Tentamen River Morphology (AW3-3005) 12 November 2003

1. Given the dataset of the flood of 1998 in the Rhine given on a separate sheet:
   a) describe the dune development in relation to the flow conditions;
   b) calculate the lag-time of dune height and length;
   c) explain why dune height lags the development of the flow during a flood like this.

2. The northern part of the east Chinese plain consists of silt accumulations deposited by the Yellow River. In this area a small artificial distributary is found which, due to the semi-arid climate and irrigation most of the time is completely dried up. However, in the wet season during a short period a discharge wave may pass the channel. In order to protect the surroundings for flooding dikes have been built along the channel that rise 4 m above the (dry) river bed. As a result of a prolonged period of dry conditions the river bed between the dikes (200 m) shows a bare surface with some local patches of grass, very short cut due to a heavy grazing pressure by sheep. The highest water level reached after dike construction was 2 m below the top of the dike.

   a) What is the hydraulic roughness (expressed in the Chezy-coëfficient) at the moment that the water level reaches 2 m below the top of the dike?

   The local peasant community decides to plant a hardwood production forest over a large length of the river bed and also covering its total width.

   b) Predict the water level at the situation that 20 years after planting of the forest the same discharge occurs that before, when the bed was bare, resulted in a water level that reached 2 m below the crest of the dikes.

   Some data: grainsize bed material $D_{50} = 80 * 10^{-6}$ m, $D_{90} = 110 * 10^{-6}$ m ; The sediment heeft een density of 2650 kg/m$^3$. 20 years after planting the trees of the production forest are 10 m high. The slope of the river bed on average is 15 cm/km. The water temperature is $20^0$ Celcius. De value of $C_d$ related to the forest is 3. De acceleration due to gravity is 9.81 ms$^{-2}$.

3. Give two reasons why the well-known diagram of Leopold & Wolman is of no use for the prediction of river pattern.

4. The hydraulic geometry of natural rivers can be predicted from empirical relations between (bankfull) water depth or channel width or flow velocity and bankfull discharge.
   a. Given the relation for channel width ($W$): $W = 8.8 * Q^{0.5}$, predict the width of the former, not embanked, river Waal with a bankfull discharge of Q = 3000 m$^3$/s.

b. Given the relation for channel depth ($h$): $h = 0.125 * Q^{0.42}$, predict the ~~width~~ depth of the unembanked river Waal with the same bankfull discharge.

c. The actual width of the Waal at its water surface is 240 m and the actual (bankfull) depth is 7.5 m. Explain why this is different from the predicted width and depth.

d. Derive a relation between the flow velocity (averaged over width and depth of the channel and valid for bankfull discharge in the not embanked situation) given the relations in question a). Now predict this flow velocity for the river Waal.

e. The actual velocity at bankfull flow is about 1.5 m/s. What is the celerity (=wave velocity) of a small discharge wave?

f. Given is a large discharge wave with peak discharge of 12000 $m^3/s$ in the present river Waal. This discharge wave is too large for the artificial levees to withstand, so all the discharge above 10000 $m^3/s$ (that is, 2000 $m^3/s$) must be redirected into a retention basin. Assume that the basin has the following dimensions: 10*20 km and 2 m deep. Now suppose that the retention basin is filled with the surplus discharge of 2000 $m^3/s$, how much time does it take before the basin is filled?

g. Argue whether the retention basin has an effect on the downstream or upstream water level (or both?) of the river.

h. Argue why the timing of opening the retention basin during a large flood is crucial (if the aim is, of course, to lower the water levels).

