wpd

Part I. Field-based hydraulic calculations.

Recall that we spent an afternoon collecting basic field data on the Luckiamute River at Helmick State Park. Our four teams were working on various geomorphic aspects of the Luckiamute River. Attached are the following results:

Channel Profile Data from Active Channel Table 1, Figure 1 (internet)

Valley Profile Data from Bridge Transect Table 2, Figure 2 (internet)

Slope and Manning's Roughness Estimates Table 3 — DATA ON FIG. 2

I have converted the profile depth measurements to elevation (m) and assembled the profiles as shown in Figure 1 and Figure 2. Refer back to the field trip lab hand-out for pertinent information, equations, etc.

$1 \, m^3 = 35.31 \, ft^3$

I-1. Referring to Figure 1 and Table 1, use the Continuity Equation to determine the discharge of the Luckiamute on the day of the field trip. Divide the channel flow into 5 sub-domains as shown on Fig. 1. Calculate the discharge for each domain and sum them to derive total discharge for the channel. **Give your answers in both m^3/sec and ft^3/sec.** The 10 x 10 transparency grid provided by the instructor can be used to determine the channel areas. SEE FIG. 1 TOTAL $Q = 3.24 \, m^3/s = 114.4 \, ft^3/sec$

$S = 0.00039$

I-1A. Using the data provided, calculate the total stream power and unit stream power for the Luckiamute on the day of the field trip. **Answer in watts and watts/m, respectively.**

TOTAL $\Omega = \gamma Q S = (9800 \, N/m^3)(3.24 \, m^3/s)(0.00039) = 12.4 \, W$ | UNIT $W = \Omega / w = 12.4 \, W / 20.5 \, m = 0.6 \, W/m$

I-1B. Using an average depth and velocity, calculate the Froude Number for the Luckiamute on the day of the field trip. Based on the Froude No., was the flow "tranquil", "critical", or "supercritical"?.

$Fr = \bar{V}/\sqrt{dg}$ $\bar{v} = 0.34 \, m/s$ $d = 0.47 \, m$ $Fr = (0.34 \, m/sec)/\sqrt{0.47 m \cdot 9.8 \, m/s^2} = 0.16$ = "TRANQUIL"

I-2. Referring to Figure 2, Table 2 and Table 3, use the Manning's Equation and Continuity Equation to determine the hypothetical discharge of the Luckiamute when the valley is flooded to the level of the bridge deck. Use the grid provided on Figure 2 to determine channel areas. **Give your answers in both m^3/sec and ft^3/sec.** SEE FIGURE 2

I-2A. Since we have estimated a range of roughness, we can bracket our velocity and discharge predictions. Calculate a "minimum" and "maximum" velocity and discharge, using the roughness range listed in Table 3.

$VEL_{min} = 0.64 \, m/sec$ $Q_{min} = 382.2 \, m^3/sec = 13{,}495 \, ft^3/s$

$VEL_{max} = 1.29 \, m/sec$ $Q_{max} = 770.5 \, m^3/sec = 27{,}206 \, ft^3/s$

I-2B. Using the data provided, calculate the hypothetical total stream power and unit stream power for the Luckiamute when it floods to bridge level. **Answer in watts and watts/m respectively.**

Minimum Power $= (9800 \, N/m^3)(382.2 \, m^3/sec)(0.00039) = 1460.8 \, W$ MAX Power $= (9800)(770.5)(0.00039) = 2945 \, W$

UNIT Power min $= 1461 \, W / 90 \, m = 16.2 \, W/m$

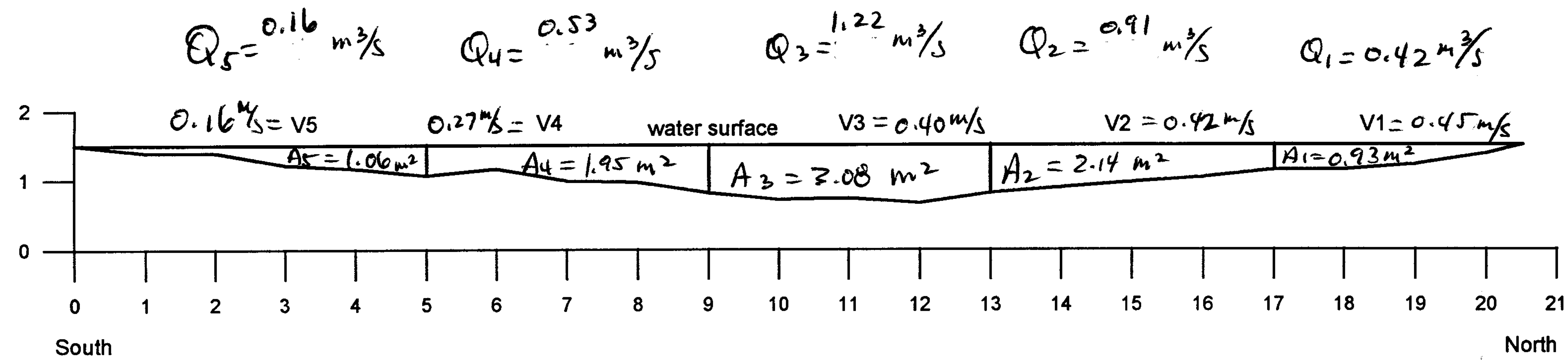
UNIT Power MAX $= 2945 \, W / 90 \, m = 32.7 \, W/m$

Part II. Historical Discharge Analysis / Recurrence Intervals.

