G476/576 Hydrology
Surface Water Exercise

Introduction

Surface water processes are driven by the interplay between meteorological processes and geomorphic configuration of the landscape. Watersheds of varying scale represent the fundamental hydrologic unit at the Earth's surface. This lab employs data techniques that are commonly applied to the analysis of surface water hydrology. Th data for this lab are available at the class web site, follow the links to the lab data section and download the "Surface Water Data" Excel file. Save to floppy or appropriate folder on your network account. NOTE: You will also need to get a copy of the "Surface Hydrology Equation List" from the web site to work on this lab.

Part 1 - Flood Climatology

Table 1 is a list of world record rainfall intensities (inches of precip.) for specific durations (lengths of time) (data from Patton and Baker, 1977). The rainfall and durations are given as Log_{10} values. Remember that $Log_{10}10^X =$ X, so the values listed represent the exponents derived from a base of 10.

Task 1. Using excel, create two new data columns in Table 1 and convert the Log_{10} exponent values back to their original, "anti-log" value.

Task 2. Plot the data on a scatter chart with a log x axis (duration in days) and a log y axis (total rainfall inch Format the scatter plot with titles, labels and grid lines.

Task 3. Fit a power-function curve to the data.

- select / highlight the graph data points (the "series" data)
- Chart-Add Trend Line-Select "Power" Trend/Regression Type
- click on the "options" tab and check the "Display Equation on Chart" and "Display R squared Value on Chart" boxes.
- click o.k. and proceed, Excel should now fit a line to the data and give you an equation that defines the relationship between the rainfall-duration data. NOTE: the R square value is a measure of the degree to which the data fit the function. An R square value between 0.7 - 1.0 suggests a very good fi
- Format the equation and R-square information so that it fits on your graph, print the graph and data to include in your lab manual.

Task 4 - Answer the "Related Questions" at the end of the lab.

Part 2 - Historical Discharge Analysis / Recurrence Intervals.

The Luckiamute River at Helmick State Park is gaged by the U.S. Geological Survey. Discharge data have been collected at the site since the 1940's. Table 2 is a summary of annual peak discharge data from the Luckiamute Helmick gaging station.

Recurrence Interval and Gumbel Plots

The recurrence interval of a given flood discharge is commonly calculated from a set of historical data. The annual p discharges for the Luckiamute gaging station are listed in Table 2. 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 (Gumbel graph paper is available in the lab data section of the class web site). Refer to the last page of the "Surface Water Hydrology Equat List" for a list of procedures on how to analyze frequency-discharge data.

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"

    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.

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

    R.I. = (n+1)/m 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)

PRINT OUT YOUR COMPLETED DATA SHEETS!

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

5. Now repeat the steps for Table 3 discharge data for the Smith River Watershed of the McKenzie Basin. Plot the Smith River data on the same Gumbel graph as the Luckiamute, but use different symbols and colors

6. Using Excel chart methods and Table 3, create a flood rating curve for the Smith and Luckiamute watersheds. A flood rating curve is a plot of Discharge (y axis-linear) vs. River Stage (x axis-linear). Using Chart-Trend Line routine that you employed in part one, determine a linear equation for each data set that

describes the relationship between discharge and river stage.

7. Answer the "Related Questions" at the end of the lab.

Part 3 - Watershed Morphometry and Hydrologic Relations

Table 4 is a collection of channel network data from three watersheds in Virginia and West Virginia (Fernow North Fork, and Little River). The data are organized by stream order and channel segment length for each area. Drainage areas, lengths from divide, and basin relief are also listed for each site.

Task 1. Calculate the drainage density for each watershed in m/km^2. Print and list your results.

Task 2. Determine the Shreve Magnitude for each watershed (M = frequency or count of first order stream segments). Print and list your results.

Task 3. Using the empirical hydrologic relations listed as item 7 on the equation sheet, calculate the maximur discharge expected for each of the Appalachian watersheds (answer in cubic meters per second).

Task 4. Using the empirical hydrologic relations listed as item 7 on the equation sheet, calculate the discharge expected for a recurrence interval of 2.33 years at each of the watersheds.

Task 5. Using the rational runoff method, assume that each Appalachian watershed is covered with a clayey-s colluvium. Now consider a regional rainfall event with an average intensity of 127 mm/day. Calcula the peak runoff discharge anticipated at each of the three watersheds, answer in cubic meters per second.

Task 5A. What would happen to the peak discharge at each watershed if they were totally paved in asphalt (like with respect to urban development).?

Task 6. Using the Time for Hydraulic Concentration empirical formula from the equation list, calculate Tc fo each of the watersheds (NOTE: for this empirical formula to work, the units must be in English as list on the equation sheet).

Task 7. Answer questions in the "Related Questions" section below.

Related Questions

Part 1. Flood Climatology

A. Express the relationship between World Record total rainfall and duration as a power-function equation. How well do the data fit this equation?

B. Predict the region of the graph where typical western Oregon Rainfall-Duration relationships will fall. Th about the style of precipitation that western Oregon typically recieves.

C. Based on the graph, discuss the types of rainfall events that are likely associated with widespread regional flooding.

Part 2. Flood Recurrence Interval

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

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

$$\text{Unit } Q = Qp/A$$

where Qp = peak discharge, and A = drainage area above the gage station.

NOTE: drainage area for the Luckiamute = 240 square miles, for the Smith River = 16.2 square miles.

Make sure you get all units in the proper metric format... thus Unit Q = $m^3/sec/km^2$

B. 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 w have to look at a basic geologic map of Oregon, locate the watersheds by long. and lat., then comment on the geologic environment, etc.).

C. Using your graphs, hypothesize what the maximum peak discharge would be for a 150 year recurrence interval on the Smith and Luciamute Rivers. Answer in cubic meters / sec. Which one is higher and why?

Part 3 - Watershed Morphometry and Hydrologic Relations

A. Discuss the relationship between watershed morphometry (physical characteristics of the watershed network), climate, and river hydrology. Consider all of the calculations and relationships that you examined this section. Place your discussion in the context of flood hazards planning.