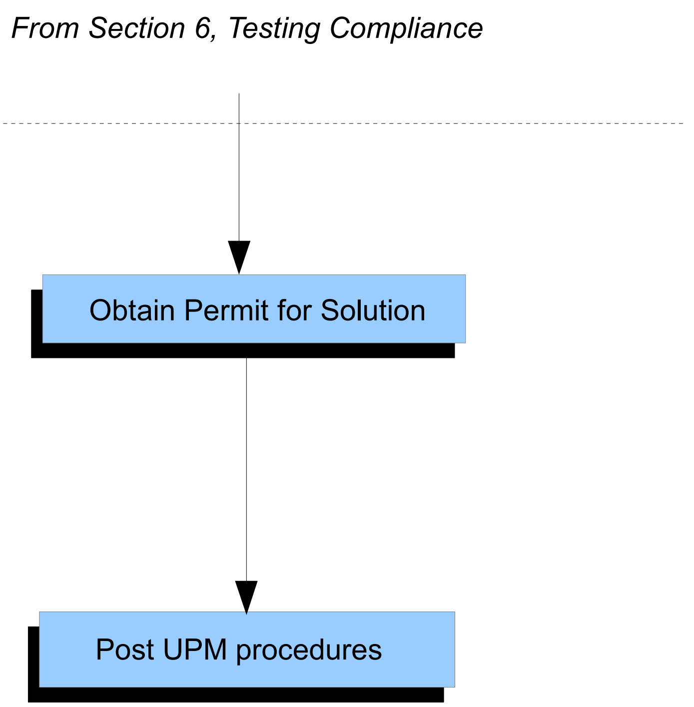
Section 7

Post Planning Study Issues



7. POST PLANNING STUDY ISSUES

This section includes all of the processes necessary for translating the conceptual design resulting from the planning procedure into a practical reality. Principal amongst these activities are obtaining the formal permit to discharge and the development of a detailed engineering design. Also included are other activities, such as Post Project Appraisal, Maintenance of Models and Databases and Cost Benefit Analysis. The need for, and benefits of, these activities are identified but none is described in detail. The provision of such information is beyond the scope of the UPM Manual.

Wherever possible, reference is made to sources of more comprehensive information.

This section includes the following subsections

7.1 Discharge permits.

7.2 Engineering design.

7.3 Performance monitoring.

7.4 Maintenance of models and databases.

7.5 Cost benefit assessment.

7.1 Discharge permits

The discharge permit is the legal document provided by the environmental regulator that sanctions the discharge of effluent. Once a UPM planning study has been completed and the necessary upgrading measures identified and agreed, permit conditions need to be set for the new or modified discharges. The maintenance of a close relationship between the regulator and discharger throughout all stages of the UPM study should ensure that the process of setting permit conditions amounts to no more than a “rubber stamping” of the approved design by the regulator.

The modelling procedures in previous sections will have produced a detailed description of predicted performance, often in terms of water quality. However, within the permit, this must be translated into more simple performance measures that can be readily monitored by the environmental regulator. For example, it is possible that a permit may be set for a CSO that might simply specify the continuation flow and that all available storage is utilised before spill occurs.

Guideline documents on permit setting may be available from the relevant environmental regulator (Environment Agency, 2011).

7.2 Engineering design

This section provides an introduction to the broad design issues that may need to be considered by the engineer in implementing a solution. It is not intended to provide detailed guidance on, for example, how to design a CSO chamber, but to provide guidance on where this information is likely to be found.

Design issues can be broadly represented under the following categories:

- combined sewer overflow structures;
- detention tanks;
- source control;
- sewer system transport capacity;
- sewage treatment works performance improvement; and,
- Real Time Control.

In certain circumstances, it may also be appropriate for the engineer to consider engineering improvements to the receiving water, for example by improving the alignment or shape of a river channel, to reduce sensitivity of the receiving water to wastewater discharges. Such options are not considered further here.