As discussed during the field trip, the Luckiamute at Helmick State Park is gaged by the U.S. Geological Survey. Discharge data has been collected at the site since the 1940's. Table 4 is a summary of annual peak discharge data from the Luckiamute / Helmick gaging station. This data is also on-line in an Excel format at www.wou.edu/taylor .... follow the links to G322 and Luckiamute Gage Data. Download the data and save it to

TOTAL $Q = 3.24\ m^3/sec$

Figure 1. Luckiamute River Channel Profile
Helmick Road Bridge

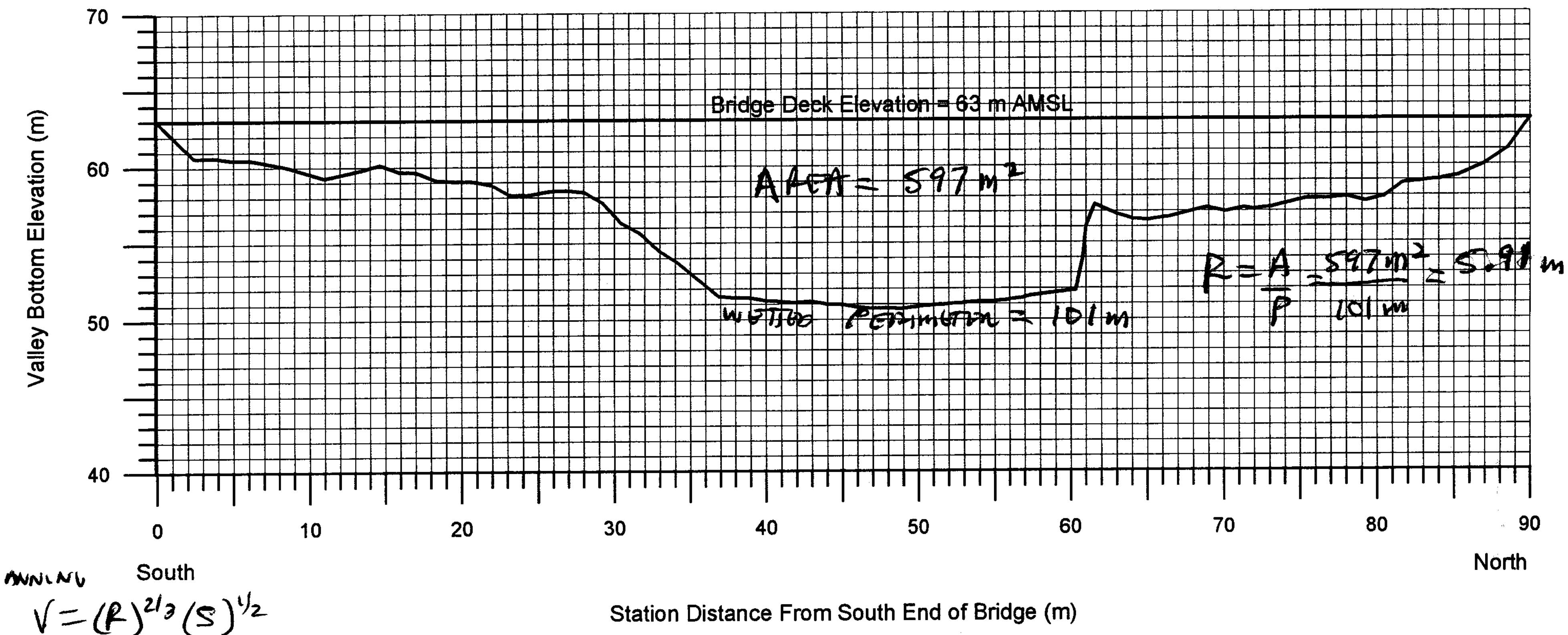


Vertical Scale: 1 in = 2.1 m
Horizontal Scale: 1 in = 2.1 m
Vertical Exaggeration = x 1

d:wou:geomorph:luckchxs.grf (d:wou:geomorph:luckchxs.dat)

Figure 2.

Profile Transect Across the Luckiamute River
Helmick Road Bridge at Helmick State Park



Vertical Scale: 1 in = 10 m
Horizontal Scale: 1 in = 10 m
Vertical Exaggeration = x 1

MANNING

$$V = \frac{(R)^{2/3}(S)^{1/2}}{n}$$

SLOPE = 0.00039

$n = 0.05 - 0.10$

$$V_{min} = \frac{(5.91\,m)^{2/3}(0.00039)^{1/2}}{0.10} = 0.64\ m/sec$$

$$V_{max} = \frac{(5.91\,m)^{2/3}(0.00039)^{1/2}}{0.05} = 1.29\ m/sec$$

$Q = AV$

$$Q_{min} = (597\,m^2)(0.64\ m/sec) = 382.2\ m^3/sec = 13{,}495\ ft^3/sec$$

$$Q_{max} = (597\,m^2)(1.29\ m/sec) = 770.5\ m^3/sec = 27{,}206\ ft^3/sec$$

d:wou:geomorph:luckprof.grf (d:wou:geomorph:luckxsec.dat) your local hard-drive or floppy disk. Then use Excel as needed to complete the following exercises.

Recurrence Interval and Gumbel Plots

The recurrence interval of a given flood discharge is commonly calculated from a set of historical data. The annual peak discharges for the Luckiamute gaging station are listed in Table 4. The "annual peak discharge" represents the maximum discharge recorded at the station for a given water year. Recurrence interval of annual peak discharge represents an estimation, based on the historical record, of the probability of a given flood discharge occurring over a given time period. For example, the "100 yr flood" is a flood-discharge magnitude that has a probability of occurring once every 100 yrs. Generally, the lower the magnitude of event, the statistically more frequent the chance of occurring, and vice-versa. Once the recurrence intervals for given discharges are calculated, the relations may be visually plotted on a Gumbel-type graph. This is more-or-less a semi-log graph relation (see the attached Gumbel graph paper).

