
**Guidelines for the management of
assets of water supply and wastewater
systems —**

**Part 3:
Wastewater collection networks**

*Lignes directrices pour la gestion d'actifs des systèmes d'eaux usées et
d'eau potable —*

Partie 3: Réseaux d'assainissement

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 224, *Service activities relating to drinking water supply systems and wastewater systems* – *Quality criteria of the service and performance indicators*.

A list of all parts in the ISO 24516 series can be found on the ISO website.

Introduction

This document is written within the overall concept of management of assets which is an activity all organizations undertake in some manner and to some degree. It focuses on the details of managing the physical assets at the operational level rather than the organizational (corporate management, structural or process) level.

Wastewater utilities are reliant on their assets to deliver their services to the resident populations in their jurisdictions. The assets (underground pipes, retention and detention tanks, treatment plants, etc.) collectively form the physical infrastructure of the wastewater utilities and are the consequence of the accumulated capital investments and operational expenditures on maintenance and rehabilitation over many years. In many of these utilities, the replacement value of these past investments will amount to many millions (even billions) of US dollars depending on the size of the community served. The infrastructure represents therefore a major societal investment in essential services contributing to public health and the protection of the environment.

In many countries, these assets have been identified as critical infrastructure, and programmes are in place to ensure their protection or their sustainability. Like many other organizations having assets, wastewater utilities undertake programmes of activities to manage the assets to ensure they continue to meet the needs of the community. These management activities can be at the strategic, tactical or operational level. The activities can be part of a formal management system, the result of specific legislative requirements, or simply the result of due diligence by the service operators and managers.

This document can serve as a supporting document for utilities operating an asset management system regardless of whether the utilities make use of any management system standard (e.g. ISO 55001).

In many countries, there is a recognized sustainability problem, sometimes referred to as the infrastructure gap, which recognizes that for various reasons, the infrastructure has not been maintained over the years on a truly sustainable basis, i.e. funding of rehabilitation programmes has been postponed, with a focus instead on short-term repairs or an allowed decrease in the level of service provided.

The condition of wastewater infrastructure greatly influences the adequacy of the wastewater service from aspects of quantity, quality, safety, reliability, environmental impact, degree of treatment and economic efficiency. System condition-based rehabilitation approaches serve to meet these requirements with a focus on a holistic approach of condition-based, risk-oriented maintenance.

As the installation and development of wastewater assets mature, the optimization of networks will become necessary in many places in order to respond to changing societal and economic conditions. Consequently, networks are subject not only to ageing as well as wear and tear but also to adaptation processes resulting from growth, new legislative requirements, or changing user service level expectations. This requires wastewater utilities not only to focus on maintenance and rehabilitation but also to keep future requirements and developments in mind. Rehabilitation will thus become essential in management of assets, with ever more stringent requirements on the design and execution of rehabilitation (partial replacement of specific sections of the entire network is also considered as rehabilitation).

In recent years, much effort has been applied to the whole issue of management of assets on two levels:

- What are the principles and structure of an asset management system?
- What are the good practices that can be implemented on a technical level to assess the condition of the assets and help decide when asset interventions (repair, renovation or replacement) take place?

This document describes the information required and how to collect and process reliable inventory, condition, operational and environment data about wastewater systems. Data on wastewater infrastructure notably include data on failure. These data serve mainly as a basis for systematic maintenance and can also contribute data needed for benchmarking.

Reliable failure statistics and the database description of the condition are of particular significance for establishing investigation, maintenance and rehabilitation priorities.

This document also provides guidance on how to define a strategy on management of assets with regard to the overall performance expected by the owner and other stakeholders. It includes several aspects of the operation and maintenance, including asset condition assessment and investment strategies (new assets and rehabilitation).

Guidance in [Clauses 4, 5, 6, 7](#) and [9](#) is taken from EN 752. This document provides a framework for the design, construction, rehabilitation, maintenance and operation of drain and sewer systems outside buildings and also focuses on “integrated sewer system management” in which management of assets is a part.

The approaches offered in this document are intended to be universally applicable, regardless of the structure of a given wastewater system. Any empirical numeric values given are mere support values; concrete plans always need to rely on utility and/or object-specific values.

The usual and expected goal of the effective management of assets is to provide maximum life and value in a cost-effective manner. However, in some circumstances where the assets are being operated to satisfy a short-term goal, this will not be to maximize the life of the assets, but could, for example, be to minimize costs while meeting other objectives within the planned timeframe.

This document is intended to provide guidance on the assets typically owned or operated by wastewater utilities that are expected to meet users’ needs and expectations over longer (multi-generational) periods.

Additional information on objectives and functional requirements of management of assets is provided in [Annex A](#).

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Guidelines for the management of assets of water supply and wastewater systems —

Part 3: Wastewater collection networks

1 Scope

This document specifies guidelines for technical aspects, tools and good practices for the management of assets of wastewater networks to maintain value from existing assets.

This document does not apply to the management of assets of treatment plants, which are also physically part of the wastewater system and can influence the management of network assets.

NOTE 1 The management of the following individual assets will be covered by ISO 24516-4: wastewater pumping stations, retention and detention in the network, wastewater treatment plants and sludge treatment facilities.

This document includes examples of good practice approaches on the strategic, tactical and operational levels.

This document is applicable to all types and sizes of organizations and/or utilities operating wastewater networks, and all different roles/functions for the management of assets within a utility (e.g. asset owner/responsible body, asset manager/operator, service provider/operator).

NOTE 2 Depending on the size and structure of an organization, the utility can decide to what extent it applies the guidance in this document, but in any case, the philosophy of this document remains applicable to small and medium utilities.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <http://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

3.1

asset

capital-forming goods used for the provision of the *service* (3.23)

Note 1 to entry: Assets can be tangible or intangible. Examples of tangible assets are: land, buildings, pipes, tanks, treatment plants, equipment and hardware. Examples of intangible assets are: software, databases.

Note 2 to entry: Contrary to consumables, assets can be depreciated (tangible assets) or amortized (intangible assets) in accounting systems.

**3.2
asset management**

processes that enable a water utility to direct, control and optimize the provision, *maintenance* (3.13) and disposal of infrastructure *assets* (3.1), including the necessary costs for specified performances over their life cycle

**3.3
asset system**
set of *assets* (3.1) that interact or are interrelated

**3.4
asset type**
grouping of *assets* (3.1) with common characteristics that distinguish them as a group or class

Note 1 to entry: Examples of asset types include, but are not limited to, physical assets, information assets, intangible assets, critical assets, enabling assets, linear assets, information and communications technology (ICT) assets, infrastructure assets and moveable assets.

Note 2 to entry: Examples of physical asset types in the wastewater sector include pipes, manholes, pumps, valves, tanks and pipe bridges of the same type, size, material and function.

**3.5
failure**
local inadmissible impairment of the operability of an *asset system* (3.3) at a certain point in time on a certain asset

**3.6
failure data**
data characterizing the occurrence of a *failure* (3.5) event

**3.7
failure rate**
ratio of the number of *failures* (3.5) of a given category to a given unit of measure
EXAMPLE *Failures* (3.5) per unit of *assets* (3.1) and time; failures per number of actions.

Note 1 to entry: In the case of pipelines, expressed per kilometre per year.

Note 2 to entry: In the case of connections, expressed per kilometre per year.

**3.8
inspection**
process to identify the actual status of an *asset* (3.1) or *asset system* (3.3) by observation and judgement accompanied as appropriate by visual control, handling, measurement, testing or gauging

**3.9
integrated sewer system management**
coordinated management of the planning, design, construction, *rehabilitation* (3.18), *operation* (3.15) and *maintenance* (3.13) of all wastewater networks in a catchment area, taking into account all aspects of their performance

**3.10
investigation**
gathering of all information necessary for a decision-making process

Note 1 to entry: This should include both qualitative and quantitative information.

3.11**level of service**

parameters, or combination of parameters, which reflect social, political, environmental and economic outcomes regarding the service to users that the water utility delivers

Note 1 to entry: The service to users can include any of the following parameters: health, safety, user satisfaction, quality, quantity, capacity, reliability, responsiveness, environmental acceptability, cost and availability.

Note 2 to entry: A defined level of service can include any combination of the aforementioned parameters deemed important by the *asset* (3.1) owner, users or relevant stakeholders.

3.12**life cycle cost**

total cost of an *asset* (3.1) or its parts throughout its life cycle

Note 1 to entry: Total cost can include planning, design, construction, acquisition, operation, maintenance, rehabilitation and disposal costs.

Note 2 to entry: Total cost should exclude any residual value obtained during disposal.

3.13**maintenance**

combination of all technical, administrative and managerial actions during the life cycle of an *asset* (3.1) intended to retain it in, or restore it to, a state in which it can perform the required function

3.14**management of assets**

all processes during the life cycle of an *asset* (3.1)

Note 1 to entry: This encompasses all necessary activities for planning, design, procurement, construction/installation, *operation* (3.15), *maintenance* (3.13), *rehabilitation* (3.18) and disposal of *assets* (3.1) of water supply and wastewater systems as a functional activity, including review.

3.15**operation(s)**

action(s) taken in the course of normal functioning of drinking water or *wastewater systems* (3.27)

EXAMPLE Monitoring and regulation or diversion of drinking water or wastewater.