7.2.1 CSO structures

CSO chambers play an important role in meeting the levels of hydraulic control and solids separation required to be compliant with specified environmental performance requirements, and in particular relevant Amenity Use Standards (Section 2.5). For example, where CSOs discharge to low amenity or non-amenity waters, guidelines (e.g. Table 2.6) might typically require that CSO chambers should be such that "solids separation is achieved by good engineering design". The whole topic of design of CSO chambers and appurtenances, such as screens, is covered in detail in "A Guide to the Design of Combined Sewer Overflow Structures" (Balmforth *et al*, 1994). Further information can be found in a report entitled "Combined Sewer Overflows" (UKWIR, 1994 see UPM2 References, Section 1.6). The following section summarises the state of the art of good engineering design of CSO chambers to achieve solids separation.

An effective CSO chamber should satisfy the following requirements:

- spill should not occur until the prescribed flow is being passed to treatment;
- there should not be a significant increase in the continuation flow whilst the overflow is operating, irrespective of any increase in the inflow;
- the maximum amount of polluting material should be retained in the sewer and passed forward to treatment;
- it should be fully automatic;
- the design should avoid any complication likely to lead to unreliable performance;
- the chamber should be self cleansing and resistant to blockage;
- safe access should be possible; and,
- construction cost should be kept to a minimum.

A CSO chamber must adhere to certain general principles in respect of hydraulic control, solids separation and construction to achieve the above design requirements. The general design approach is to size the chamber to achieve acceptable solids separation performance by following specified design guidelines. This also ensures that the necessary conditions for good hydraulic control are achieved. It is then only necessary to check the performance of the chamber under extreme event conditions to avoid upstream or uncontrolled flooding.

Many of the factors relevant to the design of a CSO chamber will have been determined at earlier stages of the study. Location, point of discharge (and, hence, aesthetic control requirements) and spill regime together with associated storage requirements are all likely to fall into this category, although all may be subject to review in the light of the detailed design considerations.

Software has been developed to facilitate the detailed design of CSOs in accordance with the current regulatory framework in England and Wales (UKWIR, 1997 see UPM2 References, Section 1.7).

7.2.2 Detention tanks

Detention tanks are used to provide storage capacity in combined sewer systems, thereby attenuating peaks in flow to allow the downstream transport and treatment systems to cope. Part, or all, of the storage may be integrated with CSO chambers to maximise the solids retention capabilities of those structures.

This section discusses some aspects of the design of detention tanks. However, for detailed information, there are a number of documents that can be consulted; e.g., Knott and Taylor (1985 see UPM2 references Section 1.7), Cant (1991 see UPM2 references Section 1.7), Roebuck (1989 see UPM2 references Section 1.7) and WRc (1997) .

A detention tank may be located either “on-line” or “off-line” in the sewer system and any type of tank design can be employed for either case. On-line tanks form an integral hydraulic component of the system. The tank consists of an enlarged section that fills when the inflow exceeds the maximum allowable through flow. Discharge from the tank is controlled by a throttle at the downstream end. A high level overflow should be provided to allow discharge of extreme flows.

Off-line tanks are physically separate from the main system. Flow only enters the tank under storm conditions when excess flow is diverted into the tank from the CSO diversion chamber. The stored flows may be returned to the system by gravity where the site allows, or by pumping. Again, an overflow should be provided on the incoming sewer and/or from the tank to relieve extreme flows.

On-line and off-line tanks have different volume and flow control requirements. All other factors being equal, an off-line tank will need to have less volume to achieve comparable performance to an on-line tank. However, on-line tanks are less complex, with a single flow regulator being used to control both through flow and tank filling and emptying. Where a throttle is used it should be designed so as not to pass more than the maximum permissible continuation flow under any operating conditions.

Off-line tanks are more complex in operation, requiring separate flow regulators for regulating the continuation flow and the flow to the tank. Off-line tanks are also more susceptible to sedimentation problems than on-line tanks that convey continuous dry weather flow.

All detention tanks should be covered, except in special circumstances (e.g. within STW compounds), otherwise they present a health and safety hazard. They must be vented to allow air to be expelled during filling and, hence, prevent covers from being blown off.

There are three basic types of tank: tank chambers; tank sewers and tank shafts.