Methods of Calculation

1. Once you've downloaded the discharge data from the internet, open the data set with Excel.

2. The data from the USGS are listed in ft^3/sec, set up a new data column entitled "Discharge m^3/sec"

SEE ATTACHED SHEET

A. Use Excel cell formula techniques to convert the discharge from ft^3/sec to m^3/sec (1 cu. m = 35.31 cu. ft) for each water year listed. ✓

2. Sort and rank the data using Excel in order from highest to lowest discharge.

a) highlight all of the data cells in Excel, but NOT the Column Titles (hint: highlight all column cells, otherwise you will mix the data).

b) Use Data-Sort, to sort the data in descending order by discharge, from highest to lowest.

c) Create a new data column, entitled "Rank - m", then numerically rank the discharges from highest to lowest; with highest being "1". ✓

SEE ATTACHED SHEET

(hint: you can do this by hand, or tell Excel to enter a string of numbers from 1 to ... n, this is done with Edit-Fill-Series-Columns-Increment = 1)

3. Create two other new columns entitled "Recurrence Interval yrs" and "Probability". Then calculate RI and P for each flood discharge by using the following formulas:

$R.I. = (n+1)/m \qquad p = 1/(R.I.)$ ✓

where R.I. = Recurrence Interval of a Given Discharge of Rank m
m = Rank of Discharge
n = total number of observations ✓
p = probability of occurrence
(1.0 = 100% chance of discharge occurring, 0.1 = 10% chance)

Try using Excel to calculate the R.I. and p for each discharge. Remember to set up cell equations, then copy and paste them to automatically calculate the numbers for each discharge. (hint: check your excel cell algebra with a

Luckiamute Gage Data: Unit Conversion, Recurrence Interval,

c:\wou\geomorph\luckiamute\anskey.xls

Water Year	Peak Discharge (ft3/sec)	Peak Discharge (m3/sec)	Rank	R.I. (yr)	Prob.
1965	32900	931.7	1	64.00	0.02
1972	31300	886.4	2	32.00	0.03
1995	24800	702.4	3	21.33	0.05
1949	23800	674.0	4	16.00	0.06
1981	23500	665.5	5	12.80	0.08
1907	22000	623.1	6	10.67	0.09
1947	20200	572.1	7	9.14	0.11
1911	19800	560.7	8	8.00	0.13
1978	19200	543.8	9	7.11	0.14
1910	19000	538.1	10	6.40	0.16
1974	18700	529.6	11	5.82	0.17
1909	18000	509.8	12	5.33	0.19
1976	16300	461.6	13	4.92	0.20
1908	16200	458.8	14	4.57	0.22
1956	16200	458.8	15	4.27	0.23
1961	16100	456.0	16	4.00	0.25
1953	14600	413.5	17	3.76	0.27
1943	14400	407.8	18	3.56	0.28
1982	14000	396.5	19	3.37	0.30
1971	13800	390.8	20	3.20	0.31
1966	13600	385.2	21	3.05	0.33
1948	13100	371.0	22	2.91	0.34
1964	12800	362.5	23	2.78	0.36
1996	12700	359.7	24	2.67	0.38
1987	12500	354.0	25	2.56	0.39
1988	12100	342.7	26	2.46	0.41
1946	12000	339.8	27	2.37	0.42
1951	10800	305.9	28	2.29	0.44
1958	10800	305.9	29	2.21	0.45
1967	10800	305.9	30	2.13	0.47
1986	10400	294.5	31	2.06	0.48
1970	10200	288.9	32	2.00	0.50
1993	9960	282.1	33	1.94	0.52
1983	9820	278.1	34	1.88	0.53
1980	9750	276.1	35	1.83	0.55
1973	9620	272.4	36	1.78	0.56
1954	9460	267.9	37	1.73	0.58
1952	9260	262.2	38	1.68	0.59
1968	9190	260.3	39	1.64	0.61
1950	9170	259.7	40	1.60	0.63
1960	9130	258.6	41	1.56	0.64
1994	9000	254.9	42	1.52	0.66
1990	8830	250.1	43	1.49	0.67
1962	8800	249.2	44	1.45	0.69
1963	8800	249.2	45	1.42	0.70
1945	8720	247.0	46	1.39	0.72
1959	8700	246.4	47	1.36	0.73
1969	8330	235.9	48	1.33	0.75
1906	8070	228.5	49	1.31	0.77
1942	8060	228.3	50	1.28	0.78
1984	7580	214.7	51	1.25	0.80
1985	7080	200.5	52	1.23	0.81
1975	7010	198.5	53	1.21	0.83
1957	6810	192.9	54	1.19	0.84
1955	6700	189.7	55	1.16	0.86
1941	6620	187.5	56	1.14	0.88
1997	5950	168.5	57	1.12	0.89
1979	5930	167.9	58	1.10	0.91
1944	5900	167.1	59	1.08	0.92
1989	5340	151.2	60	1.07	0.94
1992	5310	150.4	61	1.05	0.95
1991	5080	143.9	62	1.03	0.97
1977	3410	96.6	63	1.02	0.98

calculator to make sure you did it properly)

PRINT OUT YOUR COMPLETED DATA SHEETS! SEE ATTACHED SHEET

4. Using the attached graph paper, plot a Gumbel curve for the Luckiamute, with the recurrence interval on the log-interval x-axis, and discharge on the y-axis (choose an appropriate linear scale for the y-axis). ✓

5. On the same graph, create a Gumbel plot for the Smith River Watershed of the McKenzie basin. The R.I. and discharge data are presented in Table 5. ✓

Questions:

Based on your calculations of R.I., p, and the Gumbel Curve, answer the following:

II-A. Calculate a unit discharge for the highest and lowest peak discharge events observed in the record. The formula for unit discharge is:

LUCKIAMUTE
(1965) $Q_{p\,MAX}$ = 32,900 ft³/s = 931 m³/s A_d = 240 mi² = 622 km²
UNIT Q = (32,900 ft³/s)/(240 mi²) = 137 ft³/s/mi² = 1.5 m³/s/km²