3.16**operational plan**

documented collection of procedures and information that is developed, compiled and maintained in readiness for the conduct of *operations* (3.15)

3.17**performance indicator**

parameter, or a value derived from parameters, which provides information about performance

Note 1 to entry: Performance indicators are typically expressed as ratios between variables. These ratios can be commensurate (e.g. %) or non-commensurate (e.g. \$/m³).

Note 2 to entry: Performance indicators are means to measure the efficiency and effectiveness of a water utility in achieving its objectives.

3.18**rehabilitation**

measures for restoring or upgrading the performance of existing *asset systems* (3.3), including *renovation* (3.20), *repair* (3.22) and *replacement* (3.21)

3.19**rehabilitation rate**

percentage of entire inventory which is rehabilitated or to be rehabilitated annually

3.20

renovation

work incorporating all or part of the original fabric of an *asset* (3.1) by means of which its current performance is improved

3.21

replacement

installation of a new *asset* (3.1), which incorporates the function of the old asset

3.22

repair

rectification of a local damage

3.23

service

result of a process

Note 1 to entry: Adapted from the definition of “product” in ISO 9000:2005.^[1]

Note 2 to entry: Services are one of the four generic categories of products with software, hardware and process materials. Many products comprise elements belonging to different generic product categories. Whether the product is then called “service” depends on the dominant element.

Note 3 to entry: Service is the result of at least one activity necessarily performed at the interface between the provider of the service and, in the first place, its user and, in the second place, a stakeholder. Service is generally intangible. Provision of a service can involve, for example:

- activity performed on a tangible product supplied by the user, e.g. wastewater;
- activity performed on an intangible product coming from the user, e.g. processing new connection requests;
- delivery of an intangible product, e.g. delivery of information;
- creation of ambience for the user, e.g. reception offices.

Note 4 to entry: The word “service” in common English can also refer to the entity providing the actions related to the subject in question, as is implicit in such phrases as “bus service”, “police service”, “fire service” and “water or wastewater service”. In this context and usage, “service” implies the entity that is delivering the service, e.g. “the public transport of passengers”, “the provision of public security”, “fire protection and response”, and “delivering drinking water or collecting wastewater”. If “service” can be understood in this way, “water service” becomes synonymous with “water utility”; hence, in this document, in order to avoid confusion, only the definition in 3.23 applies.

3.24

service life

period of time after installation during which an *asset* (3.1) or an *asset system* (3.3) meets or exceeds the technical and functional requirements

3.25

strategic plan

document identifying goals and objectives to be pursued by an organization over a long-term period in support of its mission and being consistent with its values

3.26

tactical planning

identification of objectives to be pursued by an organization over the medium term on the basis of priorities derived from influencing factors/indicators on performance, costs, risk and failure probability and scale of failure

3.27

wastewater system

system providing the functions of collection, transport, treatment and discharge of wastewater and wastewater residues

4 Principal aspects of the management of assets

4.1 Objectives and requirements

4.1.1 Objectives

The key generic objectives for asset management of wastewater systems are identified from ISO 24510 and ISO 24511 as:

- protection of public health and safety;
- meeting users' reasonable needs and expectations;
- occupational health and safety;
- promoting the sustainability of the wastewater utility;
- providing services under usual and emergency situations;
- protection of the environment;
- promoting sustainable development of the community.

Wastewater utilities in undertaking management of assets should aim to manage their facilities systematically and efficiently in order to sustain their functions, through establishment of clear objectives, based on assessment and forecasting of the condition of their, often extensive and complex, facilities.

The objectives of the management of assets will help to ensure that a wastewater utility complies with an agreed sustainable level of service while also exerting a major influence on its economic performance. The level of service should be well defined, communicated, tied to risk, and current as customized to a particular wastewater utility. The objectives for the management of assets should be determined from functional requirements of wastewater networks.

For further information on objectives of management of assets for wastewater networks, see [Annex A](#).

4.1.2 Functional requirements

Functional requirements should be established to aid the achievement of objectives. Functional requirements cover the wastewater networks (as part of the wastewater system) including the effects of their discharges on receiving surface water bodies and receiving wastewater plants. The functional requirements should be considered in respect of the whole system to ensure that additions or modifications to the system do not result in failure to meet the target.

Functional requirements should be established which, while taking into account sustainable development and whole life costs including indirect costs (e.g. traffic congestion, military aid provided to the civil authorities), ensure that wastewater networks convey and discharge their contents without causing unacceptable environmental nuisance, risk to public health, or risk to personnel working therein.

Each functional requirement can relate to more than one objective. An indication of the relevance of each of the functional requirements to the achievement of the objectives is shown in [Table 1](#).

Table 1 — Relationship between objectives and functional requirements

Functional requirements	Objectives						
	Public health and safety	Occupational health and safety	Protection of the environment	Meeting users' reasonable needs and expectations	Promoting sustainability of the wastewater utility	Providing service under usual and emergency situations	Promoting sustainable development of the community
Protection from flooding	XXX	XX	XXX	XXX	X	XXX	XXX
Maintainability	XX	XXX	XX	XX	XX	XX	XX
Protection of receiving surface water bodies	XXX	X	XXX	XX	XX	XX	XX
Protection of groundwater	XXX	—	XXX	XXX	XX	X	XXX
Prevention of odours and toxic, explosive and corrosive gases	XXX	XXX	XXX	XXX	XX	XXX	XXX
Prevention of noise and vibration	XX	XXX	X	XXX	X	XX	X
Sustainable use of products and materials	—	—	XX	XX	XXX	X	XXX
Sustainable use of energy	—	—	XX	XX	XXX	X	XXX
Structural integrity and design life	XXX	XXX	XXX	XXX	XXX	XXX	XXX
Maintaining the flow	XXX	—	XXX	XXX	XX	XXX	X
Watertightness	XXX	X	XXX	XX	XXX	X	XX
Not endangering adjacent structures and utility services	XXX	XXX	X	XX	XXX	XX	XX
Inputs quality	XX	XXX	XXX	XXX	XX	XXX	XX

NOTE The number of X gives guidance on the importance of the requirement in achieving the objectives.

4.1.3 Performance requirements

In order to evaluate the performance of the network and to allow development of design criteria, measurable performance requirements should be determined from each functional requirement.

The process for determining performance requirements is illustrated in [Figure 1](#).

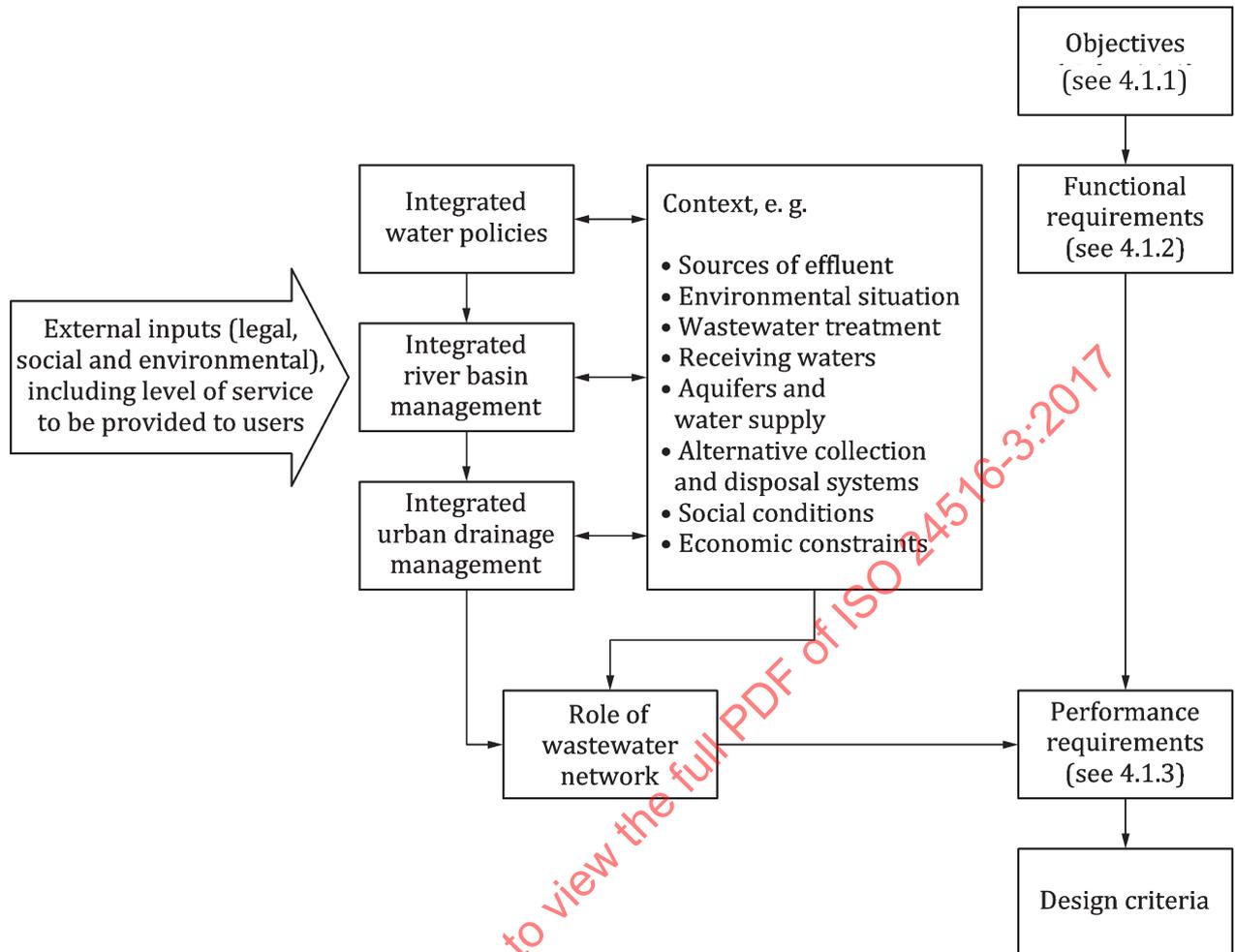


Figure 1 — Process for determining performance requirements

For each functional requirement, there can be legal requirements, public expectations and financial constraints which will influence the performance requirements. Public expectations should be reflected in the levels of service set by the utility to provide to its users.

