TECHNICAL SPECIFICATION

ISO/TS 24522

First edition
2019-02

Event detection process: Guidelines for water and wastewater utilities

Reference number
ISO/TS 24522:2019(E)

Published in Switzerland

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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 of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 224, *Service activities relating to drinking water supply, wastewater and stormwater systems*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

This document has been created in response to an international demand for guidelines on the development of an event detection process (EDP) for drinking water and wastewater utilities (water utilities). The EDP is a key element of a water utility's wider event detection system. That system relies on, and is interrelated to, the water utility's sensor and sampling systems.

This document aims to support water utilities in the development of an EDP that monitors the relevant variables across their water/wastewater services and evaluates changes in those variables that can suggest an event has either occurred or could be imminent.

This document aims to be consistent with both the World Health Organization (WHO) Water Safety Plan approach for water supply and the WHO Sanitation Safety Planning approach for wastewater collection, treatment and disposal or reuse. Both take a risk-based approach to evaluating uncertainty about the quality and significance of data that suggests the occurrence of an event.

NOTE 1 This document addresses a wider range of event causation than that implied by the definition of 'hazard' in the WHO manuals.

For example (water): a change in the hardness of the water supplied could remain within acceptable limits for public health purposes but could still represent a change in water quality of material interest to some service users (e.g. breweries).

For example (wastewater): ingress of a volatile chemical into the wastewater system ought not to represent a direct health hazard in all circumstances, but, depending on its concentrations, could result in an explosion within the network or fire damage to the wastewater infrastructure.

Outputs from an EDP could help inform those within the water utility responsible for identifying events and alerting individuals responsible for event response decision-making. Such alerts could be required despite uncertainty about the quality and reliability of the data currently available.

Event response decisions can be based on those decision makers' knowledge, experience and assessment of the cause(s) and effect(s) of the event as it unfolds – including consideration of the EDP's outputs where appropriate.

At the discretion of the water utility, design of the EDP could incorporate elements of automated decision-making.

NOTE 2 If automated decision-making is proposed, consideration could require distinguishing between situations where automation could be appropriate and those where it would not be. For example, automation with low-impact outcomes could be acceptable but automation with high-impact outcomes could require greater caution. When considering automation, it is advisable to consider the appropriateness of inputs, the complexity of the system, the nature of the water utility and the effect of time delays.

A decision on whether to implement the water utility's procedure for dealing with an abnormal situation could be required in response to an identified or suspected event.

Such a decision could depend upon the confidence in the EDP's classification and output and the process underpinning it.

The guidelines could be of particular use to those water utilities that wish to enhance their ability to recognize abnormal events as a means to: maintain or improve public health provision; improve their operational processes; enhance the levels of their service provision; or reduce risks to the continued delivery of existing service levels.

In addition, development of an EDP can be a valuable aid to organizational learning and memory. The existence of an effective and efficient EDP provides a significant control against the risk of loss of individuals' knowledge and expertise by increasing a water utility's independence from such vulnerable resources. Regular use and review of an EDP's successes and failures can contribute to organizational learning and a reduction in the time taken to detect an event.

Event detection process: Guidelines for water and wastewater utilities

1 Scope

This document provides guidance for water utilities on the detection and classification of water and wastewater events.

The following subjects are within the scope of this document:

— publicly and privately owned and operated water utilities. It does not favour any particular ownership or operating model;

— all aspects of the drinking water system and the wastewater system;

— all causes of abnormal changes in water and/or wastewater service provision capable of detection by monitoring systems including accidents, unexpected operational changes, natural hazards and intentional disruption.

This document is independent of the measurement methods used to collect the data.

The document focuses on events which could imminently affect the water utility's interested parties.

The following are outside the scope of this document:

— methods of design and construction of drinking water and wastewater systems;

— plumbing and drainage systems not under the control of the water utility.

This document does not include details about action taken as a result of event detection. For such details see ISO 24518 and EN 15975 Part 1.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 24513, *Activities relating to drinking water, wastewater and stormwater services — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24513 and the following apply.