| | | | | | | | | Primary dunes | | | | | Secondary dunes | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | River width [m] | D50 [m] | D90 [m] | Q [m3/s] | h [m] | U [m/s] | Rb [m] | height [m] | height brink [m] | length [m] | f | celerity[m/day] | height [m] | height brink (m) | length (m) | f | celerity [m/day] | abundance [%] |
| 29-10-98 | 260 | 0.0028 | 0.0098 | 4037 | 8.6 | | 8.1 | 0.33 | 0.20 | 7.5 | 1.10 | | | | | | | |
| 30-10-98 | 260 | 0.0028 | 0.0098 | 4852 | 9.4 | | 8.8 | 0.39 | 0.25 | 8.4 | 1.14 | 48 | | | | | | |
| 31-10-98 | 260 | 0.0028 | 0.0098 | 6006 | 10.3 | 1.60 | 9.6 | 0.47 | 0.33 | 10.9 | 1.28 | 61 | | | | | | |
| 01-11-98 | 260 | 0.0028 | 0.0098 | 7076 | 11.0 | 1.70 | 10.2 | | | | | | | | | | | |
| 02-11-98 | 260 | 0.0028 | 0.0098 | 8142 | 11.6 | 1.80 | 10.6 | 0.71 | 0.56 | 16.1 | 1.26 | 57 | | | | | | |
| 03-11-98 | 260 | 0.0028 | 0.0098 | 8977 | 12.0 | 1.82 | 10.9 | 0.89 | 0.78 | 20.1 | 1.16 | 55 | | | | | | |
| 04-11-98 | 260 | 0.0028 | 0.0098 | 9413 | 12.1 | 1.75 | 11.1 | 1.00 | 0.89 | 22.8 | 1.15 | 51 | | | | | | |
| 05-11-98 | 260 | 0.0028 | 0.0098 | 9093 | 12.0 | 1.71 | 11.0 | 1.09 | 0.97 | 24.4 | 1.16 | 41 | | | | | | |
| 06-11-98 | 260 | 0.0028 | 0.0098 | 8185 | 11.6 | 1.71 | 10.7 | 1.16 | 1.05 | 26.0 | 1.15 | 31 | | | | | | |
| 07-11-98 | 260 | 0.0028 | 0.0098 | 7262 | 11.2 | 1.68 | 10.3 | 1.16 | 1.03 | 28.8 | 1.17 | 25 | | | | | | |
| 08-11-98 | 260 | 0.0028 | 0.0098 | 6627 | 10.8 | 1.65 | 10.0 | | | | | | | | | | | |
| 09-11-98 | 260 | 0.0028 | 0.0098 | 6098 | 10.5 | 1.63 | 9.7 | | | | | | | | | | | |
| 10-11-98 | 260 | 0.0028 | 0.0098 | 5652 | 10.1 | 1.58 | 9.4 | 0.93 | 0.80 | 32.8 | 1.13 | 18 | | | | | | |
| 11-11-98 | 260 | 0.0028 | 0.0098 | 5331 | 9.9 | 1.53 | 9.2 | | | | | | | | | | | |
| 12-11-98 | 260 | 0.0028 | 0.0098 | 5090 | 9.7 | 1.48 | 9.0 | 0.78 | 0.67 | 34.9 | 1.08 | 15 | 0.3 | 0.2 | 6.91 | 1.16 | 55 | 20% |
| 13-11-98 | 260 | 0.0028 | 0.0098 | 4839 | 9.4 | 1.43 | 8.8 | 0.76 | 0.66 | 36.2 | 1.07 | 14 | 0.3 | 0.2 | 6.78 | 1.15 | 55 | 22% |
| 14-11-98 | 260 | 0.0028 | 0.0098 | 4681 | 9.3 | | | | | | | | | | | | | |
| 15-11-98 | 260 | 0.0028 | 0.0098 | 4617 | 9.2 | | | | | | | | | | | | | |
| 16-11-98 | 260 | 0.0028 | 0.0098 | 4516 | 9.2 | | 8.5 | 0.65 | 0.55 | 39.8 | 1.05 | 15 | 0.3 | 0.2 | 6.65 | 1.16 | 55 | 38% |
| 17-11-98 | 260 | 0.0028 | 0.0098 | 4434 | 9.1 | | | | | | | | | | | | | |
| 18-11-98 | 260 | 0.0028 | 0.0098 | 4478 | 9.1 | | | | | | | | | | | | | |
| 19-11-98 | 260 | 0.0028 | 0.0098 | 4524 | 9.2 | | 8.6 | 0.56 | 0.51 | 40.8 | 1.10 | 20 | 0.3 | 0.2 | 7.68 | 1.2 | 55 | 82% |

Table belonging to question 1: Rb = hydraulic radius; Q = River discharge; celerity = propagation velocity of dunes; u = depth averaged flow velocity; h = water depth.