For each aspect of performance, different levels can be required, for example:

- a) trigger levels which justify early upgrading action according to priority;
- b) target levels to aim for in upgrading, which should be equal to the requirements for new construction, but which sometimes can only be achievable or necessary in the longer term.

Performance requirements should be reviewed periodically and updated, if necessary. The performance requirements for the network should be updated after major extension, maintenance or rehabilitation.

In principle, the performance requirements for a rehabilitated network should be the same as those for a new network.

Performance indicators are an essential tool in understanding a utility's infrastructure conditions and needs and, in parallel, enable indicator-supported infrastructure planning and decision making. Properly implemented indicators provide information on the condition of the assets and the level of their contribution to the achievement of the utility's objectives.

Performance indicators should be defined at strategic, tactical and operational levels. They should make clear how actions at the operational level contribute to achieve strategic level objectives. Strategic level

performance indicators are often called “outcomes” while operational and tactical level performance indicators are called “inputs” and “outputs” respectively.

For further information on objectives and functional requirements, see [Annex A](#).

4.2 General aspects

4.2.1 General

A distinction can be made between aspects of the management of assets for the wastewater utility or responsible authority and aspects of the wastewater system to be managed.

Management of assets should take into account:

- attention to stakeholders’ requirements, needs and expectations;
- sustainability of the asset system and the provided service;
- the management of risk.

The management of the utility’s assets will be directed towards ensuring the utility’s objectives are met.

4.2.2 Principal aspects — Wastewater utilities

The management of the physical infrastructure of wastewater utilities is recognized as a critical activity if users’ and relevant authorities’ expectations are to be realized. Key activities include:

- the determination of the utility’s current and longer term objectives;
- the means of measuring the performance of the utility in meeting these objectives.

Additionally, for ensuring long economical life cycles, this should include:

- layout of the entire wastewater system;
- selection of appropriate materials and components;
- choice of installation technologies and installation contractors;
- quality control of materials used and of installation;
- maintenance of assets and asset system including routine and incident related inspection;
- monitoring of operational conditions;
- monitoring the system’s environmental conditions.

Efficient asset management is a balance of minimizing life cycle costs while continuously providing the levels of service and risk control established by the utility to meet users’ and stakeholders’ expectations.

Management of the assets includes:

- maintaining an up-to-date system inventory;
- monitoring and documenting data;
- assessing system condition;
- planning, maintaining or rehabilitating the system;
- operation of the system in such a manner so as to increase service life while maintaining service levels;
- optimizing life cycle costs;

- identifying and managing risks;
- ensuring the system is utilized/operated as intended;
- considering the environment in which the assets are functioning.

4.2.3 Principal aspects — Wastewater systems

The management of assets of wastewater systems should cover the complete asset system and the interrelationship of all components of the wastewater system such as collection networks, pumping stations, retention and detention tanks and treatment plants including the resulting effluent quality and its disposal/reuse as well as solids-disposal facilities. In addition, the management of assets should consider changes in needs and expectations of users and other stakeholders as well as environmental effects such as climate conditions, population migrations and demography.

Hence, this document should be used in conjunction with other standards regarding management of assets of wastewater systems, i.e. retention and detention tanks, pumping stations, wastewater treatment plants, and sludge treatment facilities, including pumping (also in the networks).

Wastewater systems are used to provide a service to the community. This can be briefly (and typically) described as the:

- removal of wastewater from premises for public health and hygienic reasons;
- prevention of flooding in urbanized areas;
- protection of the environment both natural and built.

In general, a wastewater system has the following potential functions:

- collection;
- transport;
- retention and detention;
- treatment;
- discharge;
- reuse.

4.2.4 Integrating the principal aspects

Management of assets is the application of the wastewater utility's asset management principles, as described in this document, within the management of the wastewater system.

Management of the wastewater network assets is implemented with the framework of integrated wastewater network management.

4.3 Specific aspects

4.3.1 Risk

Risk considerations are necessary at all levels in the management of assets — the strategic, the tactical and the operational levels.

Appropriate treatment of risks arising within the context of an organization is an important objective in the management of that organization's assets. Risk treatment is typically done by the introduction or

modification of existing risk controls. Selection of the most appropriate risk controls should result from a process of assessing organizational hazards (e.g. arising from an asset's positioning or failure).

NOTE Risk control can include risk mitigation.

Appropriate countermeasures can then be introduced in a prioritized manner. Such measures can include operation and maintenance activities as well as rehabilitation.

There are many alternative techniques for identifying, analysing, evaluating and treating risk in different fields (see IEC 31010 and the water sector specific EN 15975-2). The risk assessment methodology proposed in this document is based on generally recognized risk assessment principles (e.g. ISO 31000).

These principles involve:

- risk identification (in this case, principally by hazard analysis);
- risk analysis;
- risk evaluation;
- risk control including risk treatment.

Hazard analysis involves study of hazards as potential causes of risk events. Risk analysis considers the impact (and related consequences) of a risk event's occurrence and the likelihood that that event can occur. The wastewater utility should define its utility-specific risk analysis approach and criteria for risk evaluation, based on organizational objectives, and external and internal contexts. Risk criteria should be determined in terms of the same dimensions as the parameters used in the risk analysis. The order of priority for inspection/survey plans should be determined by risk evaluation (which considers the significance of each risk relative to all the risks under consideration). Typically, this comparison is conducted by comparing individual risks' "scores" (the product of a risk's impact × likelihood ratings against the organization's risk criteria) — using a risk matrix to present the results.

The prioritization of measures to treat (prevent/reduce) the impact and/or likelihood of individual risks' occurrence should be carried out by comparing the effectiveness of individual treatment measures, and their related costs, practicability and acceptability to stakeholders.

Wastewater-related asset risks can be categorized into the following two groups:

- a) non-influenceable risks, such as natural disasters (earthquakes, storms, floods, etc.) or economic situations;
- b) influenceable risks, such as accidents due to facility deterioration, service restriction or interruption due to blockages, asset malfunction, a deterioration of effluent quality.

The following are a few examples of asset data relevant for assessing impact:

A pipe's:

- diameter;
- function;
- proximity to other significant assets, infrastructure or areas;
- access constraints;
- (repair or rehabilitation) cost.

The following are a few examples of asset data relevant for assessing likelihood:

- maintenance data;
- telemetry data;

- employee feedback;
- incident data;
- condition data;
- user complaints;
- security reports;
- social behaviour;
- environmental influence.

4.3.2 Life cycle

Life cycle cost should be minimized by keeping the networks in a proper operating condition as stated in the objectives. This should include:

- optimized maintenance planning;
- inspection;
- use of suitable construction methods and durable materials;
- co-operation with other organizations;
- energy management;
- optimized stand-by service;
- proper control of operational processes;
- proper control of the network's use (e.g. industrial waste discharge control);
- efficient deployment of staff and accomplishment of tasks (by qualified and/or certified contractors, if necessary, but retaining core competences at the same time);
- participation in benchmarking projects;
- demand-based materials' management and control (procurement and stock keeping).

For example, to rehabilitate facilities, the priority of a project should be determined in the framework of the budget while aiming to minimize the life cycle cost of each facility.

4.4 Structuring the process for the management of assets

4.4.1 General

Integrated wastewater network management is the process of achieving an understanding of the existing and proposed wastewater network, and using this information to develop strategies to ensure that the hydraulic, environmental, structural and operational performance meets the specified performance requirements taking into account future conditions and economic efficiency.

The integrated wastewater network management process is illustrated in [Figure 2](#).

