PLANNING SOFTWARE FOR WASTEWATER TREATMENT DESIGN

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Introduction

The focus of wastewater modelling has moved away from steady-state to dynamic models. This reflects the greater concern with modelling the 'real world' experienced at sewage treatment plants, where the flow and load varies diurnally, and where important limits to meeting consent are the effects of such events as storms. However, many designers still use steady-state models as a starting point, as they provide an estimate for the initial sizing of units that will be required for subsequent dynamic modelling. They also require substantially less information about the wastewater before they can be applied.

Useful Design Features

The emphasis of computer packages for sewage treatment has been on the process performance. There has been much less work done on providing an integrated framework for hydraulics modelling. With the exception of Wallingford Software's CHAT hydraulic design within a sewage works appeared to be left to the development of individual spreadsheets. Hydraulics was not the only area neglected — the need to ensure that the proposed treatment processes could fit within the available footprint, and would be affordable, were also neglected.

WRc (UK/USA) and CDM (USA) have collaborated on the development of a new program, Plan-it STOAT, which is aimed at addressing these four issues — hydraulic and process capacity, cost, and footprint. Because the strength of steady-state modelling is in rapidly dimensioning a sewage treatment works, and providing design information at a time when there is little information available, Plan-it STOAT integrates these four criteria to rapidly screen out proposed designs that would be infeasible on the grounds of cost, land area required, or treatment performance.

With this end as the aim Plan-it STOAT was developed to include the following

- Process performance based on steady-state design models taken from CDM and general USA practice. As well as these 'traditional' methods the program also incorporates more recent developments, such as the IAWQ activated sludge models Numbers 1, 2 and 3. The models focus on common unit processes within the US, so that as well as activated sludge and biofilm systems there are also models for lagoons and chlorination. Different algorithms are available for the two needs - to calculate the size of a unit given the required effluent quality, or to calculate the effluent quality, given the unit size.
- Hydraulic grade lines are developed using hydraulic methods provided by CDM. These cover flow in open channels and head losses for a range of common fittings. Flow splits and unions are supported. Open channel flow automatically recognises various flow patterns and selects an appropriate numerical method to calculate the grade line.
- Costs are developed by starting with functions taken from TR 61 — the 1970s version — and using CDM's cost data to update the parameter values so that the costs are representative for the US. For use outside the US the costs can be converted through the use of a location factor. Costs cannot be converted between different countries simply by applying an exchange-rate factor — the costs are also affected by the difference in labour rates and the costs of raw materials. Based on the comparison of UK and US data, for example, the US costs were typically 50-60% greater than the UK costs. It is also possible to replace the cost function parameters with new values, or even to replace the functional form of the cost equation with forms preferred by the user's organisation.
- All units are represented by scaled circles or rectangles. These shapes can be rotated and moved around on the flowsheet. Where an exiting aerial shot of the site is available the map can be imported and used as a guide for laying out existing units, and providing quick visual feedback on other obstacles, such as buildings

and roads. These maps can be prepared from various sources, including site plans held as traditional CAD drawings.

Example Applications

The discussion of example applications is not based on any single actual site, but an amalgamation of various sites where such issues have arisen. It should not be taken as meaning that the problems described occurred through jobs undertaken by CDM or WRc.

Hydraulic constraints

Dynamic models, such as STOAT or GPS-X, are usually used to evaluate the process limits to performance — for example, how much flow can be treated before there is insufficient oxygen to remove BOD and ammonia, or before an overflow rate in a settling tank leads to too much carry-over of solids.

But this can lead to optimistic evaluations of the true limits. The true limit can be the flow that can be accepted before the headloss through splitting chambers exceeds that available. Many existing sites were designed so that they would operate with only a small available head, to minimise pumping requirements.

Many changes are made in the assumptions about tank volumes, invert locations, channel runs, and so on, as part of the evolution of a design. At one site a seemingly small change was made in the design, changing the position of some inverts. The change was seen as small, compared to the effort of recalculating the grade line, and the hydraulics were not rechecked. When the site was being commissioned it was found that it could not accept the peak flow required for the commissioning tests, as the water level exceeded the channel depth.

Footprint issues

At one site the evaluation focused on the need to improve treatment capacity. Two options were looked at: increase the MLSS, so that no new aeration volume was required. This would, however, require providing increased settling tank capacity because of the increased solids load to the settling tanks. The alternative was to increase the aeration tank volume, but operate at the same MLSS. This would allow the existing settling tanks to be used. Having looked at the capital cost the decision was taken to go for installing extra settling tanks. But the site layout was such that there was insufficient land area close to the existing settling tanks. Playing around with shapes indicated that the only place that provided sufficient land area was near the head of the works. This meant that there would be an additional pumping cost — but this would have affected the aeration tank alternative as well. The site had recently been upgraded and had the settling tanks been laid out differently there would have been sufficient land area for one extra tank — all that was immediately needed — alongside the existing settling tanks.

Plan-it STOAT allows ‘buffer zones’ to be placed around every unit. These buffer zones are used to indicate how close tanks can be placed together while still allowing sufficient space between them to allow access for maintenance. For some tank designs (e.g. common wall construction) this may not always be needed and the buffer zone can be switched for any tank. Using the buffer zone quickly allows decisions to be taken as to how closely tanks van be squeezed onto a site, and to allow for decision to be made as to where equipment such as instrumentation or pumps must be installed to maximised access.

Cost comparisons

In comparing different designs there are frequently cost trade-offs between processes that are expensive to buy but cheap to operate and processes where the reverse applies. Examples of these are trickling filters and activated sludge, or anaerobic digestion with pre-pasteurisation and TAD. Using Net Present Cost (NPC) allows these differences to be reconciled. The NPC will be affected by assumptions about the relative inflation of energy costs compared to general inflation (typically energy costs rise faster than other costs), the levels of labour required for operation and maintenance, and the replacement frequency for mechanical equipment. All these values can be altered, so that a quick assessment of the sensitivity of the costs when comparing different designs can be made.

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Plan-it STOAT was developed with the technical co-operation of CDM.

Discussion

Question John Bridgeman Severn Trent Water

What are the CAPEX and OPEX costs that are used?

Answer

They are based on old TR61 data. TR61 is a frequently updated costing database but is confidential. We use data that is outside the confidentiality period. This can be updated with the confidential information where available to the Water Company.