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
classification
category that the *event* (3.5) falls into

3.2
continual improvement
recurring activity to enhance *performance* (3.15)

Note 1 to entry: The *process* (3.16) of establishing *objectives* (3.13) and finding opportunities for improvement is a continual process through the use of audit findings and audit conclusions, analysis of data, management reviews or other means and generally leads to corrective action or preventive action.

Note 2 to entry: The nature of the activity can differ between cycles of recurrence.

[SOURCE: ISO 9000: 2015, 3.3.2, modified — Note 2 to entry replaced.]

3.3
documented information
information required to be controlled and maintained by an *organization* (3.14) and the medium on which it is contained

Note 1 to entry: Documented information can be in any format and media and from any source.

Note 2 to entry: Documented information can refer to:

— the management system, including related *processes* (3.16);

— information created in order for the *organization* (3.14) to operate (documentation);

— evidence of results achieved (records).

3.4
effectiveness
extent to which planned activities are realized and planned results are achieved

3.5
event
situation where a behaviour deviates from the normal

Note 1 to entry: An event can be one or more occurrences, and can have several causes.

Note 2 to entry: An event can consist of something not happening.

Note 3 to entry: An event can sometimes be referred to as an “incident” or “accident”.

Note 4 to entry: An event without consequences can also be referred to as a “near miss”, “incident”, “near hit” or “close call”.

Note 5 to entry: For the purposes of this document, “normal” refers to what is expected.

3.6
event detection
recognition of *event indicator* (3.9) and/or information about a new situation

Note 1 to entry: New situations can be sorted into one of the following:

— event indicator and/or situation(s) are considered known and non-hazardous;

— event indicator and/or situation(s) are considered hazardous, but a procedure to handle them already exists;

— event indicator and situation(s) are considered unknown, and for which a procedure does not yet exist.

3.7
event detection process
EDP
set of interrelated or interacting activities which transforms inputs [data or information on an actual or suspected *event* (3.5)] into outputs [to support the *water utility’s* (3.19) operational activities]

3.8
event identification table
EIT
table developed by the *organization* (3.14) that contains examples of proven connections between changes in water measurements and possible causation types

3.9
event indicator
signal to the water utility or one or more *stakeholders* (3.18) that an *event* (3.5) can have occurred with the potential to cause a significant deviation in the users' expectations of service *performance* (3.15)

Note 1 to entry: The signal can exist yet remain unobserved for a period.

3.10
influence matrix table
IMT
table developed by the *water utility* (3.19) that contains suspected connections between *event indicators* (3.9) and *performance measurements* (3.11) based on scientific knowledge and water industry experience

3.11
measurement
process (3.16) to determine a value

3.12
monitoring
determining the status of a system, a *process* (3.16) or an activity

Note 1 to entry: To determine the status there can be a need to check, supervise or critically observe.

3.13
objective
result to be achieved

Note 1 to entry: An objective can be strategic, tactical or operational.

Note 2 to entry: Objectives can relate to different disciplines (such as finance, health and safety, and environmental goals) and can apply at different levels [such as strategic, organization-wide, project, product and *process* (3.16)].

Note 3 to entry: An objective can be expressed in other ways, for example as an intended outcome, a purpose, an operational criterion, an event detection objective or by the use of other words with similar meaning (e.g. aim, goal or target).

Note 4 to entry: In the context of an event detection system, event detection objectives are set by the *water utility* (3.19), consistent with the event detection management policy, to achieve specific results.

3.14
organization
person or group of people that has its own functions with responsibilities, authorities and relationships to achieve its *objectives* (3.13)

Note 1 to entry: The concept of organization includes, but is not limited to, sole-trader, company, corporation, firm, enterprise, authority, partnership, association, charity or institution, or part or combination thereof, whether incorporated or not, public or private.

Note 2 to entry: For the purposes of this document the organization responsible for *event detection* (3.6) will usually be part of a wider organization [the *water utility* (3.19) responsible for the provision of drinking water/wastewater services].

3.15
performance
measurable result

Note 1 to entry: Performance can relate either to quantitative or qualitative findings.