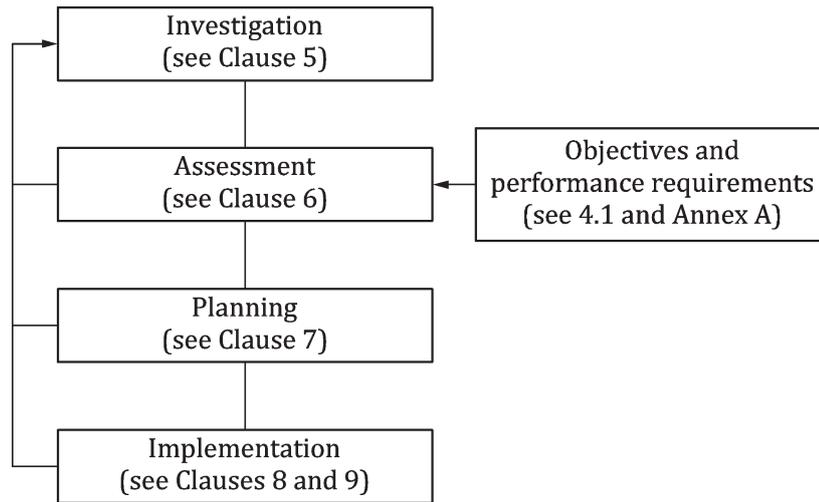


Figure 2 — Integrated wastewater network management process

The integrated wastewater network management process has four principal activities:

- a) an appropriate level of investigation of all aspects of the performance of the wastewater network;
- b) assessment of the performance by comparison with the performance requirements including identification of the reasons for the performance failures;
- c) developing the plan of measures to be taken;
- d) implementation of the plan.

The need for further investigation can become apparent either during the performance assessment or the development of the plan.

Integrated wastewater network management forms the basis for the operation and rehabilitation of the wastewater network. The information is regularly updated for the future management of the wastewater network.

For large wastewater networks, for example one serving a large city, a strategic outline integrated wastewater network management plan can first be developed following an outline investigation of the whole system. More detailed plans can then be developed for each sub-catchment within the context of the strategic outline plan.

The integrated wastewater network management plan is further developed during the implementation phase by subsequent investigation, assessment and planning to develop work programmes and individual projects to implement the plan.

The boundary conditions with adjacent wastewater networks and with other urban drainage systems or with river systems should be considered at all stages.

Management of assets requires the conducting of activities at the strategic (long-term) and tactical (medium-term) and operating (short-term) levels.

4.4.2 Strategies for the management of assets

Strategies for the management of assets should be based on objectives and requirements (see 4.1). The risks of not achieving these objectives and requirements should be identified and managed appropriately. Based on whichever of the following two strategies is chosen, the risks can be estimated and controlled:

- condition-based or inspection strategy; or

- incident-based or failure strategy.

Wastewater infrastructure assets should be managed and maintained according to the condition-based or inspection strategy to increase the likelihood of achieving the objectives and requirements as stated in [4.1](#).

A proactive inspection will enable more efficiencies, though reactive and proactive maintenance need to be appropriately balanced for a particular wastewater utility. A greater level of proactivity and subsequent ability to be more strategic and prioritized in rehabilitation will help a wastewater utility to be more capable of attaining its levels of service, as measured by performance indicators.

The condition-based or inspection strategy takes into account the development of the condition of the asset system and single assets and pursues a long-term approach. It warrants the efficient and economical use of rehabilitation funds. Although, it is possible that it does not reduce overall rehabilitation and life cycle costs over a defined long-term planning period, but can spread these costs out over a longer term and can avoid social costs. Costs depend on actual maintenance requirements.

Organizational constraints, continuance of existing practices or acceptance of low impact risks' consequences can lead to the use of an incident based or failure strategy, which incurs lower maintenance costs in the short-term but to disproportionately high costs in the long run. Probable consequences can include inadequate operating safety, increased failure rates, flooding, and premature loss of the existing structure and value of the infrastructure assets. The risk of failures and inadequacies can be extremely high.

Fundamental prerequisites for economically efficient management of assets should be defined as early as possible in the design and construction phases of wastewater infrastructure.

4.4.3 Periods of planning

The sustainable process for the management of assets is, on the basis of the planning period under review, subdivided into the following three interdependent sub-processes (see [Figure 3](#)):

- long-term planning – strategic planning;
- medium-term planning – tactical planning;
- short-term measures – operational planning.

NOTE The duration of the planning stages depends on local circumstances and the context of the installation environment.

Common time frames are:

- strategic planning, about 20 years to 40 years;
- tactical planning, about 2 years to 5 years;
- operational planning, next year.

Strategic planning for a long-term period focuses on the scope of measures and the budgets required to achieve and to maintain network condition levels.

During the sub-process “tactical planning”, the required measures will be determined and prioritized for a medium-term period based on a network evaluation and at that time, the technology and material will be preselected.

In the “operational planning” phase, the actual execution is then examined and fixed taking possible alternative measures into consideration (e.g. execution of the rehabilitation measures in terms of line routing, nominal width, material and construction method).

For this purpose, the sub-processes cannot be considered as independent and their results with regard to management strategy, planning and measures should be harmonized not only with one another, but also with the strategic network structure and capacity planning.

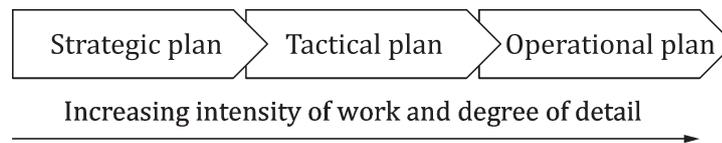


Figure 3 — Logical steps for the implementation and evaluation of rehabilitation targets

4.4.4 Strategic level activities

Decision-making support requires the identification of the strategic and measurable objectives. Activities on a strategic level should include:

- establishing acceptable/required levels of public safety, public health protection, environmental protection and user satisfaction;
- expressing those levels in the form of performance indicators;
- linking those performance indicators to asset performance indicators;
- establishing adequate billing rates to ensure sustainable revenues;
- quantifying sustainable infrastructure funding requirements and ensuring predictability;
- assessing capacity against future demands;
- evaluating and adopting maintenance and rehabilitation strategies from the possible approaches to draft the strategic plan.

4.4.5 Tactical level activities

Activities on a tactical level should include:

- analysing infrastructure asset life cycles;
- establishing information to be collected at the operational level;
- establishing information management;
- analysing reported information;
- prioritizing infrastructure spending from available funds;
- maintaining an accurate asset data collection system;
- assessing the risks of asset failure or inability to meet the intended function;
- ensuring that the required maintenance is performed.

A major activity at the tactical level is the process of reviewing indicators to determine only productive, useful and coherent information, to avoid overloading the information management process. The information should be manageable and relevant.

4.4.6 Operational level activities

Activities on an operational level should include:

- collecting, monitoring and reporting asset operational information and condition (see [Clause 5](#));

- controlling costs;
- implementing preventive and corrective maintenance activities;
- planning maintenance schedule;
- operating the system within its operational parameters;
- responding to incidents, asset failures and emergencies, and restoring service;
- implementation of rehabilitation projects.

5 Investigation

5.1 General

An investigation should be carried out in order to make an assessment of the condition and the performance of the wastewater networks and its components.

Investigation is the first stage in the integrated management of assets of wastewater networks as described in [4.4.1](#).

Damaged, defective or hydraulically overloaded drains and sewers represent a potential hazard through sewer flooding and collapses, and through pollution of receiving surface water bodies, groundwater and soil. The problems found in existing wastewater networks are frequently interrelated and upgrading works will often be designed to overcome a number of problems at the same time. The investigation and planning should be carried out on complete catchment areas so that all problems and their causes can be considered together. In large wastewater networks, it can be necessary to start by investigating appropriate parts of the networks. The procedures described in this document can be applied in any wastewater network, but detailed application should take account of the age, location and type of network, the materials used in its construction, together with functional and climatic factors.

5.2 Purpose of investigation

The investigation is carried out in order to make an assessment of the performance of the wastewater network and its components. This can include:

- investigation aimed at strategic planning;
- investigation aimed at operational planning.

The purpose of the investigation influences the way in which it will be carried out (e.g. choice of method, degree of detail, desired accuracy) and the way in which the results will be assessed.

The assets of the wastewater network included in the investigation should be those that are necessary to fulfill the purpose of the investigation. Examples include drains, stormwater, sanitary and combined sewers (both gravity and pressure/vacuum), manholes, inspection chambers, combined sewer overflows, monitoring facilities, control facilities, outfalls, gravel and sand traps, flushing facilities, ventilation facilities, sedimentation tanks, light liquid/grease separators and other access facilities. Data of other assets which are not part of the network like pumping stations, detention and retention tanks, and treatment plants should also be taken into account with regard to their interaction with the network.

5.3 Determine the scope of the investigation

Following the review of the current performance information, it is possible to decide whether to carry out an investigation and whether the extent of the problems justifies an investigation of the entire catchment area. The extent and detail of the subsequent investigation of the hydraulic, environmental, structural and operational aspects should be determined.

5.4 Types of investigation

5.4.1 Hydraulic investigation

Testing and inspection procedures can be required in order to ensure an adequate evaluation of flows [wet and dry weather, infiltration, flows through gaps in manhole tops (between the cover and frame), exfiltration and wrong connections]. Surveys should include precipitation and resulting flow measurements, identification of wrong connections and measurements on groundwater and combined sewer overflow quantity at outlets.

In some cases, it is not possible to understand the hydraulics of the system without using a hydraulic model. This sewer flow simulation model should be based on an as-built report updated after onsite investigation of the main works. However, a model is not usually recommended where:

- there are no known hydraulic problems (particularly where the wastewater network takes only wastewater flows);
- there are no combined sewer overflows;
- no significant new developments are proposed within the system; and
- structural problems are to be solved using techniques which do not reduce the hydraulic capacity of the sewer.

