SELECTION OF TIDE LEVELS

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1. INTRODUCTION

Many sewerage systems are affected by tide levels at the main outfall, or on overflows. This note considers the choice of tide levels for use with particular rainfall events for verification, analysis of flooding, and analysis of overflow spill.

2. REPRESENTATION OF TIDE LEVELS

The tide curve for a site is made up of many different components, both regular and irregular. The most important ones are:

Daily tidal cycle
The regular variation between high and low tide with a period between successive high tides of 12 hours 20 minutes.

Spring-neap cycle
The regular monthly variation between high spring and low neap tides.

There are other regular components with longer periods which have a small effect on the tide level. The regular components are independent of weather conditions, and therefore are independent of rainfall.

Surge
An irregular increase in tide level due to low atmospheric pressure or decrease due to high atmospheric pressure.

Wind set
An irregular increase in tide level due to onshore winds and decrease due to offshore winds.

Surge and wind set are particularly important on the west coast of the UK and they should be included in any analysis, elsewhere it may be possible to ignore them. The two irregular components may not be independent of rainfall. However the analysis of return periods is much easier if we assume that they are.

The two regular components can be used to define a curve of tide level against the proportion of time for which that level was exceeded. This curve would show a maximum level equal to the mean spring high water level and that this occurs once per month.

This analysis would not show extreme high tide levels above this level as they are due to the other tidal components.

If surge and wind set are important and tide level records are available then a similar level exceedance curve can be drawn from the measured tide levels. The surge and wind set will only affect the extreme ends of the curve.

3. REPRESENTATION OF RAINFALL

Rainfall return periods can be represented by the familiar depth-duration-frequency analysis. This shows the rainfall depth for a given duration increasing with return period, and the rainfall depth for a given return period increasing with duration. In order to completely represent a particular return period it is necessary to analyse a range of events of different durations.

4. JOINT PROBABILITIES

If we assume that the tide level and rainfall are independent then we can consider the probability of them happening together by combining the probabilities of each of them happening alone.

For example:

If the tide level exceeds 2.2 m for 10% of the time, it has a probability of 0.1. A storm with a return period of 5 years has a probability of occurrence in any year of 0.2. The probability of a 5 year storm coinciding with one of the tides greater than 2.2 m is given by:

0.1 x 0.2 = 0.02 = one in 50 years

However a one in 50 year probability would also be given by a one in 50 year storm coinciding with any tide (i.e. all tides above spring low water level) or by tides which are only exceeded once in fifty years combined with no rainfall.

The one in 50 year situation is taken as the worst case of this family of situations which each have a calculated probability of one in 50 years.

5. SPATIAL VARIATION OF TIDE LEVEL

For many systems, it will be adequate to use the same tide level on all overflows and outfalls from the system. However local knowledge and tide records will be useful to determine whether there is a significant difference in tide levels between different parts of a large drainage system. This is particularly important in narrow inlets where there may be a difference in both time and level between different points.

6. VERIFICATION

To verify a model which is affected by a tide level it will be necessary to have records of the tide level at the outfall. This should be the level of the tide itself not the level which would be recorded by a flow monitor in the outfall pipe. The level recorded in the pipe will be higher due to the water flowing through it. This tide level should be used in the model as a level hydrograph giving the variation with time during the verification event. A timestep of one hour should be satisfactory for this level hydrograph.

7. ANALYSIS OF FLOODING

The analysis of system performance for flooding will use the techniques of joint probabilities set out above.

1. Draw up a tide level exceedence curve either from analysis of a tide record or by generating it from the mean spring and neap tide levels.
2. Decide on the required return period of flood risk.
3. Choose the storm return periods which will be used. These should range from 1:1 year to the required return period of risk.
4. For each storm calculate the probability for the tide level P.P = storm return period I required return period of risk.
5. Mark P on the tide level exceedence curve. The tide level which is required is the average of all tides above P. This can be approximated by the tide level for 0.5 x P.
6. Use a constant tide level equal to this value with storms of this return period and a range of durations.
7. Repeat from step 4 for each return period and then tabulate the worst flooding from the entire range of storms which have been analysed.

8. ANALYSIS OF OVERFLOW SPILL

The analysis of overflow spill volumes is normally done using a rainfall time-series. As the concern would probably be with pollution during the bathing season, the analysis may use only the parts of the time series which represent summer rainfall.

If the rainfall time series is intended to represent a typical year, it should be used with typical tide levels, i.e. mean sea level. It is therefore not necessary to carry out a seasonal analysis of tide levels to use only the summer events from the time series. Any seasonal change in mean sea level is small enough to be ignored.

Choice of storm duration

Systems which are affected by tide levels will be using storage in the system to attenuate the flows. The effective time of concentration of the systems and the critical storm duration will therefore be increased compared to a system which is not affected by tides. This causes two difficulties.

For large systems or those with a large amount of storage affected by the tide, the storm duration may become sufficiently long that it is not reasonable to use a fixed tide level as described above. A time varying tide level can be derived by drawing out a single tidal cycle as a sine curve using the fixed level calculated above as the peak level. The tide levels should then be read from this curve starting half of the storm duration before high tide. This requires a different level hydrograph for each storm duration and is therefore tedious, but may show significant savings for large systems.

The other problem with long duration storms is the effect of runoff from permeable areas in the wet conditions at the end of these storms. In particular the possible need to consider winter runoff conditions should be checked.

AMENDMENTS

Ver	Description	Date
1.	First Published	August 1991
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3.	Editorial Amendments	March 2009