Note 2 to entry: Performance can relate to the management of activities, *processes* (3.16), products (including services), systems or *organizations* (3.14).

3.16
process
set of interrelated or interacting activities that use inputs to deliver an intended result

Note 1 to entry: Whether the "intended result" of a process is called an output, product or service depends on the context of the reference.

Note 2 to entry: Inputs to a process are generally the outputs of other processes and outputs of a process are generally the inputs to other processes.

Note 3 to entry: Two or more interrelated and interacting processes in series can also be referred to as a process.

Note 4 to entry: Processes in an *organization* (3.14) are generally planned and carried out under controlled conditions to add value.

Note 5 to entry: A process where the conformity of the resulting output cannot be readily or economically validated is frequently referred to as a "special process".

3.17
risk
combination of the likelihood of a hazardous event and the severity of consequences, if the hazard occurs in the drinking water system or wastewater system

Note 1 to entry: Risk is often characterized by reference to potential *events* (3.5) and consequences or a combination of these.

Note 2 to entry: The English term "likelihood" does not have a direct equivalent in some languages; instead, the equivalent of the term "probability" is often used. However, in English, "probability" is often narrowly interpreted as a mathematical term. Therefore, in risk management terminology, "likelihood" is used with the intent that it has the same broad interpretation as the term "probability" has in many languages other than English.

Note 3 to entry: Risk can also be defined as the effect of uncertainty on *objectives* (3.13), where uncertainty is the state, even partial, of deficiency of information related to understanding or knowledge of an *event* (3.5), its consequence or likelihood.

3.18
stakeholder
interested party
person or *organization* (3.14) that can affect, be affected by or perceive itself to be affected by a decision or activity

EXAMPLE Users and building owners, relevant authorities, responsible bodies, operators, employees of the operator, external product suppliers and providers of other services, contractors, communities, customers and environmental associations, financial institutions, scientific and technical *organizations* (3.14), laboratories.

Note 1 to entry: Stakeholders will typically have an interest in the *performance* (3.15) or success of an organization.

Note 2 to entry: For the application of this document, environment is considered as a specific stakeholder.

3.19
water utility
whole set of *organization* (3.14), *processes* (3.16), activities, means and resources necessary for abstracting, treating, distributing or supplying drinking water, for collecting, conveying, treating, disposing of and reusing wastewater or for the control, collection, storage, transport and use or disposal of stormwater and for providing the associated services

Note 1 to entry: Some key features for a water utility are:

— its mission, to provide drinking water services or wastewater services, or the control, collection, storage, transport and use of stormwater services or a combination thereof;

— its physical area of responsibility and the population within this area;

— its responsible body;

— the general *organization* (3.14) with the function of operator being carried out by the responsible body, or by legally distinct operator(s);

— the type of physical systems used to provide the services, with various degrees of centralization.

Note 2 to entry: Drinking water utility addresses a utility dealing only with drinking water; wastewater utility addresses a utility dealing only with wastewater; stormwater utility addresses a utility dealing only with stormwater.

Note 3 to entry: When it is not necessary or it is difficult to make a distinction between responsible body and operator, the term “water utility” covers both.

Note 4 to entry: In common English, “water service” can be used as a synonym for “water utility”, but this document does not recommend using the term in this way.

4 Principles of an event detection process

4.1 Design phase

4.1.1 General

The water utility should determine the scope of the event detection process (EDP)'s detection capabilities. This should include:

— all credible events identified via the risk assessment process;

— the ability to respond promptly to unanticipated events (actual or suspected).

The scope should be available as documented information.

The range of complexity of the EDP chosen can vary from manual data analysis of paper-based historical records through to a fully computerized system. The level of complexity chosen should be consistent with the water utility’s local conditions, to avoid unrealistic assumptions about the adequacy of the EDP’s outputs.

The EDP's design should be based on a methodology to detect the possibility of the occurrence of events; perform analysis of incoming data to identify and classify possible events; and contain a validation process to constantly ensure quality of detection and classification.

