WATER QUALITY ISSUES ASSOCIATED WITH LARGE DETENTION TANKS

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Introduction

Historically, large detention tanks have been designed with the main emphasis on hydraulic performance, with little or no account taken of the effect on the quality of the effluent after prolonged periods of storage.

This paper investigates the problems associated with the prolonged storage of wastewater within detention tanks, and in particular the effects on the sewerage system and treatment works when the contents of these large detention tanks discharge back into the system when the flow in the sewerage system has returned to its normal levels. Firstly an appreciation of the process within the detention tank itself has to be understood.

Detention Tanks

Designers at present generally design detention tanks on the hydraulic capacity needed to accommodate spills from a predetermined storm event, septicity if the storage period is going to be exceptionally long or the condition dictate that septicity is going to be a problem. Examination of the design of a number of tanks has shown that designers have not always taken account of the following factors :-

- Deposition and erosion of sediment

  Research into the behaviour of sediments in storage tanks has shown that they are affected by three processes.

  Settlement of sediment causing higher concentrations in the continuation flows, reduced concentration in the overflows and the settling out of sediment in the tank.

  The post depositional physical and chemical changes in the deposited sediment; and,

  The re- erosion of the deposited sediments at a later stage.

- Dispersion of pollutants within detention tanks

  Total BOD and COD are partially reliant on the concentration of the suspended solids. Therefore, as the suspended solids settle in the tank the concentration of both BOD and COD become increasingly strong the nearer to the tank bottom.

Both of the above should be taken into account at the design stage for two reasons. Firstly that the settlement of the suspended solids causing sedimentation in the detention tank if not eroded at the time of the tank emptying will cause both operational problems and a cost implication if manual removal of sediment is required.

The advent of the CDM Regulations in March 1995 has meant that every designer has a qualified duty to ensure that their design has adequate consideration for the avoidance of risk to health and safety of those carrying out construction work or cleaning work. Therefore, the operational maintenance of large detention tanks is something which, by law, must be considered at the design stage.

As a result of this, sediment deposition and its subsequent removal becomes a major design parameter. Efforts to predict the behaviour of the deposited silt are of great commercial importance since the CDM regulations and the forthcoming Confined Spaces Regulations mean that automated desilting methods will become much more common. These methods reduce the need for man-entry into the tanks but obviously are reliant on the efficient usage of plant to achieve optimum tank utilisation.

Secondly, that at the time when the detention tank starts to empty by either pumped or gravity discharge a plug of heavily contaminated flow will be discharged back into the system.

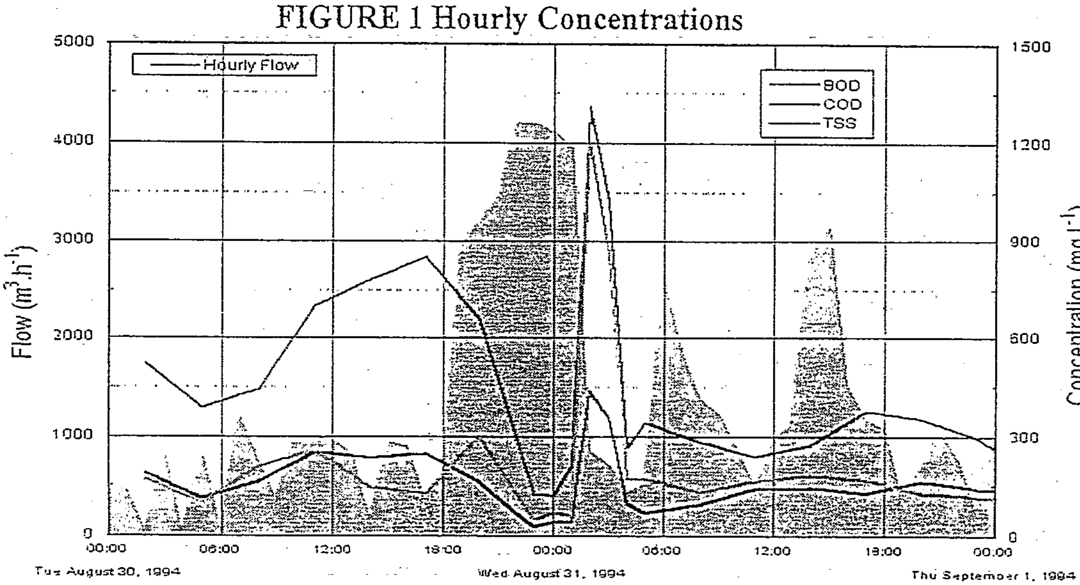
This plug of heavily contaminated flow or second flush is clearly indicated in Figure 1 which shows measured data collected from a sampling point located downstream of a large detention tank. From this data the following observations can be made;

- The first flush of contamination occurs as expected when the flow starts to increase due to the effect of the storm event passing through the system.

