

SEWAGE AND CATCHMENT CHARACTERISATION

TECHNICAL NOTE REF	:	TRPM – TN004
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VERSION	:	3.0
DATE	:	JANUARY 2016

1.0 INTRODUCTION

The difficulties in characterising 'typical' sewage with regards to gross solids / screenings content have been recognised for years by practitioners, with variables such as catchment characteristics, diurnal flows and storm conditions influencing the type and volume of screenings expected at an STW at any one point in time.

A Water Industry Seminar on STW Inlet Screening / Screenings Treatment was held on 20 October 2005 at Birchwood Park, Warrington. The Seminar took the form of short presentations on relevant issues, with at least one representative present from each UK Water Company. One of the main areas of concern identified was the lack of (or poor quality of) pre-design information provided to suppliers when new equipment is being specified.

Water Companies are constantly upgrading inlet works facilities across the UK. As part of this, the need has been identified for a greater understanding of the extreme conditions likely to be encountered at the inlet works at times of high flows and / or under storm conditions. This is particularly required for use when designing and sizing new screening and screenings handling equipment. Most inlet works, and particularly large sites, receive a wide variation in incoming flows and gross solids loadings, and in many cases existing screens etc are unable to cope with the peak conditions received.

Information regarding flows that would be useful when sizing equipment would include the minimum, average and peak flow rates, preferably based on real measurement. Indications of the maximum and minimum permissible flow approach velocities, together with 'worst-case' rates of rise in incoming flow (for example with off-site pumping station start-up) would also be beneficial.

Flow velocity can be calculated with the knowledge of flow rate and an initial design of carrier channel, etc. The minimum velocity should be such that grit is not encouraged to settle in front of the screen, the maximum velocity should be such that screenings are not encouraged to 'extrude' through the screen apertures. Traditional values for these figures would be in the region of 0.3 m/sec (minimum) in the approach channel to the screens, and 1.2 m/sec (maximum) through the screen apertures. It should of course be noted that the approach velocity in the channel upstream of a screen will increase significantly at the screen curtain due to the sudden reduction in cross-sectional area available to the flow.

Information regarding gross solids loads that would be useful when sizing equipment would include the minimum, average and peak solids loading rates, preferably based on real measurement.

The accurate prediction of gross solids loading is extremely difficult, with catchment characteristics, network operation, weather conditions and seasonal variations all being significant variables which determine the actual rate of receipt of gross solids at STW. The efficiency of the STW inlet screens then determines what proportion of this is removed and discharged into the screenings handling equipment.

Unexpected overloading of screens and screenings handling equipment is a common occurrence during storm events, leading to further problems within the STW. This can also lead to considerable operational expense, as rectification is usually by manual means involving close contact with unpleasant substances.

2.0 PREVIOUS WORK

2.1 Severn Trent Water

During the mid 1990s, Severn Trent Water carried out a series of investigations into screenings production rates at different STWs. Unfortunately this work was conducted at a time just before the current use of fine screen technology became popular.

The work did however introduce for the first time the concept of the 'peaking factor', a measure by which the 'first flush' phenomenon (the sudden arrival at the works of a large quantity of gross solids, normally flushed out of the sewerage network by the first heavy rainfall following a prolonged dry period) could be quantified.

Several internal reports compiled by STW personnel exist, with estimates and allowances for peaking factors varying widely, from a conservative 10 to an extreme of 100.

2.2 UKWIR / CSORG – Characterisation of Sewage Particles

In 1997, the UKWIR CSO Research Group commissioned two projects. One, led by Sheffield Hallam University was to assimilate relevant data from ongoing / previous studies and to carry out an evaluation process on gross solids. The objective was to categorise the different particulates, and produce distributions of terminal velocities for each category.

The second project, led by the University of Sheffield, was to evaluate the terminal velocity characteristics of the sewage particulates which entered the National CSO Test Facility at Wigan WWTW, and to monitor changes which occur due to the time of day and at different flow rates.