Unit Q = Qp/A

(1977) $Q_{p\,MIN}$ = 3410 ft³/sec ; UNIT Q = (3410 ft³/sec)/(240 mi²) = 14.2 ft³/sec/mi² = 0.16 m³/s/km²

where Qp = peak discharge, and A = drainage area above the gage station (see header on Table 4)

Make sure you get all units in the proper metric format... thus Unit Q = m³/sec/km² ✓

II-B. What was the unit discharge on the day of our field trip to Helmick?(show your work)

Q = 3.24 m³/s ; Q_{UNIT} = (3.24 m³/sec)/(622 km²) = 5.2×10⁻³ m³/sec/km² = 0.48 ft³/sec/mi²

II-C. Calculate the unit discharge for our hypothetical "flood-the-bridge" event.(show your work)

Q_{MIN} = 383 m³/sec Q_{MAX} = 771 m³/sec Q_{UNIT} RANGE: 0.62 – 1.24 m³/sec/km² = 56 – 113 ft³/sec/mi²

II-D. What is the recurrence interval of the spot discharge that we calculated on the day of the field trip. What is it's probability of occurrence? (hint: use Gumbel curve plot). (OFF SCALE)

Q = 3.24 m³/sec = 114 ft³/sec R.I. < 1.01 YR PROBABILITY ≥ 0.99

II-E. What is the recurrence interval of the hypothetical "flood-the-bridge" discharge that we calculated in Part 1? Use the conservative low-end discharge that we estimated. (hint: use the Gumbel plot to predict the R.I. ... if the hypothetical discharge is off the scale, project the curve to make an approximation of the R.I.).

Q_{MIN} = 13,495 ft³/sec R.I. = 2.92 YRS PROB. = 0.34
{ Q_{MAX} = 27,206 ft³/sec R.I. = 23.5 YR · PROB. = 0.04

According to our calculations, what is the probability of occurrence of our hypothetical "flood-the-bridge" discharge?

II-F. Calculate the unit discharges for the 30 yr floods on the Luckiamute and Smith River. Which has a higher unit discharge? Compare and contrast the Gumbel plots for the Luckiamute and Smith drainages. What geologic / climatic / hydrologic variables account for the similarities and differences between the two (you will have to look at a basic geologic map of Oregon, locate the watersheds by long. and lat., then comment on the geologic environment, etc.).

LUCKIAMUTE Q_{30} = 28,600 ft³/sec. SMITH Q_{30} = 4500 ft³/sec

LUCKIAMUTE
$Q_{30\,UNIT}$ = (28,600 ft³/sec)/240 mi² = 119.2 ft³/sec/mi² = 1.3 m³/s/km²

SMITH
$Q_{30\,UNIT}$ = (4500 ft³/sec)/16.2 mi² = 278 ft³/sec/mi² = 3.02 m³/s/km²

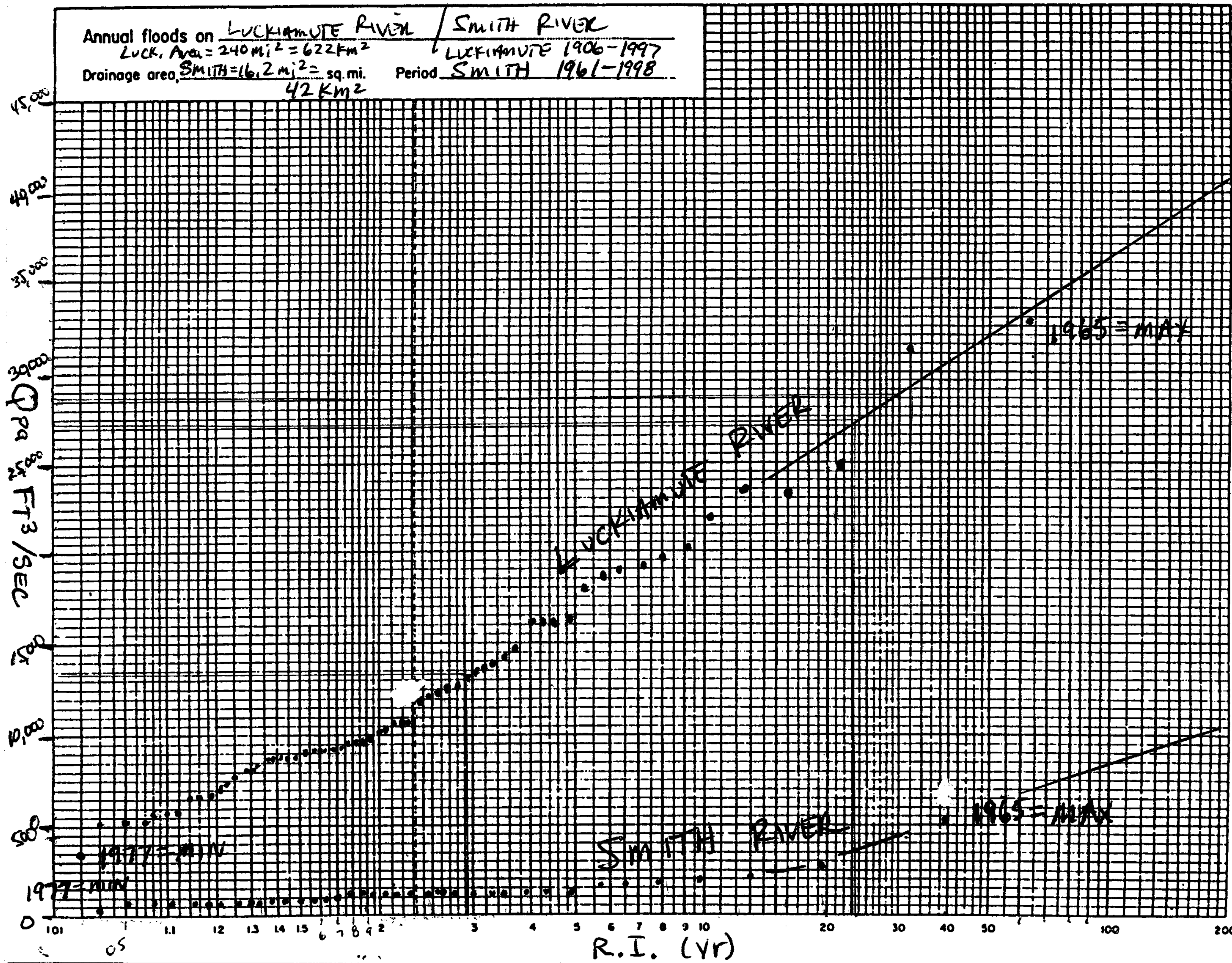
AT R.I.=30 SMITH UNIT Q ≈ 2.3 times greater than LUCKIAMUTE !!

