Hydraulic Aspects of Sewerage Risk Management and Integrated Urban Drainage

Joanne Hulance, Nick Orman, John Wood
WRc plc, Swindon, Wilts.

Introduction

Sewerage Risk Management (SRM) is the new title of the website developed to hold the information collated during the recently completed project to update the Sewerage Rehabilitation Manual. The project has been undertaken by WRc over the last two years and was funded by eleven of the UK's sewerage utilities and supported by Defra and Ofwat.

The main thrust of the work was to set the philosophy of the Sewerage Rehabilitation Manual into a new context - that of an integrated, risk based approach with the costs of planned interventions to sewer systems underpinned by economic justification, e.g. cost benefit analysis.

The Sewerage Risk Management Procedure

The SRM Procedure consists of eleven logical steps which will result in the formulation of a *Sewerage Management Plan* (SMP) for a defined area. Whilst retaining the established concept of a drainage area as a fundamental *spatial unit* for the study of all relevant aspects of a sewer system, the new SRM recognises that it may be appropriate also to consider different areas for specific purposes. The latter might include river catchments receiving discharges from several drainage areas in pollution management studies or integrated urban drainage studies, and utility wide issues such as manhole covers.

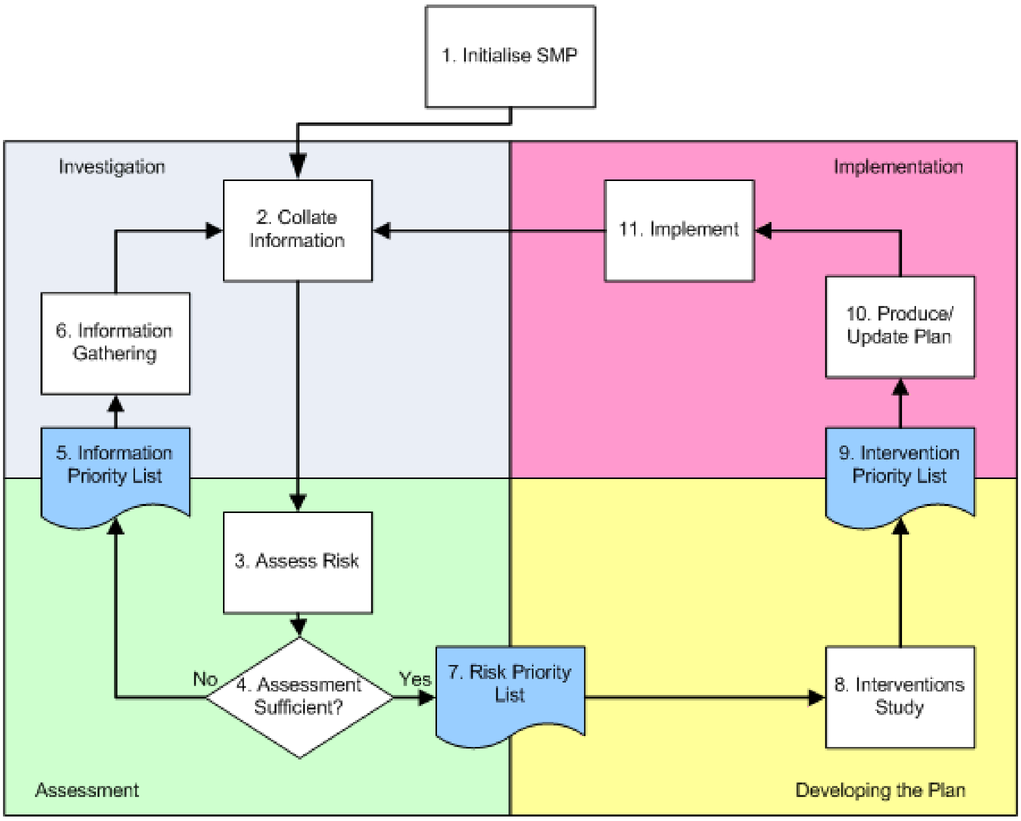

Figure 1 SRM Procedure

The eleven steps have been defined to accord with:

- The European Standard for Drains and Sewers, EN752: 2008;
- The UKWIR Capital Maintenance Planning Common Framework (CMPCF);
- The emerging UK practice for Surface Water Management Plans (SWMP), formerly Integrated Urban Drainage Management.