5.4.2 Environmental investigation

The environmental impact depends on the nature of the wastewater and its potential to escape from the system.

The quality of receiving surface water bodies should be ascertained to see whether they meet the requirements and if not, whether the wastewater network is a significant factor.

Consideration should be given to other environmental factors such as noise, odour, visual intrusion and potential soil contamination.

The investigation can include:

- review of inputs' quality;
- wastewater quality measurement;
- wastewater quality simulation modelling;
- surface receiving water impact surveys;
- leak-tightness testing;
- groundwater quality investigations;
- odour and noise surveys.

5.4.3 Structural investigation

It is important to ensure that investigation of the network is selective in order to avoid duplication of previous work. The structural investigations can include either a complete survey of the wastewater network or a more selective approach. Consideration should be given to the age and location of existing infrastructure, geotechnical data including the pipe bedding and surround, and the vulnerability of existing buildings and other utility services.

Where appropriate, other qualitative and quantitative investigation techniques can be used. These include sonar (for pipes that are filled with water) and ground probing radar or other geophysical techniques (e.g. for detecting voids behind the wall of the sewer pipe) or mechanical techniques

(e.g. internal jacking to measure the stiffness of the side wall support). Investigation of the chemical composition of the groundwater and the soil should be carried out where this can affect the structural integrity.

The results of the structural investigations can also be relevant to the assessments of the hydraulic performance and environmental impact.

5.4.4 Operational investigation

Existing operational procedures, inspection schedules and maintenance plans should be identified and documented.

The frequency and location of recorded operational incidents (e.g. blockages, sewer collapses) should be reviewed.

The impact of operational problems on the hydraulic, environmental and structural performance of the network should be determined from incident records.

The causes of significant recurrent operational incidents should be investigated.

To deal with operational problems in an efficient way, it is necessary to investigate and understand the causes.

5.5 Data collection

5.5.1 General

Acquisition of data can be important but carries a cost. The wastewater utility should consider what data are important to acquire promptly and what further data should be acquired opportunistically. This subclause contains details of types of data associated with a range of objects that can be important to inform the wastewater utility's decision-making process. The wastewater utility should consider the purpose for which the data are to be gathered and design data recording methods to suit those needs.

Where there is insufficient information, the inventory should first be updated where required and any other information should then be collected during the hydraulic, environmental, structural and operational investigations.

5.5.2 Data requirements

The quality of data should be assessed taking into account whether it is:

- complete;
- compatible;
- accurate;
- at a suitable scale;
- consistent;
- current;
- credible.

5.5.3 Inventory data

Inventory data provides essential technical information on the assets within wastewater networks. [Table 2](#) gives examples of inventory data.

Table 2 — Example of inventory data

Inventory data attribute, if applicable	Assets			
	Pipeline section	Manhole	Drain	Outfall
Location (e.g. sewer's ID, coordinates, address)	X	X	X	X
ID of connected sewer/drain/manhole	X	X	O	O
Catchment area	X	X	X	X
Type of pipeline (sewer, drain)	X	—	O	—
Type of system (e.g. combined or separate system)	X	X	X	X
Type of system (e.g. gravity, pressure, vacuum)	X	X	X	X
Type of asset (pipe, screen, valve, siphon, life-detention tank)	X	O	—	—
Combined sewer overflow	X	O	O	X
Material	X	X	X	X
Manufacturer	O	O	O	O
Length of pipe	X	—	X	—
Cross section/shape/dimension	X	X	X	X
Ground level	O	X	O	O
Depth of covering materials	O	X	O	X
Sewer invert elevation	—	X	—	X
Gradient	X	—	X	—
Year of installation	X	X	X	X
Year of decommissioning	X	X	X	X
Year of rehabilitation	X	X	X	X
Type of rehabilitation	X	X	X	X
Installation/rehabilitation cost	X	X	X	X
Connected main's ID and manhole's ID	—	—	X	X
X should be mandatory O should be optional — not applicable ID identification number of an asset				

All relevant data should be geo-referenced (with coordinates) where practical and all levels should be given in absolute elevation referenced to a datum level, e.g. sea level at a specific location.

5.5.4 Failure data

Failure data provide technical information on failures found in wastewater networks. The following data should be collected:

- date of documentation;
- date of failure occurrence;
- location (e.g. sewer's identification number, coordinates, address);
- point of failure;
- type of failure;
- cause of failure (e.g. natural deterioration, damage due to other construction);
- type of remedy (repair, renovation, replacement);

- consequence of failure (e.g. damage, infiltration, exfiltration, number of customers without service).

The data on failures which were caused by events over which there is no control, e.g. natural disasters such as earthquakes or floods, can provide crucial information and are particularly important for the rehabilitation strategy as well as for contingency and emergency planning.

5.5.5 Further condition data

In addition to failure data, more information on the condition of wastewater networks should be acquired as it provides valuable information on the prioritization of rehabilitation measures.

Condition data on wastewater networks are limited, with the data methods differing fundamentally from the collection of inventory and failure data.

The following data should be collected, if applicable and obtainable:

- date of condition data collection;
- location of investigation (e.g. sewer’s ID, coordinates, address);
- identification and plausibility information (e.g. material, nominal diameter);
- bedding;
- sewer depth;
- overbuilding;
- sewer’s condition/failure (e.g. scoring, deformation);
- internal deposits;
- context data;
- operational incidents.

Context data provide technical information about the local surroundings of wastewater networks, which should be factored into the risk assessment process. Context data can include that deriving from the content of [Table 3](#).

Table 3 — Example of context data

Context data attribute	Assets				
	Pipeline section	Manhole	Ancillary structure	Drain	Outfall
Date of context data collection	X	X	X	X	X
Location (e.g. pipeline ID, coordinates, address)	X	X	X	X	X
Type of soil	X	O	X	X	O
Soil assessment	O	X	X	O	O
Critical building area (adjacent vulnerable structures)	X	X	X	X	X
Distance to building site	X	X	X	—	—
Distance to long-haul traffic routes (e.g. A-roads and motorways, railway lines)	X	X	X	—	—
Traffic load	X	O	O	O	O
Protection strip	X	—	O	—	—
Working width	X	—	O	—	—

Table 3 (continued)

Context data attribute	Assets				
	Pipeline section	Manhole	Ancillary structure	Drain	Outfall
Underground facilities (drinking water pipes, buried electricity cables, etc.)	X	X	X	0	—
Major adjacent structures (high voltage transmission line towers, bridges, buildings, facilities, etc.)	X	X	X	0	—
Surface utilization	X	0	0	0	0
Earth movements/mining activities	X	0	0	X	0
Topography	X	0	0	0	0
Risk factor (impact and likelihood)	X	X	X	0	0
Criticality factor (relative to risk criteria)	X	X	X	0	0
X should be mandatory 0 should be optional — not applicable ID identification number of an asset					

5.6 Data registering and data assignment

5.6.1 Data registering

The stored data should be checked and updated periodically or appropriately.

The data to be registered as defined in 5.5.3 to 5.5.5 should be compiled, integrated, processed and safely stored and readily recoverable by the utility. They form the basis for developing maintenance plans and strategies.

The data collection process itself determines the value of the data for asset management. The data should relate to the assets' inventories (see examples in Tables 2 and 3). The data's value increases in line with its quantity and quality registered and with the possibility to assign individual pieces of data to the respective wastewater networks/assets under consideration.

Context data in accordance with Table 3 should be registered for individual objects in accordance with 5.5.3 and Table 2 (line or spot objects). In certain collection areas, however, context data should also be registered two-dimensionally, in which case they should be clearly assigned to the individual objects described in 5.5.3 and Table 2.

Data collection should be comprehensive, continuous and free from interpretation. Data registered for one collection area and/or utility should be uniform and based on previously and unambiguously defined default values ("multiple choice"). Free text should be avoided because it offers only limited evaluation possibilities.

Condition data pertaining to the interior of the components can be obtained by various investigation methods (including visual inspection) of the pipelines and manholes.

Condition data for the exterior of the components can be obtained by various investigation methods (including excavation of buried pipeline sections). To this end, utilities should avail themselves of the opportunities offered by excavations accompanying work on pipeline networks, or civil engineering works conducted by third parties. Other condition data should be registered during remedial activities. Data collection can be performed using either mobile data collection devices or forms to be filled in manually (preferably box-ticking forms). It should be ensured that all data can be digitally aggregated in one place or system.

5.6.2 Data assignment

All inventory, condition and context data registered should be correctly assigned to the associated asset types (e.g. concrete pipes or manholes) and/or individual assets. Failure data on manholes, for example, should not be assigned to pipeline data. Likewise, failure data should be registered in such a way as to enable the retroactive elimination of events not relevant for maintenance, e.g. pipe damage caused by third-party interference.

Inventory, condition and context data can be used for devising rehabilitation planning and strategy, depending on the object to which they are assigned.

5.6.3 Geo-referencing

Using the above-mentioned databases for medium and short-term rehabilitation planning requires geo-referencing and the unambiguous assignment of data records to the associated asset. Using selective geo-referencing condition and location data can provide important information when defining a rehabilitation strategy.