Part III. Other Data Analysis / Intro to Regression Analysis

Table 6 is a different version of Luckiamute discharge data. Listed are the average daily discharge values for the months of January, February, and August, 1941-1984. For example, on any given day in January of 1941, the Luckiamute averaged a discharge of 1771.13 cu. ft / sec. Table 5 is also available for download from the G322

LUCKIAMUTE IS A 240 mi² WATERSHED THAT HEADS IN THE COAST RANGE, and DRAINS TO WILLAMETTE. SMITH IS A 16 mi² MOUNTAIN WATERSHED THAT HEADS IN THE HIGH CASCADES (SURROUNDED BY WILDCAT MTN AND BROWDER RIDGE). SMITH IS SUBJECT TO SNOW PACK AND FLASHY MTN DRAINAGE, WHEREAS THE LUCKIAMUTE IS ASSOC. WITH WINTER RAINS, AND > FLOODPLAIN STORAGE.

GUMBEL PLOT.



NOTE:

1965 = MAX Q_p for BOTH LUCKIAMUTE AND SMITH RIVERS — WHAT METEOROLOGICAL EVENT TRIGGERED THIS??

1977 = MIN Q_p for BOTH THE LUCKIAMUTE AND SMITH RIVERS

?

↓

SAME HYDROMETEOROLOGY BETWEEN EACH BASIN (?)

web site (www.wou.edu/taylor).

Your job is to determine whether there is a statistically significant difference between the average daily discharges in January, February and August. It is safe to assume that daily discharge is directly related to the amount of precipitation the Luckiamute watershed is receiving, i.e. low discharges correlate to low rainfall periods, and vice versa (dah!).

Methodology

SEE ATTACHED SHEET

1) Run a systematic t-test between Jan-Feb, Jan-Aug, and Feb.-Aug. and determine if there is a significant difference between average daily discharges (we've been here before! Use a 99% confidence interval this time; i.e. alpha = 0.01). **Print out and attach your results.**

RESULTS: JAN-Feb=No SIG. Diff. ; JAN-AUG=SIG. Diff. ; Feb-Aug=Sig. Diff.

The next question is: "Is there a relation between January discharge levels and August discharge levels, during wet and dry years?"... that is, is there a correlation in any given year, between low/high discharges in January, and low/high discharges in August? To test this hypothesis, we will create a simple x-y scatter plot of January vs. August daily discharges. If there is a correlation between wet and dry years, we should see somewhat of a linear relation between the two. The other statistical test we will use is the regression analysis... this also tests for correlation between two phenomena. SEE ATTACHED SHEETS.

Excel Techniques:

1) X-Y scatter plots: highlight the Jan and Aug. data columns, and click on the graph tool icon. Choose the "(X-Y) Scatter" graph type. **Create the plot (you know what to do), format your graph, and print.** Make sure you label the graph axes, and give it a title... don't forget to list the discharge units.

2) To run a regression analysis, select the Jan and Aug data columns, choose "tools-data analysis-regression", analogous to the t-test methodology.

- input the Jan. cells in the "Input Y-Range"
- input the Aug. cells in the "Input X-Range"
- use a 95% confidence interval
- click on the line-fit plots radio box
- choose where you want the output located (new worksheet, etc.)
- **run the analysis, print, and examine the results.**

3) The critical information that will relate the Jan and Aug discharge data is the "R-square" value. In a regression, the software will test how well the data relation to one another, and if there is a linear relation between the two. How to interpret the R-square value:

R-square = 1.0	a perfect fit / linear relation
R-Square = 0.7-0.9	a pretty good linear relation
R-square < 0.5	no relation between the two data sets.

Questions based on your t-test and regression analysis of average daily discharge data:

III-A. Is winter daily discharge in the Luckiamute significantly different than summer daily discharge? Provide supporting data to validate your conclusion. YES – SEASONAL RAINFALL, REFER TO t-test RESULTS

III-B. In any given year, is a high discharge in January related to a high discharge in August? Do wet and dry years show up correspondingly in the Jan. and Aug. data? Or is the variation purely seasonal?

NO, $R^2 = 0.05$ – NO RELATION – PURELY SEASONAL

t-Test Results for Average Monthly Discharge on Luckiamute River

t-Test: Two-Sample Assuming Equal Variances

	Jan(cfs)	*Feb(cfs)*
Mean	2295.149	2036.418
Variance	1411979	849044.1
Observations	44	44
Pooled Variance	1130511	
Hypothesized Mea	0	
df	86	
alpha (0.01)	0.01	
t Stat	1.141361	
P(T<=t) one-tail	0.128444	
t Critical one-tail	2.370489	
P(T<=t) two-tail	0.256888	
t Critical two-tail	2.634206	

t Stat < t Critical: Accept Null Hypothesis / No Significant Difference

t-Test: Two-Sample Assuming Equal Variances

	Feb(cfs)	*Aug(cfs)*
Mean	2036.418	39.87537
Variance	849044.1	245.9199
Observations	44	44
Pooled Variance	424645	
Hypothesized Mea	0	
df	86	
alpha (0.01)	0.01	
t Stat	14.37066	
P(T<=t) one-tail	7E-25	
t Critical one-tail	2.370489	
P(T<=t) two-tail	1.4E-24	
t Critical two-tail	2.634206	