The SRM Procedure also takes into account strategic level considerations such as climate change and sustainability.

Figure 1 presents the eleven steps of the SRM procedure. There are four distinct phases; *Investigation*, *Assessment*, *Developing the Plan* and *Implementation*. The eleven steps provide a logical route through these phases to enable a SMP to be developed and implemented. The procedure is structured such that the SMP can be continually evaluated and improved.

Evaluating the Risk of Service Failure

It is very important to appreciate the clear distinction made in the SRM Procedure between the two steps which firstly identify risk (Step 3), and secondly identify interventions (Step 8). Step 3 aims to evaluate the present and future risk of service failure, i.e. how the sewer system performs in the delivery of service to customers and the environment. The results of this risk assessment will inform Step 8, the intervention study, to enable the development of economically justifiable solutions to mitigate the significant risks of service failure.

Service failure can be grouped into a number of main effects which have a direct impact on any of the stakeholders. *Service failure effects* include:

- Pollution of receiving watercourses and groundwater;
- Flooding and Restricted facilities use;
- Odour and noise;
- Disruption of the surface, and;
- Operational costs of the sewerage utility.

In the SRM Procedure, *risk* is defined in the conventional manner, i.e. as a function of the likelihood of failure and the consequences of that failure. For each of the service failure effects it is therefore necessary to assess the likelihood of the effect occurring and the consequences that could arise. This is a simple enough concept, but in practice can be very complex, as service failure effects can potentially arise from a number of problems or circumstances, which can in turn be related back to the performance failure of an asset or group of assets. A source-pathway-receptor approach is used whereby the processes (*pathway*) that determine whether an asset failure (*source*) has a service failure effect (*receptor*), are investigated.

Consider for example flooding which is a key theme of this meeting. Flooding from sewer systems arises when the hydraulic capacity of the sewers and underground assets is exceeded and sewage reaches the surface of the ground, for example either through manholes or the domestic plumbing.

There are a number of consequences that arise from flooding depending on the volume of sewage involved, the speed and direction of flow of the sewage and the characteristics of the land surface and type of property. A number of different consequence models have been identified in the SRM and methods of quantifying the consequences presented, either in direct monetary terms or a numerical manner. Models include items such as direct property damage, health related effects, traffic disruption etc.

There are a number of root causes of flooding within a sewer and often complex interactions between the causes of flooding and other service failure effects. Consideration of these causes enables the assessment of the likelihood of flooding to be determined as the ultimate expression of a series of other factors. For example the likelihood of a blockage is dependent on a number of factors such as the gradient of the sewer, the presence of sediments or the rate of flow through the sewer. Similarly, the likelihood of a blockage leading to surcharging and flooding is subject to another set of factors, such as ground level, the location of relief points and above ground flow routes.

The idea of critical assets provides a useful link between the assets themselves and the consequences of service failures effects and this principle has been extended in the new SRM.

A “critical sewer” was initially defined as one which justified pre emptive rehabilitation because the consequences of failure were far greater than the disruption caused by the pre emptive repair. The concept was originally applied to structural failure, but can be extended such that there are:

- structurally critical sewers;
- hydraulically critical sewers, and;
- environmentally critical sewers.

In each case the definition being centred on the type of consequences that arise if the sewer assets were to fail. Thus a hydraulically critical sewer is one where failure would have significant consequences regarding restricted facilities use and ultimately flooding.

The role of hydraulic modelling is therefore crucial in the detailed, comprehensive study of cause and effect and identifying hydraulically critical sewers. Careful modelling of infiltration, siltation and urban creep in relation to the original system design will facilitate the understanding of the importance of developing interventions to manage these problems in the light of the consequences that might arise.