- Tank chambers can be of variable form and are usually constructed from reinforced concrete. As a rule, the general arrangement of a tank chamber should be as simple as possible. However, layouts that use multiple chambers, especially when they are in series and involve complex systems of weirs and flap valves, may be used where spills are to particularly sensitive waters. The principal advantage of tank chambers over tank sewers is that large volumes may be contained in a relatively small area. Chambers can be used in both on-line and off-line configurations.
- Tank sewers are essentially oversized sewers designed to retain excess flows. They may be on-line or off-line. They can be circular, oval or rectangular in cross section.
- Tank shafts may be employed where the available area for construction is small, the ground conditions are unstable or a large differential head is available. Tank shafts are often relatively cheap to construct.

Stored sewage is often held in a quiescent state in detention tanks and grit particles in the sewage will tend to settle out causing a build up of sediment. This can lead to a need for frequent automatic or manual cleaning after storms. Larger tanks may incorporate some form of agitator; for example, in the form of a series of propellers, to maintain solids in suspension during storage.

Detention tanks should be designed to be, as far as possible, self cleansing whilst in operation. The deposition of sediment can be minimised by appropriate design and the use of flushing devices to aid cleaning during, or following, drain down.

7.2.3 Source control

The potential role of source control in reducing and attenuating flows and polluting loads entering sewer systems (both combined and separate) is being increasingly recognised. Source control represents prevention of the problem in the first place, rather than cure of the problem once it has occurred. As such, its application is to be favoured wherever possible.

A wide range of techniques can be considered under the broad heading of “source control” that include measures aimed at preventing the entrainment of pollutants in surface water runoff, through true controls at source, to local treatment processes designed to enhance the quality of flows that subsequently enter the sewer system. There are many standard texts addressing aspects, or the full spectrum, of source controls. Moreover, this is an area of very active research at the present time and “best practice” can be expected to develop significantly over the coming few years. At the present time useful guidance can be found in publications by CIRIA (1992, 1996 see UPM2 References, Section 1.7), Debo and Rees (1995 see UPM2 References, Section 1.7), Urbonas and Stahre (1993 see UPM2 References, Section 1.7) and WRc (1998 see UPM2 References, Section 1.7).

7.2.4 Sewer system transport capacity

The hydraulic performance of sewer systems can be improved (and hence the need to spill excess flows reduced) by maximising use of existing transport capacity and/or by engineering works to increase the transport capacity of the existing sewer system. Measures that can be considered include:

- increased pipe sizes;
- duplication or reinforcement of existing pipes;

- removal of isolated throttle sections;
- increasing gradient (where feasible);
- increased sewer maintenance to remove accumulated sediments, roots etc.; and,
- reduction in hydraulic roughness.

A more comprehensive discussion of methods to enhance the hydraulic carrying capacity of sewer systems is included in the Sewerage Rehabilitation Manual (WRc, 2014).

7.2.5 Sewage treatment works performance improvement

The impact of storm discharges can be mitigated in two major ways by improving the performance of the sewage treatment plant.

- Improving the quality of the treated effluent reduces the background load on the receiving water leaving a greater proportion of the assimilative capacity available for “shock” loading by wet weather discharges.
- A modern and well designed treatment plant should be more robust in terms of being able to accept extra flow and load during wet weather events without excessive storm tank spillage or deterioration in treated effluent quality.

Design of sewage treatment works is beyond the scope of this planning manual. A number of standard texts are available to assist the planner in this task; e.g. USWEF (1992 see UPM2 References, Section 1.7), Metcalf and Eddy (1991 see UPM2 References, Section 1.7) and, a series of publications by CIWEM, UK.

7.2.6 Real time control (RTC)

Urban wastewater systems have traditionally been designed to operate in a static or passive mode. That is to say that the performance characteristics are determined at the design stage to accommodate a specific design scenario and the system is then constructed with no moving or controllable parts in accordance with that design. In reality, the majority of drainage systems have developed in piecemeal fashion over many years and adhere to no coherent overall design practice. Moreover, operational conditions for urban wastewater systems rarely match the design scenario, because rainfall is not in practice uniform over the whole catchment, nor are storms symmetrical single peaked events.

For all of these reasons, the transport and treatment capacity of urban wastewater systems is rarely fully utilised throughout the whole system in practice. Overflows and even flooding can occur in one part of the system whilst other parts have spare capacity. Active or Real Time Control (RTC) of an urban wastewater system can minimise these failings by ensuring that the full capacity of the available system is utilised for more of the time. This is typically achieved through the use of control gates and weirs to hold back or regulate flows in one part of the system thereby freeing up capacity for use by more heavily stressed parts of the system. Clearly, the circumstances will vary from event to event, and even during an event, and a system of data collection processing, decision making and control is required to implement effective RTC at an urban catchment scale (global RTC).