t Stat > t Critical: Reject Null Hypothesis / Significant Difference

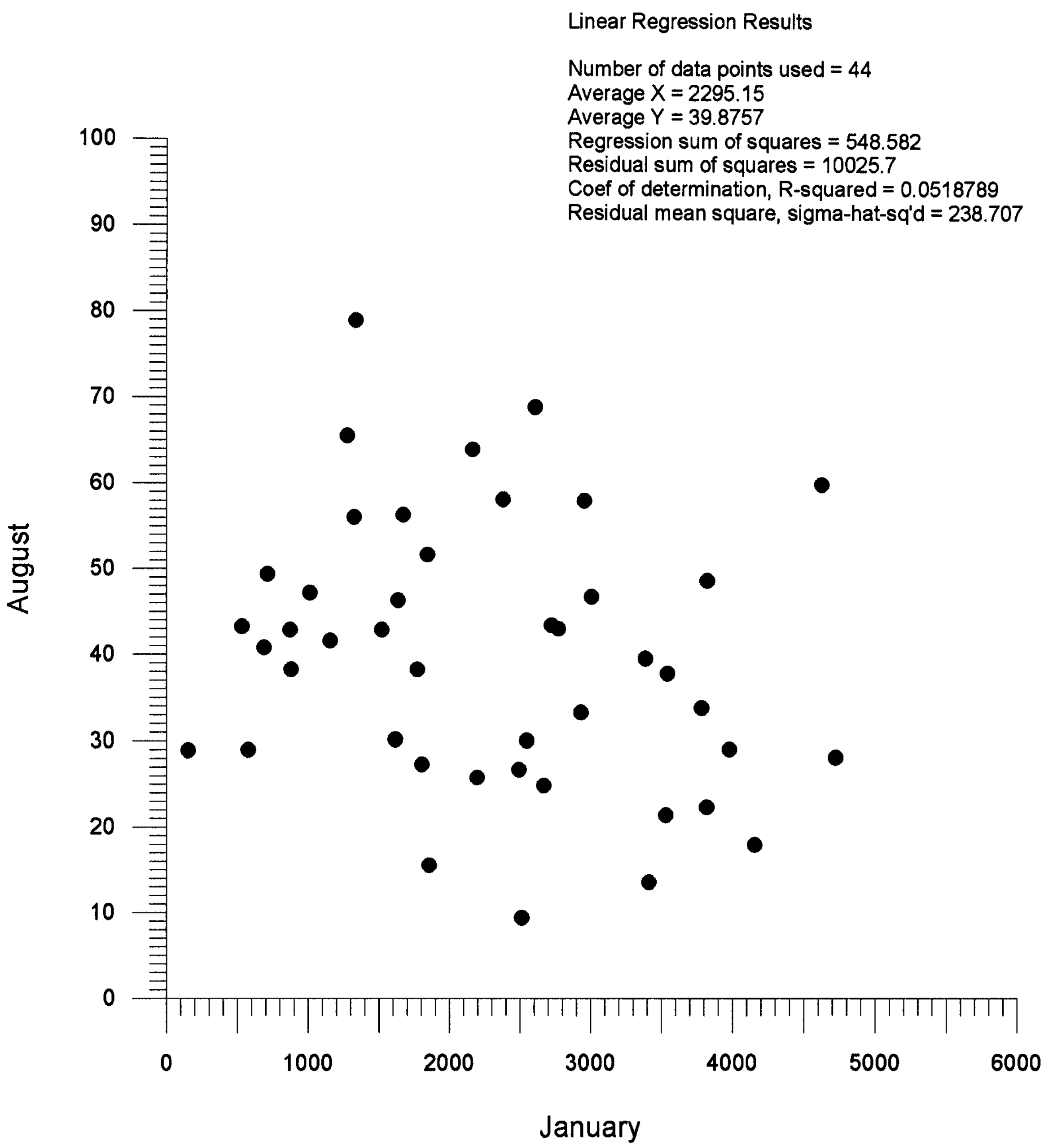
t-Test: Two-Sample Assuming Equal Variances

	Jan(cfs)	*Aug(cfs)*
Mean	2295.149	39.87537
Variance	1411979	245.9199
Observations	44	44
Pooled Variance	706112.4	
Hypothesized Mea	0	
df	86	
alpha (0.01)	0.01	
t Stat	12.58849	
P(T<=t) one-tail	1.64E-21	
t Critical one-tail	2.370489	
P(T<=t) two-tail	3.27E-21	
t Critical two-tail	2.634206	

t Stat > t Critical: Reject Null Hypothesis / Significant Difference

Plot of Average Daily Discharge for the Months of August and January

Luckiamute River (Suver Gaging Station)



SUMMARY OUTPUT: Regression Analysis of January vs. August Avg. Daily Discharges in Luckiamute River

Regression Statistics	
Multiple R	0.227792899
R Square	**0.051889605**
Adjusted R Square	0.029315548
Standard Error	1170.720284
Observations	44

R^2 = 0.05 = No Relationship Between Jan and Aug. Discharge!!!!

