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COMBINED SEWER OVERFLOWS (CSOs)

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I.0 INTRODUCTION

In the UK the development of sewerage systems has been based on the conveyance of domestic and industrial effluents and the surface runoff from catchment surfaces in underground conduits.

Three types of system are used:

- combined systems, where foul and surface waters are conveyed in the same pipe
- separate systems, where foul and surface waters are conveyed in different pipes, and
- partially separate systems, which are a combination of the combined and separate systems.

Of these, the most common type of sewerage system utilised in the UK is the combined system.

Combined sewerage systems incorporate combined sewer overflows (CSOs) to divert excess flows received during storm events into nearby receiving waters, thus relieving other hydraulic structures within the system and reducing the risk of flooding in urban areas.

Discharges from CSOs, known as intermittent discharges, contain both foul sewage and storm water and therefore contain large amounts of pollutants, including gross solids and finely suspended solids in solution. These pollutants can have a significant aesthetic, oxygen demand or toxic impact on the quality of the receiving water.

Estimates compiled in the early 1990's indicate that there are approximately 25,000 combined sewer overflow structures within the UK, and of these approximately one third were believed to have hydraulic or pollution performance characteristics that could be classed as unsatisfactory.

The Urban Wastewater Treatment Directive (UWWTD) requires member states to take action to limit pollution from CSO's and improve unsatisfactory intermittent discharges (UIDs).

In the broadest definition, an intermittent discharge may be produced from any of the following locations:

- a combined sewer overflow (CSO) structure
- an emergency overflow at a pumping station and / or detention tanks
- an overflow from storm tanks at a sewage / wastewater treatment works, and
- an overflow from an emergency spill weir at a sewage / wastewater treatment works.

This legislation, together with related directives such as the Bathing Waters Directive and the Shellfish Waters Directive, has led to significant industry-wide capital expenditure on improving recognised UID's, commencing with the second and third Asset Management Plans (AMP2 & AMP3), due for completion in 2005. THE UK Environment Agency identified a total of over 4,500 UID's which required improvement within the AMP3 period, and it is anticipated that approximately 2000 more will require attention over 5 years commencing April 2005 as part of AMP4 investment.

As a result, a significant amount of research into CSO related issues has taken place in recent years, which in turn has led to many developments in the design of these structures.

2.0 CSO RESEARCH

CSO research in the UK has been largely industry driven, with research providers such as United Kingdom Water Industry Research (UKWIR), the Water Research Centre (WRc) and Foundation for Water Research (FWR) working with leading academic bodies such as the Universities at Sheffield, Bradford, Coventry, Sheffield Hallam, Abertay (Dundee) and Imperial College, London.

Of these research providers, UKWIR is funded directly by the UK Water Companies and specialises in one-voice research designed to meet the needs of the water & sewage service providers. As a result, and in response to the large number of unsatisfactory CSOs identified in the early / mid 1990's, UKWIR has funded / supported many CSO-related research projects.

The "CSO Research Club" was founded in 1996 by Barry Thompson (then of Northumbrian Water), Roger Pacey (then of Severn Trent Water) and Professor Adrian Saul, of the University of Sheffield. Membership expanded rapidly to include representatives of every UK Water Company, and the "club" became incorporated under UKWIR, as the CSO Research Group, in March 1997.

The UKWIR CSO Research Group managed a varied programme of CSO-related research projects over the next four years, using established research providers, academic bodies and specialist consultants as research contractors.

Many CSORG projects were focussed on the performance of CSOs (with and without screening equipment in place) in achieving the control of aesthetic pollutants in intermittent discharges. Other projects researched the use of flow control devices, scale effects, characteristics of sewage particles, the use of Computational Fluid Dynamics (CFD), an evaluation of event logging equipment, the effect of climate change on CSOs, and many other related issues.

The UKWIR CSO Research Group no longer exists as a formal collaboration, although CSO-related research work continues under the control of various bodies, with many former CSORG personnel or associates still actively involved in this field.

Several of the UK Water Companies have conducted large-scale, field-based evaluations looking into the performance of various CSO designs and / or screening equipment, and a major project, funded by the Engineering & Physical Sciences Research Council (EPSRC) and UKWIR entitled "Predicting Aesthetic Pollutant Loadings at CSOs" was concluded and published to the industry in June 2002.

ThompsonRPM specialise in the management of research projects and continue to be involved with all aspects of CSO performance and research, utilising established working relationships with most of the key-contributors in this highly topical and relevant field of research.

3.0 CSO DESIGN

The design of CSO chambers within the UK has been driven by a series of laboratory studies and fieldwork evaluations conducted over the past 40 years, commencing with work done by Sharpe & Kirkbride in 1959 which was developed by many researchers during the 1960s, 1970s and 1980s, culminating in the first UK design guide for CSO chambers, entitled “ER304E – A Guide to the Design of Storm Overflow Structures” and published by the Water Research Centre (WRc) in 1988. This Guide gave recommendations for the hydraulic design of four types of CSO chamber, being the high side weir, stilling pond, vortex with peripheral spill and hydrodynamic separator.

Subsequent research however highlighted that the gross solids retention performance of these chambers was relatively poor, with solids simply dividing proportionate to the flow split during overflow events. As a result, a new report, entitled “FR0488 – Guide to the Design of Combined Sewer Overflow Structures” was published by the Foundation for Water Research (FWR) in 1994.

Subsequent full-scale research however, conducted at the National CSO Test Facility, Wigan WwTW, again demonstrated that the solids retention performance of these chambers was little better than the ratio of the flow split. As a consequence, attention has since focussed on the development of screen technology and the design of chambers for use specifically with screens.