The SRM Procedure takes an iterative approach to risk assessment, as it is appropriate to start with a simplified set of likelihood and consequence assessment methods and only iterate using more complex methods where the magnitude of the service failure risk makes it justifiable.

An Integrated Approach to Sewer Systems

Since the 1980’s the Sewerage Rehabilitation Manual has advocated an integrated approach to the study of sewer systems which has evolved over time.

In the early days “integrated” generally referred to the need to study all relevant aspects of the sewer system in conjunction, in order to develop comprehensive solutions to all problems. Replacing a structurally deficient sewer with a larger one might therefore solve a hydraulic and structural problem for an optimum cost.

With the passage of time and particularly with the publication of the Urban Pollution Manual it was appreciated that integration also necessitated the conjunctive study of sewers, Wastewater Treatment Works and receiving waters (surface and below ground) in order to develop optimum comprehensive solutions to improve water quality in the environment.

More recently the need for the integrated consideration of all the systems comprising the urban drainage network has become accepted and this is considered below.

The Risk of Sewer Flooding in the Integrated Urban Drainage System

In a typical urban drainage area three drainage systems can typically be considered:

- The *minor system*, comprising the predominantly underground assets of the sewer system;
- The *intermediate system*, composed of pavements and roads, some of which are connected to the sewer system and some of which drain directly to;
- The *major system*, consisting of the “natural” watercourses, which in places can be directly connected to the minor system.

The interactions between these three systems is often complex and in some areas there are additional items to consider relating to coastal and land drainage.

A challenge for urban planners and engineers is to design and maintain a series of systems which have the optimum benefits for the public at large and the environment, regardless of who owns or manages the individual assets that comprise the urban drainage system. However the principles of the risk based, economically justifiable approach developed in the SRM are entirely technically appropriate to the wider picture of integrated urban drainage.

This challenge is being met by the use of Surface Water Management Plans (SWMP), currently being investigated by Defra, through a series of detailed pilot studies. Guidance is currently being prepared by Defra to aid the development of these SWMP, requiring the cooperation between those organisations which have responsibility for the assets within the urban drainage system, i.e. highways, sewers, watercourses, urban development, etc.

Although the guidance was not available to WRc at the time that this paper was prepared, our understanding is that the development of SWMP would be undertaken in six phases, preparation, information gathering, risk assessment, analysis of intervention options, implementation and monitoring. These phases are very similar to those detailed in the SRM procedure, requiring the asset stakeholders to identify and understand the current and future risk of surface water flooding, then to develop solutions to mitigate these risks.

Conclusions

The Sewerage Risk Manual (SRM) is the title of the website developed to hold the outputs from work that has been recently undertaken by WRc to update the 4th edition of the Sewerage Rehabilitation Manual. This update was undertaken in response to important legislative and regulatory changes in the UK water industry. The procedure detailed in the SRM allows sewerage utilities to develop economically justifiable solutions which will address significant risks to the delivery of sewerage services to customers and the environment.

The original Sewerage Rehabilitation Manual had always advocated an integrated approach to the study of sewerage systems, and this has been continued and enhanced in the new SRM Procedure. This integrated approach is particularly important as is allows the sewer system, treatment works and receiving watercourses to be considered as a whole system.

This integrated approach has become more relevant in recent times in relation to the set of linked systems that comprise urban drainage. Such an approach is required for the management of the urban drainage system to minimise the impact of surface water flooding. The design and maintenance of the urban drainage system must provide the optimum benefits to the public and the environment, regardless of ownership of the assets which form the urban drainage system. This is the aim of the guidance being prepared by Defra which will facilitate the development of Surface Water Management Plans through the cooperative working of the organisations with responsibility for those assets.

The risk based approach developed by WRc for sewers seems entirely compatible with the approach needed in the wider integrated context for the development of Surface Water Management Plans.