Until recently, the common implementation of global RTC has been limited by practical constraints in several of the above areas. However, developments, particularly in data sensor and processing techniques and on-line simulation models, have reduced or removed many of these barriers. As a consequence, many wastewater utilities are beginning to consider RTC as a means of both optimising the performance of their existing assets and to reduce investment needs for upgrading currently deficient systems. However, it is true to say that global RTC remains a technology that is best suited to large and complex systems where the substantial costs of planning, implementing and operating global RTC are more than offset by the savings in capital investment required to achieve comparable performance by conventional passive means.

Real Time Control is an area of very rapid current development and there is no single definitive text on the subject. Useful further information can be found in documents by Schilling (1987 see UPM2 References, Section 1.7), HR Wallingford (1996 see UPM2 References, Section 1.7) and NRA (1995 see UPM2 References, Section 1.7).

7.3 Post scheme monitoring

Post Scheme performance monitoring is recommended for all schemes which have been planned and constructed using UPM Procedures.

The benefits of post scheme monitoring include:

- certain types of the monitoring, particularly Event Duration Monitoring (EDM), can be used as part of an on-going pro-active asset management regime
- confirmation that the anticipated performance is achieved and that the perceived benefits and environmental outcomes are realised.
- confirmation that each of the tools used to reach the current solution has satisfied the performance requirements of the individual wastewater system components.
- evidence to inform the future refinement of models, procedures, technologies and solutions.
- evidence for the justification of any future work programmes.

7.3.1 Monitoring of asset performance

There is an increasing trend in the monitoring of the performance of intermittent assets using event duration monitoring, either as part of a pro-active asset management strategy, and/or as part of the permit conditions.

Typically, this would involve defining a bandwidth of expected spill performance from an asset (using the associated sewer models), and then checking this against actual performance on a regular basis. Where actual performance was outside of the expected bandwidth of predicted performance, this would then trigger an appropriate investigation and, if necessary, remedial work.

It is strongly recommended that EDM is considered for at least the most significant assets on the sewer network, along with the flows that are passed forward to treatment, as recorded at the receiving works. (The Public Face of CSO Monitoring) (This reference no longer available)

7.3.2 Aesthetic monitoring.

In the UK a methodology exists for undertaking surveys of the aesthetic impact of intermittent discharges (FR0466). It is recommended that such surveys are carried out before and after the completion of aesthetic improvement schemes. Where large numbers of improvements are carried out this monitoring could be limited to a subset of those improvements. This would help confirm whether the types of screens being constructed are performing as expected. This is particularly the case for where novel solutions are constructed.

7.3.3 Monitoring of receiving water quality.

For inland waters, the UPM water quality standards that are used in the UK (99 percentiles and FIS) are generally considered to be *design standards*. It will not usually be possible to undertake any UPM water quality post scheme monitoring using the water quality data that is collected for classifying the general water quality and/or status of rivers and waterbodies. This is because routine water quality monitoring is based on a small number of spot samples and hence its resolution is too low to enable the results of this monitoring to be compared with UPM standards. Where wet weather event data or continuous sonde data has been collected as part of the UPM study then it is recommended that similar data be collected both as part of the UPM investigation and is continued after the construction of the scheme. This then allows an assessment to be made of the effectiveness of any improvement scheme.

For marine studies, use should be made of routine compliance data to establish the effectiveness of any remedial measures. In addition, where intensive monitoring has been carried out prior to improvement works, consideration should be given to equivalent follow up monitoring work, after completion of works.

7.3.4 Monitoring of the ecology.

The UPM water quality standards that are used in the UK (99 percentiles and FIS) have been derived through research as being suitable for the protection of aquatic ecology. It will not usually be possible to undertake any UPM ecology post project appraisals using the ecology data that is collected for classifying the general ecological quality and/or status of rivers and waterbodies. This is because the location of the monitoring sites is usually chosen as being representative of the whole river or water body and not for monitoring the impact of any individual discharge. In the UK post scheme monitoring of ecology could consist of an analysis of any changes to any ecology data that was available and/or collected prior to the scheme being constructed. Where ecology data has been collected upstream and downstream of any discharges as part of the UPM study then it is recommended that similar data be collected following construction of the scheme. This would allow a comparison to be made.