The two projects were summarised in one combined UKWIR report, ref 01/WW/09/10, entitled 'Characteristics of Sewage Particles' and published in 2001. The report concluded that large sanitary products may break down in the sewer system but a significant proportion remains intact. It was also found that the mass of particulates varied during the day with morning and evening peaks, and that terminal velocities of faeces were generally greater than those for fibrous sanitary products. It was suggested that a CSO that retains a significant proportion of sanitary products would also retain faecal material, with faeces likely to remain in the invert of CSO structures and pass forward to treatment.

2.3 Thames Water – SCITTER

During AMP3, Thames Water developed a Screenings Investigation Test Trial Evaluation Rig (SCITTER) in an attempt to quantify screenings concentrations. The work involved long term sampling of raw sewage at Acton STW utilizing Copasacs for solids capture.

A total of 40 storm events were captured over a 2 year period, with factors such as the number of preceding dry days also noted. Results were derived in units of mg of screenings per litre of flow, thus direct comparison with the more normal rate based on population is not possible. As an example, however, dividing the highest event maximum load found by the lowest event average load would give a 'Peaking Factor' of 1,616 !

The project report concludes that further investigation should be conducted, and also recommends the evaluation of the "Grossim" software package (see below).

2.0 PREVIOUS WORK (CONT)

2.4 UKWIR – Screenings Quality & Quantity

The only major national level collaborative attempt to examine extreme conditions commenced in 1998, when the UK Water Companies, via their research collaboration UKWIR, launched a project entitled “Screenings – Quality and Quantity”.

The project, led by Sheffield Hallam University, aimed to provide basic information and data for good practice in design, installation and operation of inlet screens and screenings handling plant. A methodology to determine the performance of different types of screenings handling plant was to be developed and applied to five screenings handling systems.

This project was not completed however, due to funding restrictions imposed mid-way through the project life. The work that had been carried out was the subject of an UKWIR report, ref 00/WW/06/03, entitled ‘Screenings: Quality & Quantity’ and published in 2000. The report concluded that the mass and proportion of screenings particulates varies throughout the day, and that faecal material, fine paper and sanitary products make up approximately 70% of screenings. Between 10% and 30% of the screenings caught were classed as faecal material, identified as the main contributor to screenings BOD.

The report noted that the quantity of screenings arriving at treatment plants may increase in wet weather and affect the screenings handling plant, and that there were at the time no models available to predict the quantity of screenings arriving during wet weather, thus causing difficulties in specifying the performance requirements of screenings handling plant. The report also concluded that increasing legislation may make sending screenings straight to land fill a costly option, or not an option at all, and predicted that the rising cost will make incineration a viable option of pre-treatment before going to land fill.

The report also predicted that future documentation requirements will drive the need to measure the quality of screenings, and one of the key recommendations stated that ‘there is a perceived need for a study to develop a design tool that will predict the variation in screenings material arriving at treatment plant during wet weather’.

2.5 MWH Global – Grossim

During early AMP3, funding from the Engineering & Physical Sciences Research Council (EPSRC) led to the initial development of a software package intended to ‘bolt on’ to existing network modelling software such as HydroWorks / InfoWorks. The objective was to develop a ‘tool’ which would quantify catchment characteristics, track solids movement and predict solids loadings at CSOs and Treatment Works. Field work was conducted on three catchments within the city of Sheffield, each with different physical and socio-economic characteristics. The eventual ‘Gross Solids Simulator’ was published as “Grossim”.

Following initial development, consultants MWH Global secured the IPR for the product, and developed the software to work in conjunction with InfoWorks and in-house software such as Data Manager. MWH saw the product as best used as a predictive comparator, for example indicating the proportional increase in gross solids arriving at STW as more CSOs in the catchment are fitted with screens, although little development or evaluation work has since taken place.

