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Hydrologic Science and Engineering
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CIVE522 ENGINEERING HYDROLOGY

Homework No. 4

1. For events of various return periods, the damage costs and the annual capital costs of structures designed to control those events are presented in the table below. Using hydro-economic analysis, determine the expected annual damages as a function of return period and determine the optimal design return period, for both Case A and Case B.

	Case A		Case B	
Return Period (yr)	Damage	Capital Cost	Damage	Capital Cost
1	0.	0.	0.	0.
2	20000.	6000.	40000.	3000.
5	60000.	28000.	120000.	14000.
10	140000.	46000.	280000.	23000.
15	177000.	50000.	354000.	25000.
20	213000.	54000.	426000.	27000.
25	250000.	58000.	500000.	29000.
50	300000.	80000.	600000.	40000.
100	400000.	120000.	800000.	60000.
200	500000.	160000.	1000000.	80000.

2. A hydrologic design has a loading with mean value of 10 units and standard deviation of 2 units. a) Calculate the risk of failure if the capacity is fixed and equal to 12 units. Assume the loading is normally distributed. Repeat assuming that the capacity is normally distributed with mean 12 units and standard deviation 1 unit.

3. A trapezoidal channel with bottom width 150 ft and side slopes 1:3 has a bed slope of 0.5%, an estimated Manning's *n* of 0.04, and a design discharge of 10000 cfs. Calculate the design flow depth. If the coefficient of variation of the design discharge is 0.2, and that of Manning's *n* is 0.15, calculate the standard error of the flow depth. If structures are built 1 foot above this design flow depth, what is the probability that the structures will be flooded during occurrences of the design event? Within what range of depths can the water level for the design event be expected in 70% of events?

4. Let $Z(u)$ represent the precipitation along a straight line, as a function of position u on the line. Use Kriging to obtain an estimate of the mean total precipitation along this line, such that

$$P = \frac{1}{L}\int_0^L Z(u)\,du$$

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for the following conditions:

a) The total length of the line is 5.

b) There are three raingauges located at coordinates $u_1 = 0$, $u_2 = 2$ and $u_3 = 5$.

c) The total rainfall measurements at the three gauges are: $Z(u_1) = 5$, $Z(u_2) = 3$, and $Z(u_3) = 2$.

d) The covariance function of $Z(u)$ is:

$$\text{cov}(u_i - u_j = h) = \sigma^2 \exp(-|h| / D)$$

In addition, compute the variance of the estimation error associated with your estimate. In the covariance equation above let σ^2 be equal to 1 and D equal to 3.

This problem is equivalent to obtaining an estimate of the integral of an unknown function, $Z(u)$, but of which a limited number of values are known, $Z(u_i)$. Thus, Kriging can be used as an alternative to other commonly used methods for numerical approximation of definite integrals.

5. Develop the Kriging equations for the case of point estimation. That is, the problem is to estimate the value $Z(u_o)$ of a random field at u_o as a linear combination of n observations, $Z(u_i)$ at points u_1 through u_n.