Events can be water- or wastewater-related, and have water or wastewater quality consequences or other consequences (e.g. physical ones such as pressure or flow fluctuations, or operational ones such as chlorinous taste or foul odour complaints).

An EDP should aim to detect the occurrence of an event, provide guidance as to the event‘s likely cause and assist in the classification of the event's severity, urgency and possible consequences (see Figure 1).

The extent to which an EDP should be capable of distinguishing between the severity and urgency components of abnormal conditions should be a key consideration in the design phase.

Such guidance should permit the description of one or more possible risks (by postulating one or more chains of cause/effect/consequence).

The effectiveness of the EDP's design and the efficiency of its application should thus reduce the uncertainty surrounding possible alternative causes of an event pending actual confirmation of the cause.

To be successful, event detection should rely on the water utility's prior establishment of effective control over and conformity with warning values and limit values and their incorporation into operating procedures.

Since the EDP is based mainly on statistical analysis, the water utility should be aware that the existence of an EDP cannot guarantee that the event's causation and consequences for service provision will always be recognized before any interested party is affected or that the cause will always be quickly identified.

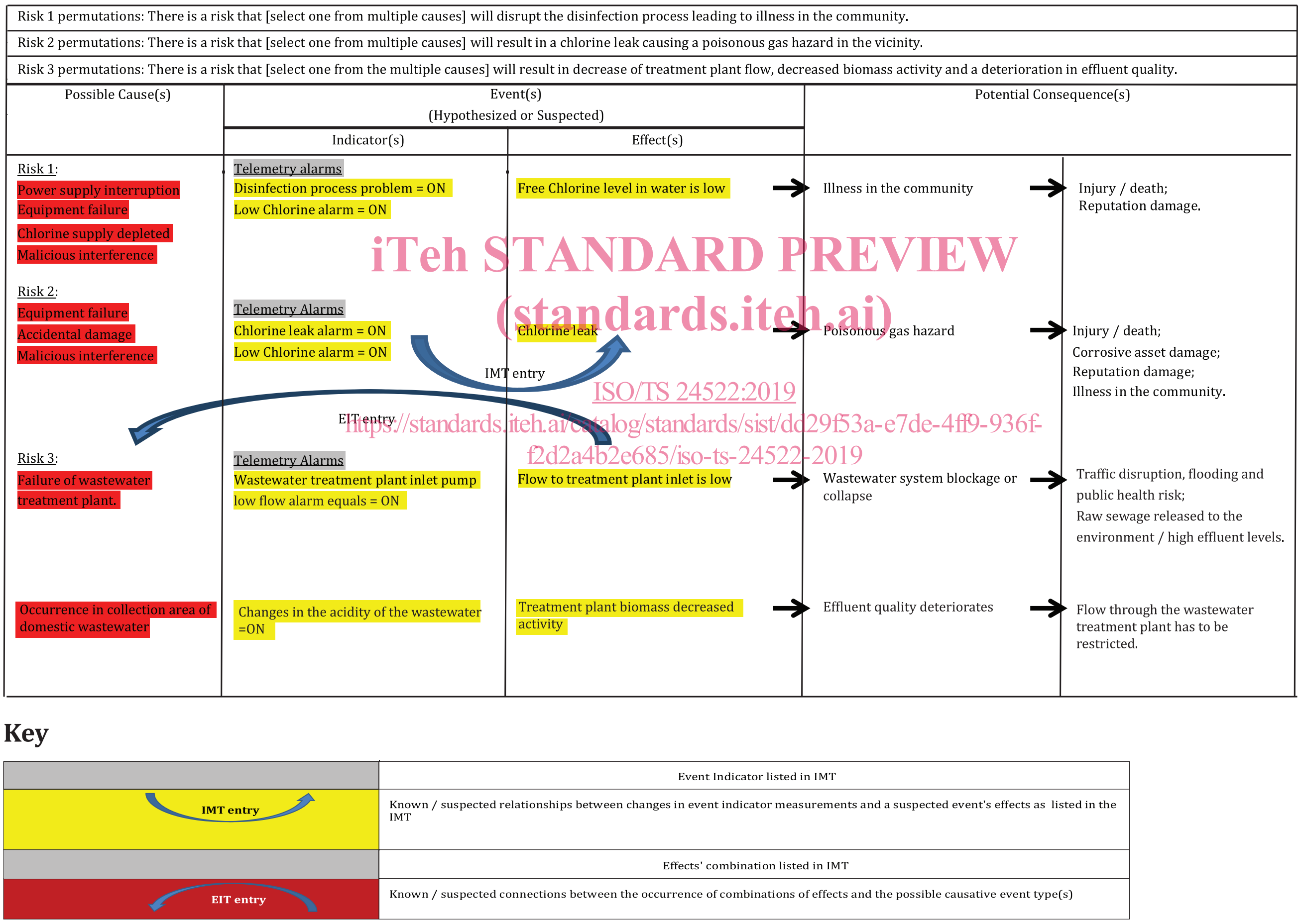

Figure 1 — Illustration of the relationship of the influence matrix table (IMT) to the event identification table (EIT) in the event detection process (EDP)

4.1.2 Influence matrix table and EDP

Event indicators are a list of measurable indicators based on available knowledge that would change when an identified risk actually occurs (Annex A contains examples of some typical event indicators that could be used as EDP system inputs).

System inputs should be used to construct a tool (e.g. table or flow chart) – described henceforth as an influence matrix table (IMT) – related to the water utility's function(s). The IMT should describe the relationship(s) between individual inputs (event indicators) and their hypothesized, suspected or “known” (in a probabilistic sense) effect(s). Annex B contains examples of water and wastewater IMT. The relationship between the IMT and the event identification table (EIT) is described here. Their relative positioning within the EDP is described in 5.2.3 and 5.2.4, and illustrated in Figure 3.

The content of the IMT should provide inputs to the process of constructing an EIT in three stages.

Firstly, the IMT should contain an “if”/”then” relationship(s) between changes in event indicator measurements and the effects becoming evident in the system they are indicative of.