- The pollutants decrease rapidly to approximately a third of the dry weather flow when the flow is at its highest.

- When the flow subsides after the storm event and the tank starts to empty the pollutant concentrations increases to approximately 1.5 times greater that the first flush. This second flush in the example below is very peakish and has a short duration whereafter the pollutant concentrations return to their normal dry weather values. This pattern would vary dependent on the type and amount of storage available.

FIGURE 1 Hourly Concentrations



Effect of the Detention Tanks Discharge on the Downstream Gravity Sewerage System and Treatment Works

The effect on the downstream sewerage system when a large detention tank discharges is dependent on a number of factors ;

1 The gradient of the downstream sewerage system from the point of discharge of the detention tank. The relevance of the gradient is that if the discharge from the tank is constant i.e. a pumped discharge and the flow is steady then sedimentation will take place within the sewerage system. This has two implications. Firstly the sediment which will have a high concentration of pollutant may be eroded at the start of the next storm event causing a greater first flush at the works , or secondly the sedimentation is not eroded at the time of the next storm event causing an operational problem.

2 The discharge from the detention tanks discharges back into gravity system at the lowest point in the dry weather flow diurnal pattern. This again may result in low velocities in the sewer causing the identical problem as above.

3 The discharge from the detention tank may be septic after prolonged storage which has major implications on the operational maintenance of the drainage system.

4 The discharge flow with a high suspended solid concentration will have operational effect on any downstream pumping stations. ie sedimentation of wet well, excessive wear on pumps etc.

The following are the possible problems caused at a treatment works when these large detention tanks start to discharge back into the gravity system;

1. High loads/concentrations from tank effluent coinciding with normal diurnal peaks in load/concentration therefore increasing the chemical dosing requirements in primary treatment and the oxygen demand in secondary treatment processes.

2. Peak in poorly settling wastewater from tank effluent - the solids in the wastewater may have already flocculated and settled in the tank. Resuspension of the solids via high rate (high shear) pumps will cause the settling performance of the wastewater to deteriorate. Hence higher concentrations of BOD/TSS will breakthrough to the effluent or secondary treatment processes.

3. High concentration wastewater will settle better than weak wastewater but no. 2 will also apply.

4. Wastewater may be septic after prolonged storage - hence potential odour problems.

5. Effect on secondary treatment processes - after prolonged storage in the tank a form of degradation will have occurred resulting in an increase in dissolved BOD/COD concentrations. This dissolved material will pass through the primary treatment units to

the effluent or secondary treatment processes where there will be a increased demand for oxygen or chemical dosing. In addition it is possible that the increase in COD may be in a less readily treatable form than in fresh wastewater and hence pass through to the effluent.

6. Analysis and treatability trials would be advantageous in predicting the additional treatment capacity and operating costs required to cope with such wastewater.

Water Quality Model

An attempt has been made to simulate this second flush using Hydroworks QM on a very simplistic 10 pipe model. The model consisted of a gravity system with a large off-line tank connected to a pumping station by a small orifice. The pumping station discharges back to the gravity system just upstream from the outfall.

The model was used with a design storm of 600 minute duration, a return period of 50 years, and a simulation time of 30 hours to attempt to reproduce the observed result shown in Figure 1.

The result of this run showed that the pollutant concentration in the initial dry period reduced dramatically when the flow in the drainage system increased. This low level remained fairly constant until the storm event abated at which time the pollutant concentration returned to the normal dry weather levels. No further changes occurred in the pollutant concentration until the return pumps from the storage tank switched on. At this point the pollutant concentration returned to approximately the same level of pollutant consentrations as experience when the storm event was taking place.

These result were as expected except the model did not predict either a first or second flush. This is due to the fact that in the current version of Hydrowork QM does not yet model the transportation of bed load, gross solid transportation and deposition and erosion of sediments in storage tanks. It is understood from Wallingford Software that these issues are under review and will be included in future developments.

Conclusions

From the information above it is clearly apparent that the discharge from large detention tanks do have an affect on the sewerage system and treatment processes. However if the engineer at the onset of the design of a large detention tank takes into account the affect of storing large quantities of wastewater for long periods of time, the resultant problems can be minimised.

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Comment Brian Sharman North West Water

This is a good paper that clearly highlights the need to look carefully at the process implications of what we do in the sewer system.

Comment Richard Kellagher IHS

Richard Long , Adrian Saul and myself are looking at the operational implications of pumped detention storage and would be happy to have any comments from operators.

Answer

The tanks are getting bigger and more widely used but we still do not understand the processes that are going on.