A wide range of many generic types of screens are now available in the UK, and site evaluation has shown that almost all can meet the UK Environment Agency “6 mm x 2D” standard, which calls for separation from the effluent of a significant number of solids greater than 6 mm in any two dimensions. Although other EA standards exist, including “10 mm x 1D” and “Good Engineering Design” the appliance of these has been limited, partly because of the anticipated poor solids retention performance of a chamber designed against these standards, and partly because screen design has defaulted to the most stringent of the standards likely to be encountered.

As a direct consequence of the increased use and interest in utilising screening equipment at CSO’s, a further deign guide, entitled “The Design of CSO Chambers to Incorporate Screens” was published by the Wastewater Planners Users Group (WaPUG) in June 2001. To date this “WaPUG Guide” remains the industry standard in the UK, with wide-spread use as the Water Companies seek to improve over 4000 CSOs identified as unsatisfactory within the current Asset Management Plan (AMP) Period.

The WaPUG Guide focuses primarily on the design of a chamber to incorporate an appropriately designed screen. The Guide seeks to ensure that flow patterns are commensurate with effective screen operation, the chambers are compact and therefore more cost-effective, and the risk of sedimentation or blockage is minimised. The WaPUG Guide does not however seek to give advice on the selection, design, installation or operation of screens.

As a result, ThompsonRPM have worked with a number of UK Water Companies in developing CSO Design Guides. These guides are specific to each clients individual needs and offer advice on screen selection, followed by the development of standard CSO chamber designs, using the WaPUG Guide as a basis then incorporating the particular requirements of each identified screen solution.

Ancillary items such as event loggers and flow control devices can be included, and the Guides are updated, normally on an annual basis, to take account of developments in existing technologies and the emergence of new technologies. Seven of the eleven major Water Companies in the UK are currently using CSO Design Guides produced by ThompsonRPM.

4.0 CSO POST PROJECT APPRAISAL

The UK Water Industry has recognised for some time that a standardised method for reporting the environmental impact of CSO discharges on receiving water courses would be good practice in urban pollution control. Such a methodology could assist in identifying CSO's that perform unsatisfactorily, be used in prioritising improvement schemes, and then act as a "certification" that previously unsatisfactory locations are now performing to an acceptable standard.

Work in the early 1990's funded jointly by the-then National Rivers Authority (later to form part of the Environment Agency) and the Foundation for Water Research (FWR) led to a report published in April 1994 entitled "FR0466 – User Guide for Assessing the Impact of Combined Sewer Overflows". This report suggested a procedure involving field-collected data, such as visual assessments of dry weather operation, sewage related debris, sewage fungus, public access and water amenity value, together with historical record data, such as the number of public complaints, the number of pollution incidents, and the status of the receiving water course.

Following the issue of FR0466, United Kingdom Water Industry Research (UKWIR) commissioned a review of Post Project Appraisal techniques, with a specific objective of developing simplified, quicker methods of PPA which would allow findings to be assimilated into best practice design. The resultant report, entitled "01/WW/08/11 – Simplified Post Project Appraisal of CSO Performance", was published in 2001. The report serves as a collection / review of historical and current techniques which could be applied, and seeks to identify which of these would be the most simple to conduct in the field, but it does not attempt to draw any of these into an all-encompassing structure, nor does it suggest any new techniques which could be used.

With the increased usage of screening equipment at CSO's in order to meet aesthetic control regulations, greater emphasise has been placed on the performance of this equipment following installation and commissioning. As a result of the huge number of such installations currently being undertaken by the UK Water Companies, issues such as operability, maintainability and whole-life cost have emerged alongside the more traditional, regulation-driven, concerns such as chamber / screen solids retention performance and the condition of the receiving water course.

ThompsonRPM, working in conjunction with several of the UK Water Companies, have developed a structured protocol covering the on-site assessment of CSO / Screen performance. This Post Project Appraisal protocol consists of a series of one-off site inspections reported individually, then summarised with conclusions, recommendations, etc, in a project end-report. Issues under review typically include the following:

CSO Chambers - Type / Design Guide Compliance / Location / Responsibility for Site Operation

Chamber Access - General, Vehicle & Personnel / Screen Removal & Maintenance

Screens - Screen Type / Installation Issues / Condition

CSO / Screen Performance - Operation of Relief / Premature Operation / Self Cleansing

Operation / Maintenance - Operator Awareness / Maintenance Routines

Receiving Watercourse - Location of Outfall / Condition of Receiving Watercourse

4.0 CSO POST PROJECT APPRAISAL (CONT)

The TRPM Protocol includes for each CSO chamber under review to be inspected internally and each screen to be subjected to a detailed mechanical, structural and operational inspection. Operatives are interviewed at each location, and the condition of the receiving watercourse is assessed wherever possible.

Typically, the project End-Report contains site-specific individual Inspection Reports, with the findings summarised in the form of generic conclusions. The report findings give an indication as to where investment has been correctly targeted and expended, but also indicate areas where the overall investment may not have fully achieved the original objectives.

With regards to the work carried out to date, several design issues have come to light, which will be fed back into the design process. The End-Reports also highlight areas, (such as Op-Ex allowances for locations with difficult access), where additional investment may be required.

For a detailed summary of Post Project Appraisals conducted by TRPM on over 200 CSOs within the AMP3 period, refer to Thompson RPM Technical Note Ref TRPM-TN003 – 'AMP3 CSO Post Project Appraisal' – Version 1.0, issued October 2006.