Capturing data in geo-referencing systems (GIS, network information systems, computer network models etc.) is the best approach for processing and using maintenance-related data. If the data are assigned only to pipeline or material groups instead of individual pipeline sections, location-related information (e.g. about location conditions) is rendered useless for rehabilitation planning purposes even if such information is available. Reference to assets as well as geo-referencing information should be preserved even when assets have ceased to form part of currently existing networks. Historical data also supply important information for devising a rehabilitation strategy.

5.7 Review existing information

The collection and review of all available relevant information about the wastewater network should be carried out and is the basis from which all other activities are subsequently planned.

A review should also be undertaken of the information required to manage the wastewater network system.

This information should be assessed to determine what further information is required in order to carry out the investigation (see EN 13508-1).

5.8 Inventory update

Where the inventory is incomplete, it should be updated so that a sufficient record of the wastewater network is available to carry out the investigation.

NOTE The update of the other information is included in the hydraulic, environmental, structural and operational investigations.

As a minimum, each asset should be assigned a unique identification number. Formulating a hierarchical structure in the data is also helpful for information retrieval, analysis, and reporting needs. Asset data attributes should be captured for each asset and their source (e.g. design documents, information system). Mapping the data workflows among their sources and recipients helps to enable better functionality, efficiency and quality.

5.9 Review of performance information

An indication of the type of performance problems, if any, on existing systems is likely to be known through reports of incidents such as sewer collapses, flooding or polluted watercourses and from previous investigations. Records of past incidents and any other relevant information should be brought together and a detailed review should be carried out to establish the scope of the investigations.

Where large numbers of complete or partial catchments are in need of investigation, the existing information collected can also be used to assign priorities to the investigation of the perceived problems in each catchment (for example, by comparing the cost of the investigation with the benefit that might be achieved). These can then be used to draw up a comprehensive programme so that the catchments with the most serious problems are investigated first.

5.10 Planning of investigation

The following should be evaluated for modelling of survey work:

- target facilities and period for inspection/survey;
- determination of survey type (see [5.5.5](#));
- survey method, items, standards;
- estimated cost.

Target facilities and execution period for medium-term survey plans should be decided according to the priority order based on risk assessment. The medium-term plans should be based on the total work amount mentioned in the long-term survey plan.

5.11 Performance testing

It is necessary to assess the performance of the wastewater network during construction and at the completion of the construction stage. The network should also be monitored during its operational life.

The following are examples of test methods:

- watertightness test with water;
- watertightness test with air;
- infiltration test;
- visual inspection;
- dry weather flow assessment;
- monitoring of inputs to the network including substances toxic to the treatment process;
- monitoring effluent quality, quantity and frequency at point of discharge to receiving surface water bodies;
- monitoring within the networks for toxic, corrosive and/or explosive gas mixtures;
- monitoring of discharge from network to treatment works.

The tests to be undertaken or the methodologies to be followed to determine the performance being achieved by the wastewater locations depend on whether it is a new system, a rehabilitated system, or an existing system being tested.

The effectiveness of maintenance should be assessed by comparing the performance of the wastewater locations with the wastewater utility's objectives for wastewater collection. In addition, for reactive maintenance, target response times can be used as an assessment. This also forms the basis for future planning to identify some constraints that impact proactive maintenance. More proactivity will enable more efficiencies, though reactive and proactive maintenance need to be appropriately balanced for a particular wastewater utility. A greater level of proactivity and subsequent ability to be more strategic and prioritized in rehabilitation and renewal will help a wastewater utility to be more capable of attaining its levels of service, as measured by key performance indicators. These service levels and key performance indicators should be well defined, communicated, tied to risk, and current as customized to a particular wastewater utility.

6 Assessment

6.1 Principles

The performance of the network should be assessed against the performance requirements (see 4.1.3). The performance assessment should include the evaluation of risks to achieve the performance requirements. Figure 4 shows the process of assessment.

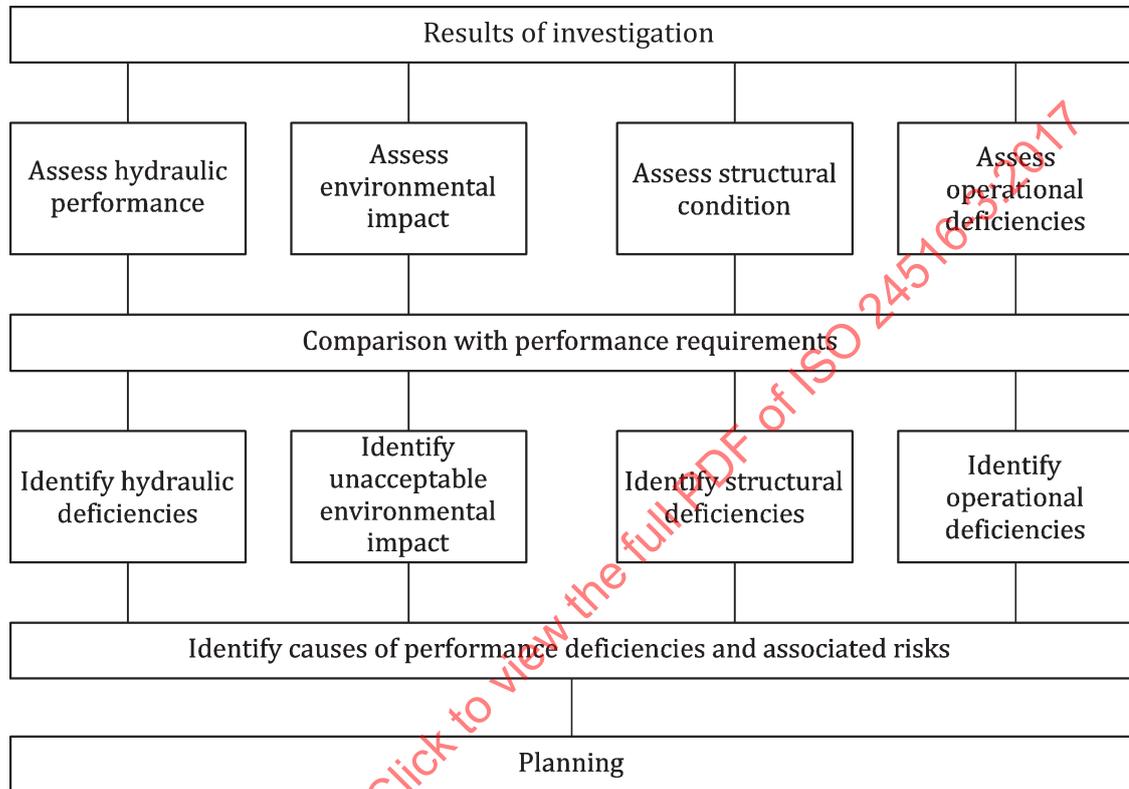


Figure 4 — Process for assessment

6.2 Assessment of the hydraulic performance

The results of the hydraulic investigations and/or the verified flow simulation model should be used to assess the hydraulic performance of the network for a range of rainfall conditions related to the performance requirements.

6.3 Assessment of environmental impact

The results of the investigations should be considered together with information on the frequency, duration and volume of discharges to receiving surface water bodies, determined using a verified flow simulation model where this is available or from site measurements. This information should then be used to assess the environmental impact (including impact on soil and groundwater) of the wastewater network.

The results of the structural investigation, the trade effluent industrial wastewater survey and other relevant investigations should be examined to identify:

- sources of hazardous effluents;
- exceedance of permissible concentrations and discharges including social consequences;
- other deviations from permits.

6.4 Assessment of structural condition

Once the network has been investigated, the next stage is to examine the results to identify those areas requiring action.

6.5 Assessment of operational performance

The operational performance of the network as measured by the number of operational incidents or failures should be assessed. This should be recorded in a database.

6.6 Comparison with performance requirements

The results of the assessment of the hydraulic, environmental, structural and operational performance should be brought together so that the overall performance of the network and its components can be compared to the performance requirements.

Performance indicators are one method of comparing the overall performance of networks with performance requirements. Any performance indicators used should be:

- clearly defined, concise and unambiguous;
- verifiable;
- simple and easy to use;
- tied to the level of service.

6.7 Identification of unacceptable impacts

Details of those parts of the network where the hydraulic, environmental, structural or operational performance of the network or its components does not meet the performance requirements should be recorded.

6.8 Identification of causes of performance deficiencies

Based upon the results of the hydraulic, environmental, structural and operational investigations, the causes of performance deficiencies should be determined. The relative impact and likelihood of a risk event resulting from each cause should be assessed against the utility's risk criteria in order to develop appropriate solutions and to set the priority for action.

7 Planning

7.1 General

The integrated wastewater management plan can take one of two forms.

- a) The plan describes the approach to be taken (e.g. a major new sewer to alleviate sewer flooding or reduce discharges to receiving surface water bodies). An outline plan is likely to take this form; further information can be included in detailed plans for parts of the catchment.
- b) The plan outlines the proposed activities and measures (e.g. a major new sewer or separation of surface water to alleviate sewer flooding or reducing the discharges to surface receiving waters) and specifies the resources and timescales.

Outline (strategic) plans are likely to be more long-term (e.g. 20 years to 40 years) than medium-term (tactical) plans (e.g. 2 years to 5 years) or detailed work programmes (next year).

