

## **Diurnal Fluctuations of Stage and Discharge in the Danish River Suså**

**Jørgen Erup**

Danish Land Development Service, Hydrological Survey,  
Slagelse, Denmark

Distinct and regular diurnal fluctuations of stage and discharge have been observed in the river Suså during dry summer periods. Examples of the fluctuations are shown and some pertinent characteristics of the fluctuations are pointed out. The effect of various factors contributing to the generation of the diurnal fluctuations are discussed in this paper. It has been found that diurnal variations of the rate of evapotranspiration from riparian zones adjoining the river is the most significant single factor contributing to the fluctuations in the river. The mechanisms by which diurnal variations in the rate of evapotranspiration generate fluctuations in the river are discussed using simple qualitative models of the river-riparian zone.

### **Background**

Attention was first drawn to the diurnal fluctuations of stage and discharge in the Suså when studying water level recordings from this river in connection with the hydrological research programme in the area (Danish Committee for Hydrology 1982a). Subsequently it was decided to make a detailed study of the phenomenon. A full exposition of the study is given by the Danish Committee for Hydrology 1982b. Similar diurnal fluctuations have been observed in several rivers throughout the world (cf. list of references, Danish Committee for Hydrology 1982b).



## Diurnal Fluctuations of River Flow

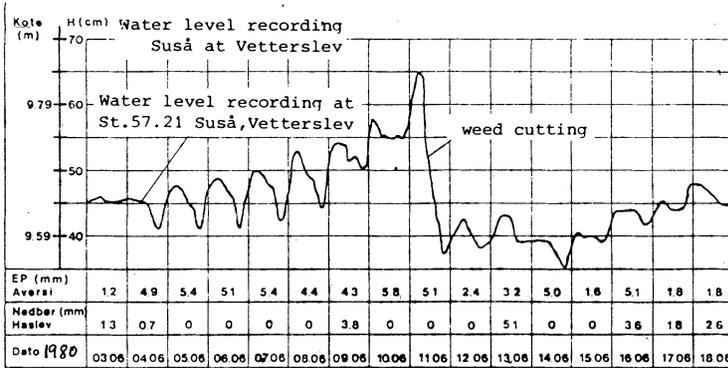


Fig. 2. Water level recording from gauging station No. 57.21. Also shown: figures for daily potential evaporation (Penman, EP) and precipitation (Nedbør).

the main river reach for several years. Using the stage-discharge relationships for the gauging stations in question, diurnal variations of discharge corresponding to the observed stage-recordings were computed.

As an example is in Fig. 3 shown the seasonal variation of the magnitude of diurnal discharge-fluctuations at Vetterslev (catchment area 256 km<sup>2</sup>) for the year 1976. Graphs of daily values of potential evaporation and discharge from the sub-catchment are also shown in Fig. 3.

The daily discharge figures ( $DQ_v$ ) given in the diagram exclude flow from leaking wells and from tributaries without diurnal fluctuations. Also waste-water from Haslev town is excluded.

The following characteristic attributes were found for the diurnal fluctuations:

- a) The largest regular diurnal fluctuations (at Vetterslev about 10 cm corresponding to a difference of about 200 l/s between daily maximum and minimum discharge) usually occur during a short period early each summer. In winter there are no discernible daily fluctuations.
- b) Diurnal fluctuations, although of a smaller size, occur further upstream in the main river reach.
- c) The time of daily maximum and minimum vary from place to place as well as over the seasons.
- d) During periods of precipitation regular diurnal fluctuations are usually absent (cf. the days without records in the diagram Fig. 3.)