3.0 SEVERN TRENT / THAMES WATER JOINT STUDY – SEWAGE CHARACTERISATION

During 2006, Severn Trent Water and Thames Water combined to fund a brief study into how Water Cos and their Consultants / Purchasers / Specifiers can characterise incoming sewage approaching inlet works in order to provide better information to potential screen / screenings handling equipment suppliers for use in tender, sizing & design exercises. It was determined that this study should be a desk-top exercise identifying what techniques and parameters are already available, any areas where knowledge could be improved, and what characterising techniques could be developed (or imported from other industries).

Representatives from each funder met with representatives from some of the UK's leading screen suppliers to discuss these issues. As the screen suppliers are the ultimate end users of design information, and have the responsibility to use this and correctly size equipment, it was felt that understanding their experiences and opinions would be of great value to the study.

The report concluded that the Water Company preference for WIMES Specifications is not necessarily reflected amongst Consultants / Contractors, and there is evidence of incorrect use. Nevertheless, WIMES offers the best means of information transmittal available and the potential exists, within the regular reviews, to extend the Datasheet prompts, thereby improving the information provided. Whatever means of transmittal is used, it is clear that screen sizing and design could be improved with the provision of more, and more accurate, information. Particular areas to address include the provision of more catchment characterisation information, and the provision of more accurate, fact-based, information regarding peak flow and load conditions.

The report also noted that individual constituents such as grit, FOG and fibre are not seen as major issues by suppliers, partly because quantification is difficult, but also because the knowledge is not necessarily available from which to create a suitable design response. Issues such as tanker discharges and saline concentration are however easily quantifiable and can be easily addressed within equipment design.

The report identified that whilst current design guidance appears to be generally adequate, extreme conditions are not necessarily covered. The tendency can be to over-design, rather than under-estimate. An industry-wide acceptable system of establishing average and peak gross solids loadings is required, and a standardised 'Catchment Characteristic' should be developed to provide designers with appropriate information. This could possibly be incorporated in future WIMES Specifications.

The report recommended that, wherever possible, flow surveys should be carried out as part of Feasibility Studies. These should be of as long duration as practical, and include flow level monitoring if headloss is likely to be an issue.

The report also recommended that Catchment Characterisation should be applied to known results from 'peak load' field work to establish trends, and that more 'peak load' investigative work should be done across a broad range of STW (selected by size, characteristic, process, etc) in order to ultimately establish a system of quantifying average and peak conditions for use in screen design which is acceptable to all parties. This should include the development of a 'Peaking Factor Matrix' taking into account as many variables as possible.

4.0 PEAK FLOWS / LOADS SURVEYS

4.1 Background

Working on behalf of Severn Trent Water, TRPM developed a methodology for quantifying peak flow / gross solids load conditions at STW inlet works. The protocol allowed the measurement of existing average and maximum flows and loads, which led to site specific 'peaking factors'. These were then used to predict future flows / loads when designing and sizing screens and screenings handling equipment.

To date (January 2016) a total of 11 inlet works within Severn Trent Water have been surveyed. In addition, a further 8 locations have been surveyed within other Water Cos – being Scottish, Southern, South West, United Utilities, Wessex and Yorkshire Water.

4.2 Procedure

The monitoring involved a site survey of incoming flows, either by existing instrumentation or by temporary ADFM or FLO-DAR monitors. Screenings loads were identified by the continuous monitoring of temporary weighbridges inserted under the screenings skips, to establish the rate of production of screenings by the STW. Existing influences such as screen efficiency, screenings handling equipment dewatering efficiency, etc, were incorporated by assessment and within data manipulation, to assess the total volume / mass of screenings arriving at the STW at any one point in time.

The duration of the monitoring period varied from 3 to 9 months, with 6 months being typical, including wherever possible the wetter, winter months. Surveys were preceded by a brief Feasibility Study / Research Proposal identifying practicalities, total costs, risk to accuracy of results, etc. Each assessment was funded by capital means as part of individual project Feasibility Study expenditure. Individual projects therefore benefitted, whilst contributing to company-wide and nation-wide knowledge development.