The process of planning to fulfil the performance requirements is outlined in [Figure 5](#).

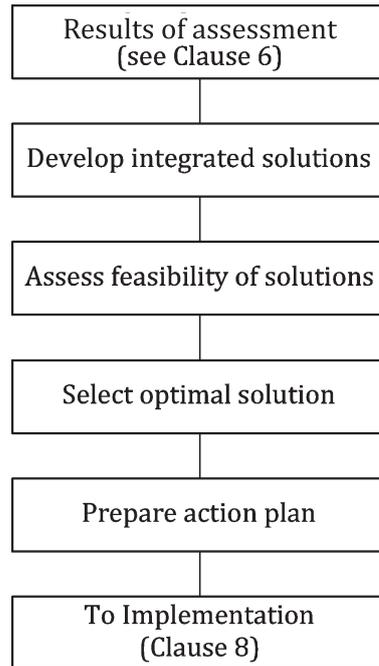


Figure 5 — Process of planning

7.2 Develop integrated solutions

Integrated solutions that fulfil the performance requirements should be developed, taking into account risk considerations and expected future conditions. Different types and groups of solutions are listed in Table 4. For further information on developing solutions for rehabilitation of existing wastewater networks, see EN 14654-2.

Table 4 — Solution types and groups for rehabilitation

Type	Group
Hydraulic	Maximize use of existing flow capacity
	Source control – Reduce the hydraulic input to the wastewater network
	Attenuate peak flows
	Increase wastewater network flow capacity
Environmental	Reduce pollutant inputs to system
	Decrease planned pollutant discharges to receiving surface water bodies
	Decrease impact by relocation of points of discharge
	Reduce exfiltration by rehabilitation measures
Structural	Protect fabric of pipeline by provision of appropriate linings or internal coatings
	Rehabilitate fabric of pipeline
Operational	Undertake planned inspection and cleaning of a wastewater network
	Optimize frequency of maintenance of wastewater network
	Provide additional resilience in the event of future failure (e.g. provision of stand-by equipment or emergency storage)
NOTE This list is not exhaustive.	

7.3 Assess solutions

Solutions should be assessed and the optimal solution selected with regard to the basic performance requirements and factors to be considered such as:

- a) **Safety in construction and operation** – The minimization of risks to health and safety during construction and subsequent operation of the network.
- b) **Social disruption** – The disruption to local residents and other members of the public due to traffic delays, dust, noise and other social factors.
- c) **Sustainable use of resources** – The use of energy and other finite resources in the construction and operation of the network. The ability to recycle materials used in the rehabilitation works and any waste produced. See ISO 21931-1 for greater detail on assessing the environmental performance of construction works.
- d) **Phasing of the works** – The possibility of integrating the solution into a staged programme of works. This should take into account the priorities of the works and the benefits in terms of improved performance associated with each identified phase of the works, and the cost savings associated with deferral of the later stages.
- e) **Relationship to other infrastructure works** – The benefits of phasing the works with other infrastructure works.
- f) **Capacity and resource constraints** – Resource constraints (e.g. personnel, supply chain and financial) in the selection and phasing of the options.
- g) **Future maintenance liabilities** – The cost of future maintenance works and other operational costs of the network. The environmental impact of disposal of maintenance residues.
- h) **Economic appraisal** – The costs and benefits of one solution over another to determine whether the additional benefits of increased asset life, are justified.
- i) **Whole life cost** – The whole life cost of the solution is the present value of all the costs over the life of the solution including temporary works and diversion of other utility services. All design, construction, investigation, maintenance and operational costs should be taken into account as well as the indirect costs (e.g. cost of social disruption). When comparing different options, the whole life cost should be calculated over the same period for each option.

7.4 Prepare an action plan

The selected integrated solution should be documented to give a single plan for the wastewater network. The documentation should include:

- detailed objectives;
- legal requirements and permits;
- performance criteria;
- priorities;
- proposed works including costs and phasing;
- relationship to other construction or planned development;
- consequences for operation and maintenance.

Four types of plans can be prepared:

a) **New development plan**

Where significant new development or redevelopment is proposed in the catchment, a plan should be produced showing:

- 1) whether the wastewater and stormwater from the new development should be drained by extension to an existing wastewater network or by an independent system or, for stormwater - by an infiltration system;
- 2) if the network is an extension of an existing network, the upgrading works to the existing network to accommodate the additional flows should be described in the rehabilitation plan for that network;
- 3) whether surface water should be managed by surface water drains and sewers, a system of open channels or by an infiltration system;
- 4) the attenuation requirements for surface water management, e.g. roof greening, on-site ground infiltration;
- 5) an outline of the main sewer systems to serve the development.

b) **Operations and maintenance plan**

The operations plan should include inspection schedules, operational procedures and contingency plans. The operations plan should indicate the approach to be taken in a particular wastewater network. The plan should include:

- 1) Inspection routines, including which assets are to be inspected and the inspection frequencies, should be established for the system, taking into consideration the requirements and importance of each component. Routines should include the inspection of:
 - i) pipelines including inspection chambers, manholes, pipe bridges, above ground pipelines and outfalls, taking into account the gradient and/or velocity;
 - ii) overflows and detention tanks, taking into account storm frequency;
 - iii) inverted siphons, depending on risk of blockage and potential consequences;
 - iv) separators, according to technical requirements;
 - v) grit chambers, gullies etc., taking into account storm frequency, capacity and land use.
- 2) Procedures for the operation of the components of the system should include plans for:
 - i) operation of any special components (e.g. vacuum or pressure installations within the system);
 - ii) setting dam boards, valves and weirs;
 - iii) operation of detention tanks;
 - iv) showing the assignment of responsibilities for carrying out procedures.

The maintenance plan should be based on maintenance objectives and schedules for each component of the system including a cleaning plan, a pest control plan, and an electrical and mechanical equipment maintenance plan.

The maintenance plan should consider the type of maintenance strategy to be used in each component of the system and the monitoring requirements and frequencies and related risk assessments which take into account the probability of failures and their consequences. The

strategies for maintaining wastewater networks are planned or reactive maintenance, or a combination of both.

Planned maintenance includes a programme of work to remedy the defects and problems identified during inspection. Particularly, the incidence of failure should be reduced where the consequences are severe.

Reactive maintenance involves responding to failures and problems as they are identified. It is appropriate for those parts of the system that can function with little or no maintenance.

c) Rehabilitation plan

Rehabilitation includes a wide range of activities to restore or upgrade the performance of a wastewater network including those examples shown in [Table 5](#).

Table 5 — Scope of a rehabilitation plan

	Examples of system related measures	Examples of asset related measures
— Restore original performance	— Remove extraneous flows	— Repair — Renovation — Replacement (like for like)
— Upgrade original performance	— Maximize use of existing flow capacity — Reduce hydraulic input to the wastewater network — Attenuate peak flows	— Replacement (increased flow)

The rehabilitation plan should include information on proposed rehabilitation works. The options to be considered fall into one or more of the four categories: hydraulic, environmental, structural and operational performance. The works necessary to upgrade an existing wastewater network to meet the performance requirements should be incorporated into a rehabilitation plan. This should include:

- 1) details of the necessary upgrading works;
- 2) other options for upgrading the network;
- 3) any anticipated phasing of the work;
- 4) whether any of the items are conditional on any planned developments.

Rehabilitation includes a plan of work to remedy the defects and problems identified during investigation.

d) Contingency and emergency plan

Contingency and emergency planning is the process of setting out procedures to be used in case of crisis, e.g. breakdown of a part of the system. Efficient contingency and emergency plans should aim at restoring functional requirements (see [4.1.2](#)). It should also include procedures for dealing with major failures and other emergencies resulting from the risk considerations. They can include procedures for a range or incidents including:

- 1) accidental spillages of toxic, noxious or explosive substances;
- 2) discharge of special substances used in firefighting;
- 3) failure of pumping stations or pre-treatment facilities;
- 4) sewer flooding due to an exceptional rainfall event;
- 5) the effect of other forms of flooding on the system;

6) major sewer collapse.

Contingency and emergency planning should in particular guide the allocation and prioritization of resources. Examples include investments in monitoring devices, emergency plant and network redundancy. Knowledge gained from past crises should also be taken into account for future strategic planning and adjustment of operation and maintenance planning.

8 Implementation

8.1 General

The implementation plan should take into consideration the financial risk(s) to the wastewater utility and be based on the principle of the “plan-do-check-act” (PDCA) approach (see [Figure 5](#)).