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3150482.218	3150482.218	2.298638871	0.136978448
Residual	42	57564611.3	1370585.983		
Total	43	60715093.52			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2983.424018	487.0708897	6.125235733	2.62298E-07	2000.474857	3966.373179	2000.474857	3966.373179
Aug(cfs)	-17.26066116	11.38471213	-1.51612627	0.136978448	-40.23594768	5.714625358	-40.23594768	5.714625358

Table 4. Annual peak discharge, Luckiamute River, Helmick Park

US GEOLOGICAL SURVEY
PEAK FLOW DATA
#
Station name : Luckiamute River Near Suver, Or
Station number: 14190500
latitude (ddmmss).............................. 444700
longitude (dddmmss)........................... 1231400
state code................................... 41
county.. Polk
hydrologic unit code.......................... 17090003
basin name................................... Upper Willamette
drainage area (square miles).................. 240
contributing drainage area (square miles).....
gage datum (feet above NGVD).................. 171.92
base discharge (cubic ft/sec)................. 6600
Gage heights are given in feet above gage datum elevation.
Discharge is listed in the table in cubic feet per second.
#
Peak flow data were retrieved from the
National Water Data Storage and Retrieval System (WATSTORE).
#
Format of table is as follows.
Lines starting with the # character are comment lines describing the data
included in this file. The next line is a row of tab-delimited column
names. The next line is a row of tab-delimited data type codes that
describe the width and type of data in each column. All following lines
are rows of tab-delimited data values.
#
----Water Years Retrieved----
 # 1906 - 1997; Note that Water Years Run from October to October!!

Table 4 (cont). Annual peak discharge, Luckiamute River, Helmick Park

Station I.D.	Water Year	Date of Maximum Discharge (Mo/Day/Year)	Peak Discharge (ft^3/sec)	Gage Height at Peak Q (feet)
14190500	1906	2/25/06	8070	23.9
14190500	1907	1/4/07	22000	30
14190500	1908	12/26/07	16200	27.7
14190500	1909	1/19/09	18000	28.4
14190500	1910	11/23/09	19000	28.8
14190500	1911	1/18/11	19800	29.1
14190500	1941	1/19/41	6620	26.49
14190500	1942	12/20/41	8060	27.73
14190500	1943	4/1/43	14400	29.4
14190500	1944	12/5/43	5900	26.23
14190500	1945	2/8/45	8720	27.87
14190500	1946	11/27/45	12000	29.05
14190500	1947	12/15/46	20200	31.86

Table 4 (cont). Annual peak discharge, Luckiamute River, Helmick Park

Station I.D.	Water Year	Date of Maximum Discharge (Mo/Day/Year)	Peak Discharge (ft^3/sec)	Gage Height at Peak Q (feet)
14190500	1948	1/7/48	13100	29.42
14190500	1949	2/18/49	23800	33.1
14190500	1950	2/25/50	9170	27.72
14190500	1951	1/18/51	10800	28.42
14190500	1952	2/4/52	9260	27.76
14190500	1953	1/19/53	14600	28.89
14190500	1954	12/20/53	9460	27.85
14190500	1955	12/31/54	6700	26.4
14190500	1956	1/4/56	16200	30.46
14190500	1957	3/8/57	6810	26.5
14190500	1958	12/20/57	10800	28.4
14190500	1959	1/10/59	8700	27.5
14190500	1960	2/9/60	9130	27.7
14190500	1961	11/25/60	16100	30.42
14190500	1962	12/21/61	8800	27.8
14190500	1963	11/26/62	8800	27.8
14190500	1964	1/20/64	12800	29.3
14190500	1965	12/22/64	32900	34.52
14190500	1966	3/9/66	13600	29.55
14190500	1967	1/28/67	10800	29.01
14190500	1968	2/19/68	9190	28.07
14190500	1969	12/5/68	8330	27.82
14190500	1970	1/23/70	10200	28.73
14190500	1971	1/17/71	13800	29.94
14190500	1972	1/21/72	31300	33.44
14190500	1973	12/22/72	9620	28.45
14190500	1974	1/16/74	18700	31.47
14190500	1975	1/14/75	7010	26.82
14190500	1976	12/5/75	16300	30.78
14190500	1977	3/9/77	3410	20.67
14190500	1978	12/14/77	19200	31.6
14190500	1979	3/6/79	5930	24.38
14190500	1980	1/13/80	9750	28.51
14190500	1981	12/26/80	23500	32.69
14190500	1982	12/6/81	14000	30.12
14190500	1983	1/7/83	9820	28.56
14190500	1984	2/14/84	7580	27.28
14190500	1985	11/29/84	7080	26.9
14190500	1986	2/24/86	10400	28.82
14190500	1987	2/1/87	12500	29.63
14190500	1988	1/15/88	12100	29.46
14190500	1989	1/11/89	5340	25.18
14190500	1990	1/8/90	8830	28.11
14190500	1991	4/6/91	5080	24.76
14190500	1992	2/21/92	5310	25.12
14190500	1993	2/25/94	9960	28.62
14190500	1994	2/18/95	9000	28.19
14190500	1995	2/8/96	24800	33
14190500	1996	12/27/96	12700	29.69
14190500	1997	12/17/97	5950	25.9

Table 5. Annual Peak Flow Data for Smith River - McKenzie Basin

```
# Station name  : Smith R Ab Smith R Res Nr Belknap Sprgs,Oreg.
# Station number: 14158790
# latitude (ddmmss)............................ 442005
# longitude (dddmmss).......................... 1220245
# state code.................................. 41
# county...................................... Linn
# hydrologic unit code......................... 17090004
# basin name.................................. Mckenzie
# drainage area (square miles)................. 16.2
# contributing drainage area (square miles).....
# gage datum (feet above NGVD)................. 2610
# base discharge (cubic ft/sec)................ 800
# Gage heights are given in feet above gage datum elevation.
# Discharge is listed in the table in cubic feet per second.
#
# Peak flow data were retrieved from the
# National Water Data Storage and Retrieval System (WATSTORE).
#
# Format of table is as follows.
# Lines starting with the # character are comment lines describing the data
# included in this file.  The next line is a row of tab-delimited column
# names.  The next line is a row of tab-delimited data type codes that
# describe the width and type of data in each column.  All following lines
# are rows of tab-delimited data values.
#
# ----Water Years Retrieved----
# 1961 - 1998
```