4.3 Objectives / Benefits

- Quantification of incoming flows and loadings for any proposed new inlet equipment
- Confirmation of suitability / capacity of any existing screen / handling equipment / skip, etc
- Verification (in terms of physical measurement of flow levels) of physical or hydraulic models
- Development of, or comparison to, existing in-house design guidance
- Contribution to ongoing development of national knowledge / design guidance

4.4 Outputs

As well as providing valuable site-specific information on peak flows and loads for use by the individual design teams, the work has indicated a wide range of Peaking Factors across the 19 locations monitored, from 7 (at Seafeld WwTW) to 110 (at Derby STW). This led to an interest in catchment characterisation, in order to identify similarities, trends, etc across catchments which may help determine the appropriate peaking factor to be applied within designs.

5.0 CATCHMENT CHARACTERISATION

It is clear from the above that catchment characteristics have a direct influence on flow and gross solid load arriving at STWs.

Catchment-descriptive information which could be useful when sizing screening and screenings handling equipment could include the following:

- whether the inflow is pumped, gravity or mixed (with % indicators where appropriate)
- an indication of any 'plug-flows' likely from pumping stations immediately upstream
- a general description of catchment size / topography / gradient, etc
- a % split of combined versus separate sewers in the catchment
- catchment domestic population
- catchment population equivalent, if any industrial element includes significant gross solids
- an indication of the industrial / domestic split within the area
- proportion of holiday makers etc versus permanent population
- demographic spread in the domestic population
- number of dairies in the catchment
- number of abattoirs in the catchment
- number and size of hospitals in the catchment
- number of nursing homes in the catchment
- an approximate number of upstream CSOs, and the percentage of these which have screens
- the 'setting' of the first CSO upstream of works, type of screen incorporated, if appropriate
- whether there is significant storage in the system, the return of which could give plug flows
- run-off rates in the catchment
- infiltration rates to the sewers, and
- known run-off problems in a catchment during storm periods (agricultural debris etc)

Some UK Water Cos attempted to use basic catchment characteristics as part of creating 'peaking factor matrices' - simple guidance on a suggested peaking factor to apply. Southern Water and Yorkshire Water are two companies known to use such a matrix within their design guidance / specifications. In addition, Severn Trent Water developed a simple spreadsheet intended to calculate appropriate peaking factors based on basic catchment characterisation inputs.

By their own admission however, all the UK Water Companies accepted that there was insufficient scientific or field-derived evidence behind these guidelines to give an acceptable level of confidence in their use. It was agreed that more work, of a collaborative nature conducted at national level, was required in order to be able to accurately characterise sewerage catchments and the sewage carried therein to assist in STW inlet works design.

6.0 PEAKING FACTOR ASSESSMENT PROTOCOL – (P-FAP)

In 2009, nine of the UK Water Cos formed a loose collaboration and commissioned TRPM to compile a 'Catchment Characterisation' database, examining the different aspects of each catchment / STW which had been subjected to a Peak Flows / Loads Survey. The ultimate aim was to develop nationally-acceptable design guidance regarding incoming gross solids loadings for use with future design and sizing of inlet works equipment.

To compile this database, a series of "catchment characteristics" were identified – these being the issues considered most likely to influence the wide range of Measured Peaking Factors found in the Surveys to date. The database was interrogated to establish which particular characteristics gave a 'trend' where larger Measured Peaking Factors polarised towards one extreme, which in turn led to the development of a draft weighted points scoring system placing proportionate emphasis on each of the 'trend-setting' issues identified.

In order to validate the PF points scoring system, 'calculated' Peaking Factors were then compared to the 'measured' equivalents from the P F/L Surveys completed at that time. It was found that at 9 of the 13 locations compared, the 'calculated' Peaking Factors were within 10 points of their 'measured' equivalents, whilst 3 of the remaining 4 had 'failed-safe' – ie the 'calculated' version was larger than the 'measured' version.