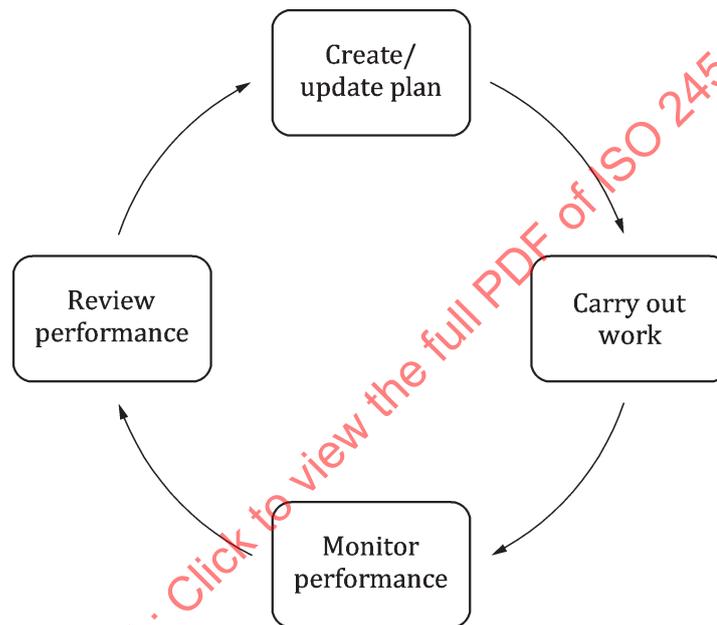


Figure 6 — Process for implementing the PDCA Approach

8.2 Create/update plan

The objectives and functional requirements should firstly be established followed by the technical processes to investigate, assess and create maintenance, rehabilitation and operational plans to maintain or improve the performance of the asset system.

Necessary works to rehabilitate, maintain and operate the wastewater network should be defined in the rehabilitation, maintenance and operational plans. The implementation plan should be updated as necessary and also be updated to identify a path forward to enable the organization to further improve its asset management practices to better attain its levels of service while minimizing costs and managing risk. Improvement should be a continual process. If the performance requirements change, then the whole planning process should be repeated, as necessary, so that the entire plan remains up to date.

8.3 Carry out work

Where it is necessary to extend, reduce or rehabilitate the wastewater network, these works should be designed.

The management of assets should include:

- selection of appropriate technologies and materials;

- selection of installer(s) appropriately experienced in use of the technology and materials;
- quality control of materials (specification and procurement);
- quality of installation and compliance with installation requirements.

8.4 Monitor performance

It is important to monitor the effectiveness of solutions, including the records (inventory) and the hydraulic model by the use of performance indicators.

Monitoring data should be identified and captured that is specifically relevant to identifying the extent to which performance indicators are attained in meeting the committed levels of service. Only this specific data should be captured for the asset management effort.

8.5 Review performance

The performance requirements should be reviewed periodically. The monitoring data captured should be reviewed to identify the extent to which key performance indicators are attained to meet the committed levels of service.

9 Operation and maintenance

9.1 General

The purpose of operation and maintenance is to ensure that the wastewater network performs in accordance with the functional requirements defined in [Clause 3](#) and in accordance with any operation and maintenance plans.

Operation and maintenance should ensure that:

- the entire network is operationally ready at all times and functions within the performance requirements;
- the operation of the network is safe, environmentally acceptable, and economically efficient;
- as far as possible, the failure of one section of the wastewater network does not adversely affect the performance of the other parts.

Examples for the relation between major terms of management of assets are shown in [Table 6](#).

Table 6 — Major terms of management of assets

Term	Existing systems			Examples
	Retain original performance (routine activities)	Restore original performance	Upgrade performance	
Operation	Yes	No	No	Monitoring, regulation of flow, diversion of wastewater flow, operation of pumps and valves.
Maintenance	Yes	Yes (routine)	No	Cleaning or flushing sewers, adjusting metering equipment, cleaning, local repair and replacement and or lubrication of a pump or valve.
Rehabilitation	No	Yes	Yes	Relining of pipe, repair of a broken pipe, pump or valve, replacement or enlarging of an asset.

Effective operation and maintenance of the wastewater network depend on, for example:

- planning;
- rights of access;
- sufficient number of competent personnel;
- clear assignment of responsibilities;
- suitable equipment;
- knowledge of the system, its operational components and the users connected;
- adequate records and analysis.

There can also be requirements relating to the resolution of performance deficiencies, for example, to remedy failures and problems within acceptable timescales.

Flexibility of operation of the wastewater collection network (i.e. its ability to function when a section of it is taken out of service for maintenance, rehabilitation or repair) is usually dependent on its design and existing features such as pipeline looping, duplication or interconnection. However, if such features are absent or insufficient, other measures (e.g. temporary by-passes, sewage re-pumping, etc.) should be implemented to avoid network performance interruptions. If warranted by functional and economic factors, the measures implemented to avoid service interruptions during rehabilitation or repair work can be executed as permanent features and left for future use by the utility.

9.2 Operation

The purpose of operation is to ensure that the wastewater network performs in accordance with its functional requirements and in accordance with any operational plan.

Operation includes:

- controlling gates and dam boards;
- regulating valves and weirs;
- acting in accordance with contingency and emergency plans;
- monitoring and controlling flow and wastewater quality;
- measuring combined sewer overflow quantity and quality at outlets;
- pest control;
- making connections to existing sewers and to users;
- control of disused larger sewers;
- control of building activities over or adjacent to sewers;
- processing complaints.

Urgent interventions that are generally intended to be temporary are included in operation.

9.3 Maintenance

The purpose of maintenance is to ensure that the wastewater network performs in accordance with its functional requirements and in accordance with any maintenance plan.

Maintenance includes:

- pursuing a complementary balance of proactive maintenance with reactive maintenance to enable a more strategic approach to better enable cost savings and risk mitigation;
- local repair or local replacement of damaged pipes, valves or other structures including their accessories in order to maintain their functioning;
- cleaning and removal of sediments, obstructions etc. to restore hydraulic capacity (see also EN 14654-1);
- maintenance of mechanical equipment.

10 Rehabilitation

10.1 General

Rehabilitation should take into consideration all aspects of selection, installation, maintenance, repair, renovation, replacement and decommissioning to fulfil the objectives.

Once an asset system is installed and operated, the highest expenditure in costs over the life cycle is determined by the decision on rehabilitation of the single assets. Preferred manner and timing of the rehabilitation of the assets essentially influence life cycle costs. Therefore, a sustainable process for managing wastewater assets should be subdivided into the following three logical steps that build upon each other so as to be able to identify and assess, by way of comparison, the short, medium and long-term impact of rehabilitation (see [Figure 6](#)):

- a) Determining a long-term rehabilitation strategy,
- b) Drafting a medium-term rehabilitation tactic,
- c) Implementing operational rehabilitation measures required in the short term.

Determining a strategy starts by identifying the scope of rehabilitation works required and the pertinent budget on the basis of a long-term perspective so as to obtain and/or maintain adequate system condition and service quality levels. The tactic includes identifying and defining the sequence of rehabilitation measures required in the medium term and pre-selecting the rehabilitation technology and materials. The operation level includes reviewing the actual execution of the rehabilitation work and taking into account possible alternative options.

Shorter periods of review require more intense work on and higher degrees of detailing of the respective sub-processes, entailing a higher total expenditure in terms of both time and cost. More precise details render the necessary rehabilitation measures more concrete. The results of the individual logical steps should be synchronized with one another.

10.2 Strategic plan on rehabilitation

10.2.1 General

A rehabilitation strategy should be worked out for the entire catchment of the wastewater network. In larger networks, it can be necessary to develop specific strategies for sub-catchments. The rehabilitation strategy should consider all components of the wastewater network and their interaction.

The rehabilitation strategy should be defined at a point in time that permits identifying and responding appropriately to the probable long-term need for rehabilitation. Any subsequent review should be sufficiently frequent to address developments affecting the wastewater network (see [Clause 10](#)). Function, condition and operation of all components of the wastewater network should be considered in setting the review period.

10.2.2 Strategic approaches

A number of different approaches are possible for the formulation of the strategic plan on rehabilitation. These approaches can be combined to achieve the optimal strategy for a wastewater network. Different approaches can be suitable for different parts of the network, depending on local conditions and the risk attached to consequences of failure. Service life can be simply estimated by age as a first step. The statistical estimation can be used to grasp future rehabilitation needs if aging deterioration was recognized in the inspection. When investigation results have been accumulated and assessed, it is advisable to improve the level of estimation.

Possible approaches (dependent on the organizational context and planning horizon) include:

- a) **Asset value approach** – A financial based approach that is used to ensure that rehabilitation is carried out at a rate that ensures that the value of the network at the end of a specified period does not fall below a specified threshold.
- b) **Area-related approach** – One part of the network is selected having common characteristics, requirements and properties, for example: a pumping station catchment area, a groundwater protection zone, a residential or commercial area or the whole of a specific street.
- c) **Condition-based approach** – All drains and sewers are inspected and those drains or sewers that do not meet some specified threshold condition are rehabilitated. If all sewers cannot be inspected in a short period, a sampling survey and a screening method can be used.
- d) **Multi-utility approach** – The rehabilitation of wastewater networks is carried out jointly with rehabilitation of other utility services in the same location in one construction activity.
- e) **Functional-related approach** – This is built around the need for changes to improve the performance of the network (e.g. the need to reduce or eliminate discharges to receiving surface water bodies, or to improve seismic resistance) and takes the opportunity to do other rehabilitation work where this can be done more efficiently at the same time.
- f) **Reactive approach** – This involves responding to failures and problems as they are identified. Examples can include restoring structural integrity following a collapse, removing a complete or partial blockage in order to restore the flow, or increasing hydraulic capacity following a sewer flooding incident.

The above listed strategic approaches including their advantages and disadvantages are shown in [Table 7](#).