### Causes of the Daily Fluctuations

It was found that the following processes all contribute to some extent to the daily variations of the flow in the river:

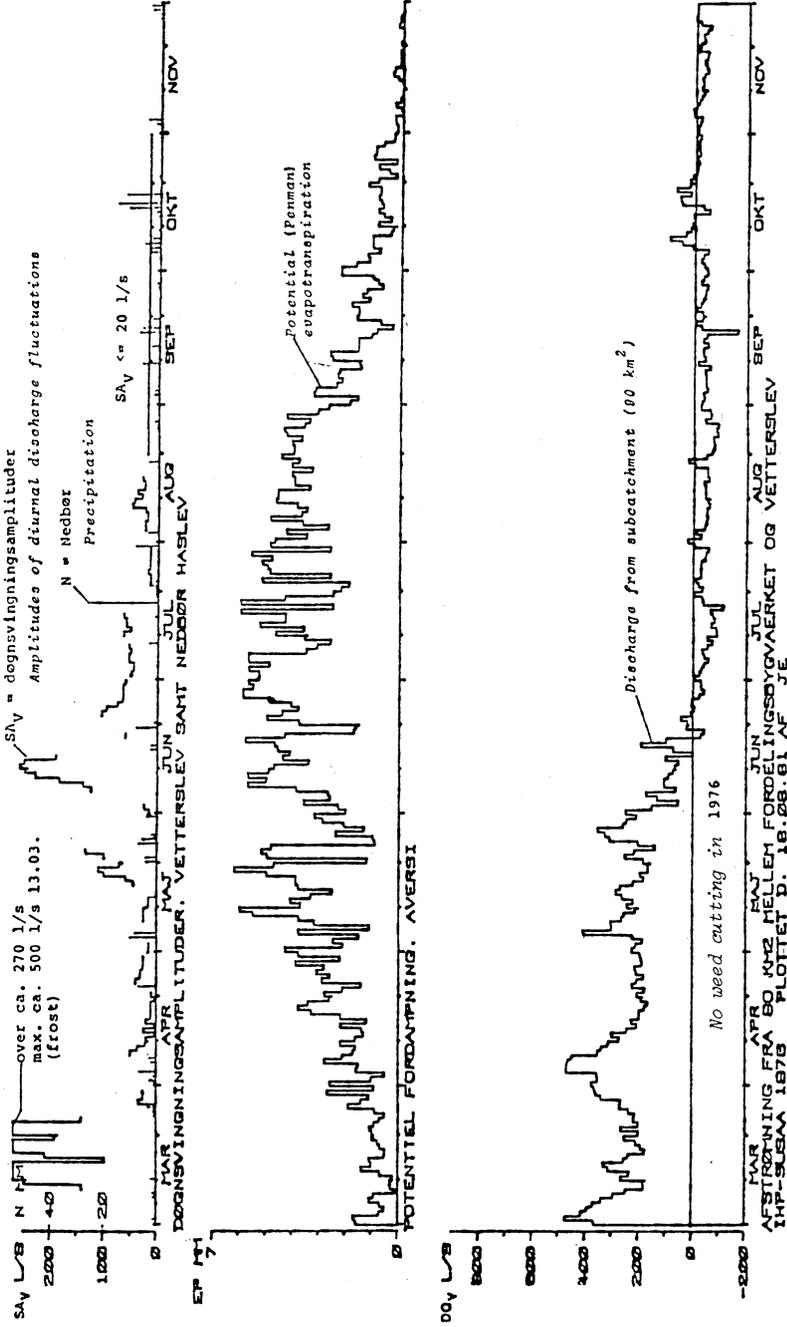


Fig. 3. Amplitudes of diurnal discharge fluctuations, precipitation, potential evapotranspiration and subcatchment-discharge, 1976.

## Diurnal Fluctuations of River Flow

- a) Diurnal variations of evapotranspiration from moist riparian zones.
- b) Diurnal variation of evaporation from the free water surfaces of the river and its tributaries.
- c) Diurnal variations of waste water outlet to the river.
- d) Diurnal variations of the amount of water pumped directly from the rivers for irrigation purposes.

Scrupulous registration of waste-water outlets and irrigation and estimates of the evaporation from river surfaces have shown, that the daily fluctuations that may be caused by b), c) and d) are much smaller than the largest diurnal fluctuations found in the river. Furthermore the following processes have been considered:

- e) Diurnal variations of hydraulic conductivity in the rivers due to diurnal changes of weed properties.
- f) Diurnal variations of contributions from leaking wells.
- g) Earth tide and barometric pressure changes.