Table 5. Annual Peak Flow Data for Smith River - McKenzie Basin

Station	Water Year	Date Mo/D/Yr	Discharge Cu. Ft/Sec	Discharge Cu. M/sec	Gage Height Ft	Gage Height meters	Rank	R.I. (yrs)	Probability
14158790	1965	12/12/64	5160	146.1	11.9	3.63	1	39.00	0.03
14158790	1996	2/7/96	2960	83.8	9.48	2.89	2	19.50	0.05
14158790	1988	12/10/87	2010	56.9	8.76	2.67	3	13.00	0.08
14158790	1978	11/25/77	2000	56.6	9.38	2.86	4	9.75	0.10
14158790	1997	11/19/96	1930	54.7	8.72	2.66	5	7.80	0.13
14158790	1961	11/24/60	1720	48.7	6.38	1.94	6	6.50	0.15
14158790	1990	4/27/90	1590	45.0	8.39	2.56	7	5.57	0.18
14158790	1986	2/23/86	1430	40.5	8.27	2.52	8	4.88	0.21
14158790	1963	2/3/63	1400	39.6	6.15	1.87	9	4.33	0.23
14158790	1966	1/6/66	1310	37.1	8.64	2.63	10	3.90	0.26
14158790	1981	12/25/80	1300	36.8	8.15	2.48	11	3.55	0.28
14158790	1982	2/20/82	1290	36.5	8.14	2.48	12	3.25	0.31
14158790	1989	11/22/88	1250	35.4	8.06	2.46	13	3.00	0.33
14158790	1992	11/26/91	1250	35.4	8.06	2.46	14	2.79	0.36
14158790	1995	1/31/95	1230	34.8	8.03	2.45	15	2.60	0.38
14158790	1972	1/21/72	1200	34.0	8.53	2.60	16	2.44	0.41
14158790	1984	2/13/84	1120	31.7	7.97	2.43	17	2.29	0.44
14158790	1980	1/12/80	1070	30.3	7.92	2.41	18	2.17	0.46
14158790	1998	1/17/98	1070	30.3	7.85	2.39	19	2.05	0.49
14158790	1985	11/2/84	1060	30.0	7.91	2.41	20	1.95	0.51
14158790	1993	3/17/93	1060	30.0	7.84	2.39	21	1.86	0.54
14158790	1974	1/15/74	1030	29.2	8.3	2.53	22	1.77	0.56
14158790	1983	12/4/82	1000	28.3	7.85	2.39	23	1.70	0.59
14158790	1979	12/4/78	986	27.9	7.83	2.39	24	1.63	0.62
14158790	1971	11/24/70	981	27.8	8.23	2.51	25	1.56	0.64
14158790	1968	2/23/68	925	26.2	8.15	2.48	26	1.50	0.67
14158790	1969	11/8/68	911	25.8	8.13	2.48	27	1.44	0.69
14158790	1964	11/8/63	904	25.6	5.68	1.73	28	1.39	0.72
14158790	1991	11/25/90	860	24.4	7.58	2.31	29	1.34	0.74
14158790	1962	11/22/61	832	23.6	5.59	1.70	30	1.30	0.77
14158790	1970	12/21/69	818	23.2	7.99	2.44	31	1.26	0.79
14158790	1975	12/20/74	793	22.5	7.94	2.42	32	1.22	0.82
14158790	1987	11/27/86	789	22.3	7.6	2.32	33	1.18	0.85
14158790	1976	12/4/75	781	22.1	7.92	2.41	34	1.15	0.87
14158790	1994	3/30/94	705	20.0	7.41	2.26	35	1.11	0.90
14158790	1967	1/28/67	680	19.3	7.74	2.36	36	1.08	0.92
14158790	1973	12/21/72	635	18.0	7.65	2.33	37	1.05	0.95
14158790	1977	4/7/77	289	8.2	6.77	2.06	38	1.03	0.97

6,
Table 6. Average Daily Discharge for Luckiamute River at Helmick P

c:\wou\geomorph\luckiamute\avgmon.xls

Year	Average Daily Discharge by Month		
	Jan (cu. Ft / sec)	Feb (cu. Ft / sec)	Aug (cu. Ft / sec)
1941	1771.13	663.79	38.26
1942	1324.03	1914.25	56.03
1943	2163.03	2673.75	63.94
1944	1153.39	1052.21	41.61
1945	1637.55	2267.79	46.32
1946	2725.29	2128.82	43.42
1947	1275.74	1894.50	65.52
1948	2380.23	2127.72	58.16
1949	870.26	4769.29	42.90
1950	3389.68	3374.29	39.55
1951	3785.81	2100.57	33.81
1952	1805.16	2514.83	27.32
1953	4627.42	2390.57	59.84
1954	2957.74	3180.36	57.97
1955	1519.65	1201.50	42.87
1956	4726.77	1570.41	28.13
1957	686.84	1530.07	40.77
1958	2196.52	3393.21	25.77
1959	2933.00	1958.57	33.23
1960	1013.06	2587.38	47.19
1961	1616.90	3961.07	30.19
1962	879.48	1199.14	38.23
1963	530.06	1676.89	43.26
1964	3824.84	998.07	48.58
1965	3820.97	1323.96	22.35
1966	3413.55	1144.07	13.52
1967	2511.68	1381.07	9.39
1968	1334.35	3326.52	78.97
1969	2666.77	2135.32	24.90
1970	4155.16	2027.89	17.94
1971	3978.71	1664.29	29.10
1972	3533.52	1732.72	21.39
1973	1854.94	582.50	15.55
1974	3545.13	2608.21	37.77
1975	3008.39	2034.29	46.74
1976	2770.81	2170.07	42.97
1977	151.35	253.46	28.94
1978	1843.29	1109.14	51.68
1979	575.61	2444.57	28.97
1980	2493.55	1205.41	26.74
1981	709.97	1392.43	49.42
1982	2546.23	2879.11	30.10
1983	2606.61	3113.00	68.87
1984	1672.39	1945.28	56.35