Secondly, the water utility can then, by identifying a further set of “if”/”then” effect combinations, postulate possible causes for these simultaneous effects — progressively refining its analysis by causation type(s) (identifying unique or possible alternative causation options).

Thirdly, the IMT should contain a value and timestamp a value.

Table C.1 in Annex C contains examples of simultaneous relationships which could form part of an EIT's content.

It can be seen in Figure 1 that the IMT is the starting point, first to look “downstream” in the indicator/effect relationship(s) and then, by combining knowledge of simultaneous effects causation, to look “upstream” to (with increasing maturity as the EDP develops) hypothesize, propose or predict a suspected event’s cause.

NOTE The probability of successfully identifying causation is likely to increase with the developing maturity of the EDP. This maturity is likely to arise from refinement of the "if"/"then" rules created in the IMT and the EIT. The former’s rules are likely to have a high degree of commonality across water utilities and be relatively easy to establish from literature. The latter will vary between water utilities depending on a range of factors and require more local knowledge. Ultimately a fully mature EDP will be unique to an individual water utility. By that stage the IMT and the EIT ought to be capable of referencing specific locations and indicator measurements associated with a prediction of causation of individual events affecting the water utility.

4.1.3 EDP inputs

The EDP requires one or more inputs before it can generate an output. The input(s) derived from operating a water supply/wastewater system could depend on the:

— size of the system,

— system management resources available;

— system management resources’ capabilities;

— economic state of the system;

— size and structure of the water utility's service area;

— infrastructure of the water utility's service area;

— technical state of the system and the level of automation.

4.1.4 EDP design

The design considerations of the EDP should include:

— preferred time frame in which each event should be detected and classified;

— severity and order of priority in which events should be handled;

— number of inaccurate event detection alerts to be tolerated (by location and type) over a defined period of time [known as false positive (FP) or false negative (FN) alarms — see Annex D].

NOTE Acceptable levels of FP and FN alarms could change over time due to changes in the hazard(s) to which the water utility is exposed.

Some of the event indicators listed in Annex A are among those that could be identified and used to establish a target service level for detection by the EDP.

