A Realistic Approach to Real Time Control

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1.0 Introduction

RTC presents a very attractive solution to wet weather flow management. Implementation of RTC also introduces significant risks and costs. The goal of the sewerage manager in implementing RTC should be to minimise risk and cost. The phased approach suggested here offers one route to achieving this.

RTC is a big step to make from our current level of understanding of sewer system performance. A phased approach to real time control schemes provides a logical link between current collection system performance assessments and the refined understanding required to implement RTC. The approach presented here recommends 2 steps between the Drainage Area Studies and RTC. The goal is to maximise system understanding and minimise the number of locations where control is implemented.

2.0 Why RTC?

It may be useful to re-iterate the main reasons why there is currently so much interest in the use of real time control in sewerage networks.

- ***reduce pollution*** - the EC directives, public health and the environment demand that we control the discharges from urban drainage areas.
- ***reduce flooding***
- ***reduce costs associated with reducing flooding and pollution*** - optimising treatment works and collection systems provides an alternative to the construction of new facilities. Sewer system optimisation with RTC or simpler means (discussed in 5.2 below) have proven to have a 10:1 to 100:1 cost benefit.
- ***the technology exists*** - the fact that RTC has been implemented a number of times and that the technology exists means that it cannot be ignored. Sewage no longer just "happens". The promise of RTC is that wet weather flows can be controlled, managed. Therefore it is incumbent upon responsible managers to evaluate it.

3.0 Phased Approach - Managing Cost and Risk

The sewerage manager can use available technology to gradually introduce RTC in areas where it is prudent using 4 steps. These steps increase in cost and risk. The highest costs and risks occur where and when RTC is implemented.

The aim of the four phases is the following:

- to use lower cost and lower risk schemes to reduce the use of higher cost and higher risk schemes.
- to allow the manager to take the first steps to sewer system optimisation without committing to a particular strategy (RTC or other) at the outset.
- to provide a base of modelling and monitoring that can be steadily modified to progress to the next phase.

The rest of the discussion and the figures will attempt to define the 4 phases and illustrate the progression in general terms. The scope, cost and risk factors presented for each phase are realistic without attempting to be exacting - all of these factors have wide ranges. The cost and risk trends are undeniable.

4.0 *Phase 1 - Modelling and Drainage Area Studies (DAS)*

Scope - A DAS will be performed on most of the sewer networks. Exceptions would include most low population and rural catchments and those for which the engineer determines that no model validation was necessary.

Goals - The DAS model building and verification activities have given sewerage managers a fundamental understanding of the sewer networks performance characteristics. These have been successfully used to help tackle the problems of inundation and sewer collapses and to provide the basis for assessing major investment goals.

This first phase of system performance understanding is based upon 5-10 weeks of flow data and force-fitted models. More extensive system performance data and accurately verified models will be required to confidently develop water pollution control schemes.

Technology - A DAS is performed with standard hydraulic models such as WALRUSS, SPIDA and with flow survey loggers. The flow meters and models employed have limited reliabilities and operating ranges.

Cost - DAS's have a relatively low cost per node.

Risk - There is relatively little risk associated with the DAS. The error margins are fairly high in both the modelling and the monitoring. These errors are understood and accepted.

5.0 *Long Term Monitoring and Modelling (LTM)*

Scope - This phase involves long term performance monitoring of key elements of the collection system and refinement of the models.

Permanent, telemetered monitoring technology will be placed at key locations in the collection system. These locations will include major trunk sewers, significant branches of the collection system, key overflows and at other structures where RTC might be implemented (such as existing retention facilities, etc.).

The number of sites selected for monitoring in this phase will be dictated by the collection system configuration and the judgement of engineers and operators. The number of sites will be less than that required by DAS's.

The length of the monitoring will be for several years and in many cases the sites will become a permanent part of the network.

Models will become "living models" - they will be continuously refined through continuous verification and improvements in the modelling tools themselves.

Goals - The goals of this phase are as follows:

- ***sewer system optimisation** <u>without major construction and RTC</u>* - measurement of flow and level at key points over longer periods will allow the managers and operators to make the following changes to optimise the system:

    1) ***remove bottlenecks*** - flooding and overflows are frequently caused by fixed or transient bottlenecks in the network. These are frequently caused by capacity restrictions such as flat grades, pipe diameter changes, crushed pipe, siltation in pipes and siphons, malfunctioning machinery such as pumps and penstocks, etc. These can be identified by continuous monitoring and modelling.