It was found that f) and g) give no appreciable contribution to the daily fluctuations in the river.

As to e) diurnal variations of channel roughness, it was found to be unlikely that this can account for any major diurnal fluctuations of the flow. One significant point towards this conclusion is that the periodical cleaning of the channels and cutting of weeds (Figs. 2 and 3) seem to have no discernable effect on the magnitude of the daily fluctuations of river flow. (A proposal for a conclusive investigation of the effect of a possible diurnal variation of channel roughness is given by the Danish Committee for Hydrology 1982b).

### Riparian Evapotranspiration

Diurnal variations of the evapotranspiration from riparian zones thus seems to be the most important single cause of the diurnal fluctuations of the flow in the rivers. Fig. 4 shows an example of diurnal variation of potential evapotranspiration.

Figs. 5 and 6 show schematic cross-sections through the above mentioned moist riparian zones adjoining the main river reach.

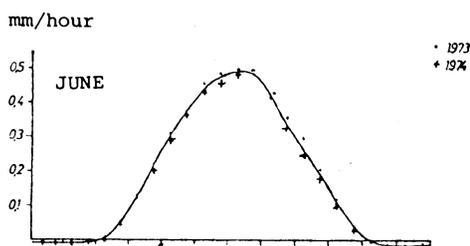


Fig. 4.  
Diurnal variation of potential evaporation at Højbakkegård, computed from Penman's formula.

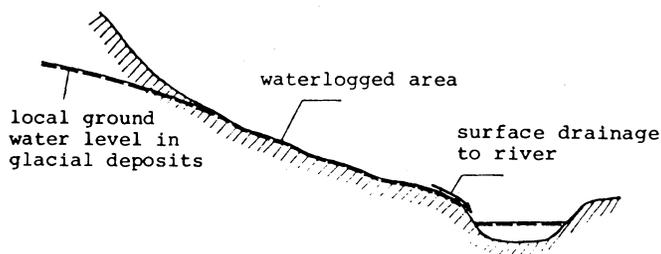


Fig. 5. Waterlogged riparian zone with surface drainage to river.

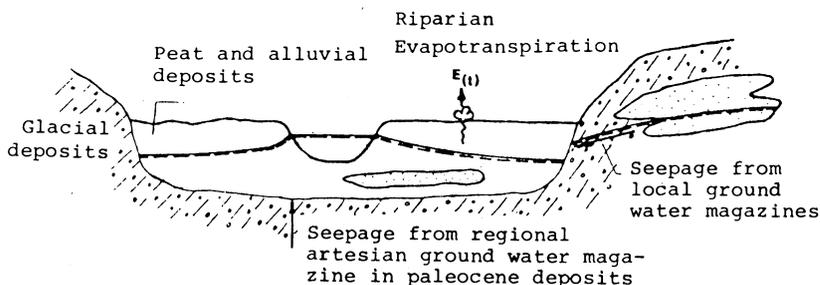


Fig. 6. Schematic cross section through river valley, at a reach with loss of water from the river.

Assuming an evapotranspiration from the riparian zones of same magnitude as the potential evaporation, and using coefficients of permeability obtained by field measurements in shallow boreholes, it has by simple calculations been rendered probable that diurnal variations of river flow compatible to those observed, may be caused by diurnal variations of evapotranspiration from the riparian zones.

## References

- Danish Committee for Hydrology (1982a) Samlerapport vedrørende Suså-undersøgelsen.
- Danish Committee for Hydrology (1982b) Døgnsvingninger i Susåens vandstand og vandføring. (SUSÅ H 11).
- Danish Committee for Hydrology (1982f) Vandudveksling mellem grundvand og vandløb. (SUSÅ H 17).

Received: 28 September, 1982

**Address:** Danish Land Development Service,  
Hydrological Survey,  
Nytorv 13,  
P.O. Box 4,  
DK-4200 Slagelse, Denmark