The EDP target service level for detection should be a sub-set of the utility's general objectives regarding the provision of water/wastewater services. For further details see ISO 24510, ISO 24511 and ISO 24512.

4.1.5 EDP target service level design

Given the potential for an event to escalate into a crisis, the EDP target service level for event detection should be designed to support achievement of the minimum levels of service determined by the utility.

Considerations should include:

— the EDP's required availability and the acceptability of any planned unavailability;

— the availability of staff competent to operate the EDP and interpret its outputs within and outside normal working hours;

— the EDP's resilience to loss or disruption of its normal operating facilities;

— the water utility's capability to restore an acceptable level of the EDP's functionality within the maximum tolerable period of disruption determined by the water utility's business continuity management policy.

For further details see ISO 24518, ISO/TS 24520 and EN 15975-1.

4.2 Detection phase

4.2.1 General

There may be several ways to detect an event's occurrence based on the event indicators. Clause 5 contains a methodology for constructing an EDP that seeks to capture all these opportunities.

Awareness of and access to regular performance measurements undertaken by the water utility should support the detection of water/wastewater quality changes.

4.2.2 Validation process

Data's suitability as a dataset input could require a two-step validation process before any further analysis.

Failure to satisfy all of Step 1's validation should preclude progress to Step 2.

Step 1: The readings should represent actual reflections of field values. The six basic data validations are:

— physical limits are not violated;

— data are not 'frozen';

— essential data are not absent;

— rates of change in that variable remain credible;

— duration of the change in the variable is significant;

— no fixed repetitive patterns are present.

Step 2: Each variable presented should then be analysed separately to see how it is now behaving compared with historical data trends. In this process, relevant seasonal factors, hours of the day or day of the week (e.g. reflective of industrial routines) should be considered together with human behaviour. Technical problems or changes in the operational processes should also be considered where appropriate.

If any variable is deviating from its historical trend, normal boundaries, rate of change or develops fixed repetitive patterns (given local consideration of time and season), then reference should also be made to the EIT to see if it contains rules justifying an alert based on this variable.

Visible inspection of the single data charts may support abnormal condition identification. Design of the EDP should not preclude continued access to visible inspection of data charts (see EDP verification methods in Annex F).

In the case of wastewater, information regarding abnormal discharge of industrial material to the public network should also be taken into consideration.

4.2.3 Further event monitoring

Decisions on further event monitoring to be undertaken should be made, based on the initial alert, ongoing uncertainties and accumulating knowledge of the unfolding event.

If no escalation is required it may still be desirable to undertake further monitoring as part of the water utility's quality assurance process using the 'Plan, Do, Check, Act' cycle. For further details see ISO 24510, ISO 24511 and ISO 24512.

If escalation is required, the type and extent of further monitoring should be established as part of the operational management system. Where the event may require a crisis management response, the escalation should form part of the 'pre-crisis phase' of the crisis management system. For further details of how the EDP should align with the crisis management system see ISO 24518.

4.3 Ongoing activities

4.3.1 Post-event EDP evaluation

Post-event evaluation of the EDP should establish whether the prediction was accurate, inaccurate or ambiguous. This evaluation should consider both inputs and outputs, and possible uniqueness of the water utility, in an attempt to establish the validity of the output. This should result in an updating of the documented information and continual improvement of the EDP.

NOTE Annex C illustrates varying levels of complexity in the EDP for both water and wastewater utilities.

4.3.2 Periodic reviews

The vulnerability of the drinking water/wastewater system should be periodically reviewed. This review should include consideration of the list of potential risks derived from the methodology identified in 4.1.2.

NOTE For more details of this approach see the WHO *Guidelines for drinking-water quality*[22] (or the WHO *Guidelines on sanitation and health*[23]) and EN 15975-2.

The detection process should be evaluated periodically in order to address two aspects:

— does it look at the most relevant event indicators with respect to the possible risks it tries to assess?;

— what is the reliability of its answers?

Assuming satisfactory answers to these two questions, the process can be utilized with confidence to classify events as positive (i.e. a real event) or negative (i.e. a non-real event), before the actual result is obtained.