    2) ***minor changes*** - raising weirs, sealing marginal overflows, modifying existing control structures. These are "safety critical" decisions that cannot be made confidently without intimate knowledge of historical performance and immediate feedback.

    3) ***infiltration reduction*** - infiltration can comprise 50% or more of annual flow in a network. This robs treatment plants and pump stations of capacity. Infiltration can be cost-effectively removed. Long term gauging is the key to documenting the effectiveness of these "flow reduction" activities.

- ***finely tuned models***

- ***development and testing of "what if scenarios"*** - the fine tuned model and the feedback from the long term performance monitoring can be used to begin "playing" with more costly and risky schemes. This would include ***identification of locations where RTC might be applied.***
- ***enhanced, proactive operational management*** - LTM has been embraced by many sewer agencies as the key to effective operational management of the network. This is a concept that is practiced in all other pipeline management fields (gas, oil, water) and is only now reaching the sewer.

Technology - The technology in the Long Term Monitoring and Modelling phase must exceed what has been applied in the DAS. Long Term or Permanent Monitoring in sewers will require various features not available in flow survey technology such as:

- telemetry - sending field crews to collect data and maintain the sites will be impractical and too costly. Since this is historical data gathering, telemetry should be low cost PSTN (standard dial-up phone lines).
- low maintenance features - the outstations will need to be robust and incorporate fault tolerance, low power requirements and non-ragging sensors (very small or non-intrusive).
- no construction should be required - existing sewer structures should be used.
- automation - data collection, archiving and reporting should not require operator "hand-holding".
- data storage - data is not required on a real-time basis in the LTM phase. Thus data can be stored remotely and collected as needed or on a regular basis (1/week).

Long term model refinement will mean "maintaining" models. It will also mean doing serious detective work to resolve anomalies instead of force-fitting.

Cost - The costs for LTM will be significantly higher than those associated with the DAS. The justification for the costs is in the capital and operational savings that can be achieved with LTM alone. The Sydney Water Board in Australia has achieved greater than a 100:1 cost benefit through optimising in this phase.

All of the investment and all the technologies put in place in the LTM phase can be amortised. Further, the measurement and modelling can be applied in the RTC phase to come.

Risk - The risk with LTM is low. There are no "safety critical" decisions required here, no RTC and no construction. The monitoring system is completely flexible. Sites can be removed or relocated and the sensor systems can be applied to the future investment in RTC. The LTM phase can be said to reduce risk since it allows time to gain system understanding and to do informed planning. It increases the confidence in future, higher risk decisions such as sizing of new facilities and RTC implementation.

6.0 *Real Time Data Acquisition (RTDA)*

Scope - The RTDA phase involves selecting key points in the sewer network critical to RTC. Flow and level data will be collected from these points on a real-time (on-line) basis. A finely tuned, on-line model will be used for simulation of real-time control. Various models may need to be tested.

Long Term Monitors used in the previous phase will need to be added or moved to locations critical to real-time control. The number of sites selected will be limited. The RTDA sites will be a small fraction of the number applied in the LTM phase.

Goal - RTC strategies will be "tested" and modified according to the results. Monitoring sites may be moved or added during the feasibility testing as needed. The engineer can be certain RTC will work at the locations selected. Mid-course corrections can be made easily. Is the selected model robust enough for the task? This question can be answered. It may be useful to test several models.

Technology - The same outstations installed in the LTM phase will be used here. However, the selected sites will require the following:

- mains power.
- pavement mounted or buried enclosures.
- real-time telemetry - leased lines, radio or other.
- dedicated, real-time central station and SCADA package

Cost - All of the above technology enhancements will increase the costs.

Risk - The risk is higher with RTDA due to increased investment, loss of flexibility due to the minor construction required for the remote sites. There are still no safety critical decisions involved. The risks of making mistakes in the final implementation of RTC are reduced by this phase.

7.0 *Real Time Control (RTC)*

Scope - This phase will involve all the planning and construction associated with RTC. RTC should be used in the smallest number of sites possible and the technologies applied should be the simplest and most robust.

Goal - The goals have been discussed at the outset and will not be restated here.

Technology - The RTDA network can be modified with the addition of the following elements:

- remote or local control facility including PLCs and control programs.
- control structures such as gates, weirs and valves.
- flow storage may be required depending upon the capacity of existing storage.

Cost - The costs are considerable due to the design and construction required.