The collaborators agreed that this comparison was close enough to be acceptable and therefore the 'draft' protocol become the 'final' protocol. This protocol was then named the **Peaking Factor Assessment Protocol (P-FAP)**, and the final developed version, together with User / Guidance Notes, was widely circulated and publicised within the funding Water Companies.

It was however recognised that this should be seen as a 'start-point' for an ongoing, constantly reviewed design tool, although any future development of P-FAP would depend on more Peak Flows / Loads Surveys being conducted in order to provide more source data.

In 2014, therefore, a consortium of five Water Companies appointed TRPM to conduct an interim review of P-FAP and further develop the protocol based on the 40% increase of source data in the five year period since the original development. This was completed in November 2014 with the issue of Report Ref TRPM – REP289.

The modified P-FAP Protocol and Guidance Note from this Report are included as Appendix 'A' to this Technical Note.

APPENDIX 'A'

P-FAP – (PEAKING FACTOR ASSESSMENT PROTOCOL)

PEAKING FACTOR ASSESSMENT PROTOCOL – (P-FAP)

USER / GUIDANCE NOTES - (VERSION 2.0 – OCTOBER 2014)

This protocol has been developed by a collaboration of UK Water Companies and is based on data compiled by extensive site surveys at various locations within the UK together with a 'Catchment Characterisation' exercise for each location. Key catchment characteristics which appear to heavily influence the resultant peaking factor found at the STWs / WwTWs surveyed have been identified, and compiled into a weighted points-based scoring system, thus:

1. CATCHMENT POPULATION - 40 pts in total, being made up of:

Catchment Population Equivalent (25 pts) - The development work has highlighted that more extreme conditions / higher PFs were found at STWs / WwTWs with smaller Population Equivalents, therefore:

UP TO 40,000 PE = 25 pts, 40,000-100,000 PE = 20 pts, 100,000-500,000 PE = 15 pts, OVER 500,000 PE = 5 pts.

Catchment Domestic Population Seasonal Variation (15 pts) - The development work has highlighted that locations with high seasonal variations in Domestic Population, such as holiday resorts or university-dominant towns, gave higher PFs, therefore:

OVER 100% = 15 pts, 100-60% = 10 pts, 60-20% = 5pts, LESS THAN 20% = 0 pts.

2. CATCHMENT OVERFLOWS / SCREENING - 20 pts in total, being made up of:

Approximate % of Catchment CSOs with (6 mm) Screens (20 pts) - The development work has highlighted that screened CSOs in the catchment, giving higher screenings retention in the catchment, gave higher PFs, therefore:

OVER 75% = 20 pts, 75-50% = 15 pts, 50-25% = 10 pts, LESS THAN 25% = 5 pts.

3. CATCHMENT CHARACTERISTICS - 40 pts in total, being made up of:

Approximate % 'Combined' element of Catchment (15 pts) - The development work has highlighted that catchments with a higher 'combined' element gave higher PFs, therefore:

100-80% = 15 pts, 80-65% = 10 pts, 65-50% = 5 pts, LESS THAN 50% = 0 pts.

Approximate % Pumped / Gravity Flow Split to Works (15 pts) - The development work has highlighted that catchments with a higher 'pumped' element gave higher PFs, therefore:

100-80% = 15 pts, 80-65% = 10 pts, 65-50% = 5 pts, LESS THAN 50% = 0 pts.

Gradient of Gravity Sewers (10 pts) - The development work has highlighted that catchments with 'steeper' sewer gradients gave higher PFs, therefore:

STEEP = 10 pts, AVERAGE = 5 pts, FLAT = 0 pts. (N/A – eg "100% Pumped" = 0 pts)

The maximum Peaking Factor to be found by the application of the above would be 100.

The facility has been provided to manually adjust a calculated PF if site-specific knowledge suggests that this would be appropriate. Although not necessarily so, this may result in a final PF in excess of 100.

