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Wind effects on retention time in highway ponds

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The paper presents results from an experimental and numerical study of wind-induced flows and transportation patterns in highway wet detention ponds. The study presented here is part of a general investigation on road runoff and pollution in respect to wet detention ponds. The objective is to evaluate the quality of long term simulation based on historical rains series of the pollutant discharges from roads and highways.

The circulation in large water bodies like lakes and estuaries has been studied on high scientific level for decades (e.g. Lavel et al., 2003; Herb and Stefan, 2005). But the literature concerning wind effects on ponds and basins seems almost non-existing. The intention of this paper is to introduce some methods applied on larger scale to the small scale of basins and ponds.

The pollution of the water environment (primarily ditches, streams and rivers) caused by highway run-off focuses especially on heavy metals and PAH's. Accordingly a proper description of the transport of this pollution must emphasize on an accurate modelling of the transport of fine particles trough the detention ponds to the receiving waters. The weather influence on the transport mechanisms in the ponds has not been studied as intensive as e.g. the pond bathymetric. Potentially the wind-induced flows in these shallow ponds can exceed the size of the inflow generated flows. As a measure for the wind effects – the retention time for a dissolved matter are used as basis for comparison. The retention times for a tracer solution have been measured under different wind condition and modelled with the 3D CFD software MIKE 3 in a wet highway pond in the northern part of Denmark. The pond has a surface are of approximately 2500 m^2 a water depth of 0.6 m under dry weather condition and handles run-off from a 2,7 hectare highway cathment. The model has been calibrated on that location. Afterwards the model has been used on another pond placed in the middle part of Denmark. This pond has a surface are of approximately 2400 m^2 a water depth of 0.7 m under dry weather condition and handles run-off from a 4 hectare highway cathment. At this location the numerical part of the study is divided into two phases:

1. The wind effect on the retention time based on a spatial *uniform distributed* wind field (from the 4 corner of the world).
2. The wind effect on the retention time with spatial *non-uniform distributed* wind field due to the topography and vegetation of the surrounding. This is done by a combination of a wind model and a pond advection and dispersion model.

Phase 1 is more or less finalized and some of the results can be seen on figure 2a and 2b. Figure 2a and 2b shows to simulations with steady inflow and outflow. The colour graduation indicates the concentration of a

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dissolved matter 45 minutes after and momentary dosing. Figure 2a with no wind applied and figure 2b with a spatial uniform distributed wind from east (of 5 m/s)

Phase 2 (the non-uniform wind field) is still in progress, but it is obvious that the non-uniform wind field caused by local lee conditions can induce rather different circulation field in the ponds. Figure 1 shows the topography of the area around the studied pond used for the wind model. The interesting point is to see whether this significantly can have influence on the retention time of the ponds. The result of the one simulation with a spatial non-uniform distributed wind from east (of 5 m/s) can be seen on figure 2c.

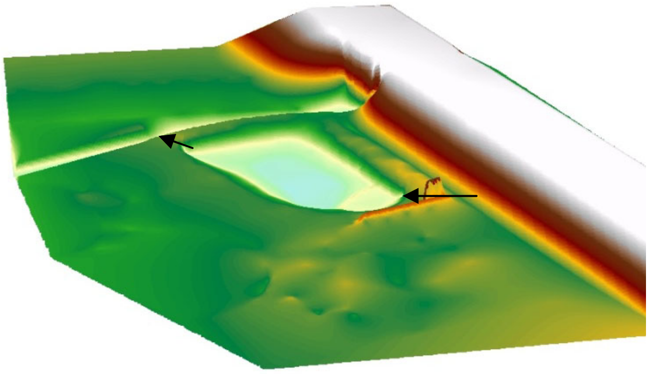

Figure 1. The topography nearby the highway detention pond.

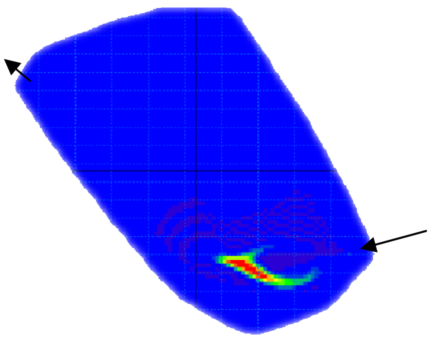

Figure 2a. No wind (45 minutes after dosing)

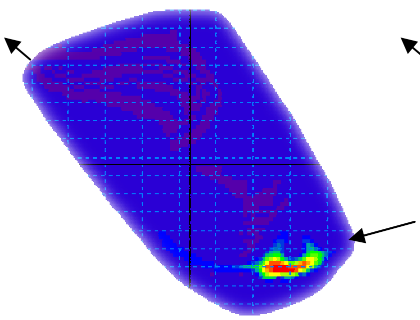

Figure 2b. Uniform wind 5 m/s east (45 minutes after dosing)

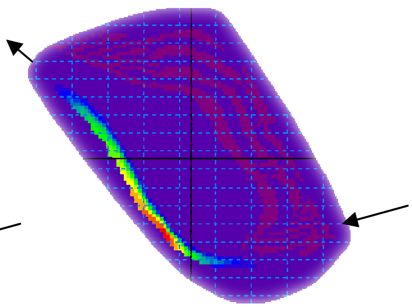

Figure 2c. Non-uniform wind 5 m/s east (45 minutes after dosing)

Some of the potential results of the study are summarized in figure 3. Figure 3 shows a comparison between models with no wind, uniform wind fields and non-uniform wind fields. The comparison parameters are the relation between the peak arrival and the hydraulic retention time and the relation between the arrival of the centre of mass and the hydraulic retention time.

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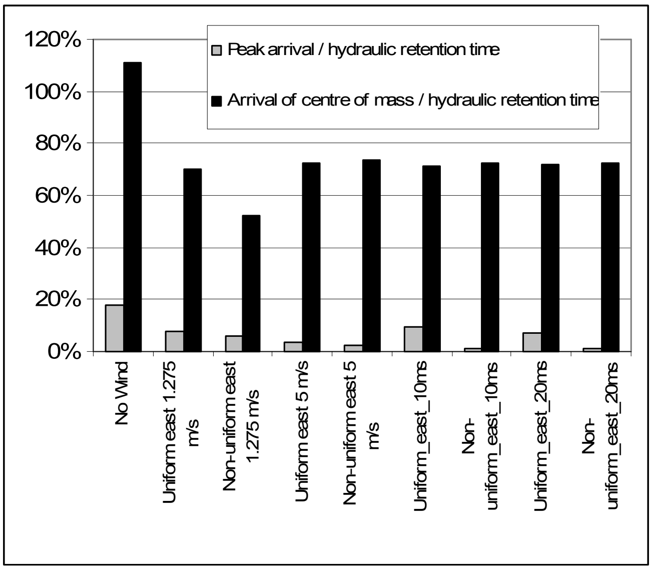

Figure 3. Comparison of peak and centre of mass arrival in relation to the hydraulic retention time.

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