Risk - Risks are considerable. These can be reduced by limiting the amount of sites where RTC is applied, by keeping the technology simple and by having failure modes that prevent flooding in critical areas.

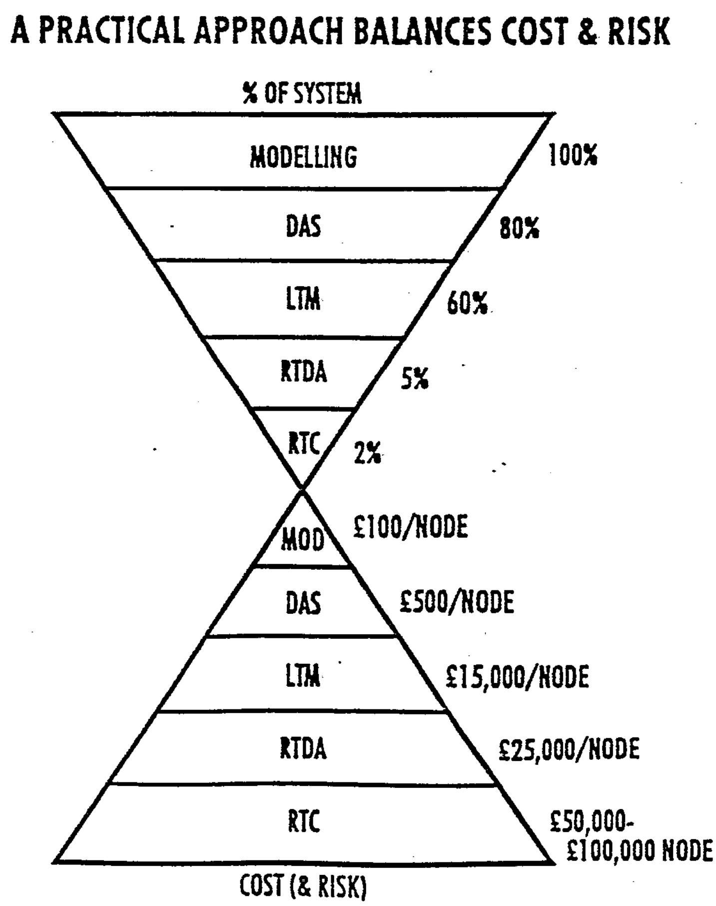

Figure 1 - Lower cost and lower risk activities help reduce the high cost and high risk schemes

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Question Robin FitzGerald Reid Crowther

What are the risks in real time control is it the equipment or is it that we often don't understand the system?

Answer

Yes both, particularly in the US where there has been a backlash on the legal implications of CSO spills in areas controlled by RTC systems.

Comment Sam Serkin ADS Environmental Services

The big push to automate sewage plants in the 70's and early 80's resulted in failures. This was because the treatment was not clearly understood prior to implementation of control schemes and because the control schemes relied on sophisticated sensors and software systems that were not applied correctly and were not accepted by the operators. The result was the headline that appeared in a US journal "High-Tech Junk Litters Waste Water Landscape".

Written Question Camylyn Rainey Wallingford Software Ltd

I think there is great benefit in applying a staged approach,similar to the approach which you set out in your paper, to the implementation of RTC. However I feel that the greatest benefits will arise from an approach that which makes use of all available information. How can sewer system models and data be complementarily applied, in each of the 4 stages identified in your paper, to develop RTC solutions?

Answer

At each stage of the phased approach to RTC suggested there are complimentary and equally important modelling phases:

Phase 1 - Drainage Area Surveys

The existing modelling using WALLRUS and SPIDA is probably sufficient. However, for RTC planning more accurate and more intensive data may be needed for better verification.

Phase 2 - Long Term Monitoring and Modelling

The existence of longer term data will provide for more accurate model verification, lead to seasonal understanding and allow the development of dynamic solutions using live models. Instead of comparing model results for a single storm or for 5 weeks, the model will be reinforced with a year or more of data. The hard detective work to resolve anomalies between measured and modelled flows will require more field investigations. All this will increase model accuracy and the engineers' confidence in its ability to predict.

Phase 3 - Real Time Data Acquisition

On-line and off-line simulation using models and actual data from the sewerage network will allow the development of "what-if" scenarios in a non-safety critical environment. Where control structures (penstocks etc) may already exist in the network, manual control can be used in this phase to test the on-line predictive modelling.

Phase 4 - Real Time Control

The use of good modelling once RTC is implemented is well documented and will allow the continual improvement of the operational control strategy.