7.4 Maintenance of models and databases

Models are expensive to produce and, therefore, adequate documentation should be provided to ensure that the maximum benefit can be obtained from the investment. All modelling work should be carefully documented to ensure that the reasons for any decisions can be reviewed both during and after the completion of the planning work and that the implications of any changes in source data or assumptions can be easily identified. This information will also be necessary if the model is to be revised at a later date. Details of assumptions will also be required by subsequent users to establish the applicability of the model for later use.

Model building requires the use of large amounts of data. Quality systems provide a good framework for controlling this flow of data. Quality systems should comprise a series of procedural guidance documents covering general areas of information management such as filing, document control, document approval and issue, etc. Although potentially time consuming to develop and maintain, there are clear advantages in having a detailed working procedure for modelling work to maximise the use of skilled personnel while maintaining high standards of work.

It is essential that the work involved in building and verifying a model is properly documented in order that future users of the model can properly assess how appropriate it is for a particular purpose and to allow for updating and upgrading of the model. As a minimum requirement, it is recommended that following actions relating to reporting and data management should be undertaken;

- **Reporting**
  A Model Building Report should be produced. This should contain a description of the work involved in building the model, including any work carried out on gathering or checking data. The report should include a project definition giving the background to the planning study, a clear statement of the purpose for which the model is intended and description of the type of model built and any of its constraints. The report should also provide details of the data used including reference to the source (details of any specific surveys carried out that are not archived elsewhere should be included as an appendix to the report).

  A Verification Report should also be produced to provide a detailed description of any changes made to the model during the course of the verification and the justification for making these changes.

  A Solution Development Report may also be appropriate. This should provide a record of the assumptions made in developing the solutions; changes made to the models to represent the proposed scheme; and, details of the event scenarios against which the scheme's performance was tested.

- **Data management**
  The model should be archived to reliable digital media for short-term or long-term storage. Files should be fully referenced; for example, individual model runs should be referenced by date and associated text files should be created that briefly describe the activities in each run. A distinguishable naming convention should be adopted for individual files and old versions of software should be archived during model development. Further general guidance on this topic may be found in the CIWEM Code of Practice for Hydraulic Modelling of Urban Drainage Systems (CoP, 2017).

7.5 Cost benefit assessment

Defra has recommended that improvement schemes involving major capital expenditure should be subject to cost-benefit analysis. Whilst the costs of engineering improvements are relatively easy to calculate, evaluation of the benefits is a more difficult exercise. Methodologies have recently been developed for assessing the improved water quality in receiving systems in relation to identified uses including informal recreation, angling, drinking water treatment, bathing, shell fisheries and agricultural abstractions (FWR, 1996). There is a growing commitment by the water industry and its regulators to the principles of cost-benefit analysis in the belief that it can serve two important functions:

- acceptance of new environmental obligations can be based on a proper consideration of the balance between costs and benefits; and,
- once standards have been set, schemes can be prioritised on cost-benefit grounds.

UPM technology can play a significant role in supporting both of these types of application by providing the basis for improved insight into the engineering costs associated with achieving a range of possible environmental improvements. The former application is primarily associated with the policy of environmental regulators and, as such, is not discussed any further here. The latter is more directly related to the technology described within this Manual and can be considered in a little further detail.

As identified in Section 1.7, cost-benefit analysis can be used to address which of a number of mutually compatible revenue competing projects to undertake, particularly where there is a need to establish priorities between wet-weather related water quality improvements in different catchments but where investment funds are limited. Where estimated upgrading costs for different improvement schemes to meet the environmental planning framework within UPM (Section 3.4) are similar, benefit assessment can be used to define the broader environmental benefits; i.e., benefits gained by complying with the defined set of UPM standards.

It is also important to validate the original assumptions on the cost-benefit of implementing the proposed upgrading measures in the catchment once the UPM Procedure has been applied to reach the desired solution. In the vast majority of cases this exercise should simply confirm that the design provides benefits justified by cost, except in circumstances where preliminary estimations of scheme costs were significantly underestimated.