Technical Rule on Installation Safety 310:

Precautions and Measures against the Hazard Sources Precipitation and Flooding

Short Version[1]

pursuant to the decision of the Commission on Process Safety of 3rd and 4th November 2011, adopted following consultation with the public and the supreme competent authorities of the Länder

[1] For official version in German and guidance see: http://www.kas-bmu.de/publikationen/tras_pub.htm

This Technical Rule serves to define in concrete terms the responsibilities of operators of establishments that derive from the German Major Accidents Ordinance (StörfallV) and the responsibilities of operators of installations that derive from the Federal Immission Control Act (BImSchG). Where it is applied, attention is additionally to be paid to the provisions of the Federal Water Act (WHG) and the water legislation of the Länder. This applies in particular with regard to the requirements placed on the handling of substances constituting a hazard to water pursuant to Article 62 and 63 of the Federal Water Act and, on flood plains, pursuant to Article 78 of the Federal Water Act. Furthermore, it is recommended that operators make use of the opportunities to participate in the drafting, review and updating of (flood) risk management plans pursuant to Article 79 of the Federal Water Act.

1. Preamble

Technical Rules on Process Safety (TRAS) set out regulations on and knowledge about safety technology that are consistent with the state of the art of safety technology within the meaning of Article 2(5) of the Major Accidents Ordinance (StörfallV, 12th Ordinance on the Implementation of the Federal Immission Control Act). Requirements concerning the operation and characteristics of such installations that derive from other regulatory instruments and are intended to fulfil other protection aims remain unaffected.

2. Foundations

According to Article 3(1) of the Major Accidents Ordinance, the operator of an establishment within the scope of this Rule has to take the precautions required in keeping with the nature and extent of the potential hazards in order to prevent major accidents. When action is taken to fulfil this obligation, environmental hazard sources, such as earthquakes or flooding, are also to be taken into consideration pursuant to Article 3(2) of the Major Accidents Ordinance. Hazard sources that can reasonably be excluded as causes of major accidents do not have to be taken into consideration.

Hazard sources that can reasonably be excluded may trigger major accidents despite precautions and, while it may not be possible to prevent the occurrence of such accidents, additional precautions are to be taken to mitigate their effects, irrespective of the precautions taken to prevent major accidents under Article 3(1) of the Major Accidents Ordinance (Article 3(3) Major Accidents Ordinance).

Hazard sources of this kind may include e.g.:

1. The failure of precautions taken under Article 3(1) of the Major Accidents Ordinance
2. Flooding or precipitation that occur more infrequently than a reasonably presumable annual recurrence interval[2]

This means that, in particular where a hazard is posed by the release of a substance or by the disturbance of facilities intended to prevent or mitigate major accidents due to hazard sources that can reasonably be excluded, additional measures are to be taken in order to mitigate the harmful effects on humans, the environment and property.

The penetration of water into an establishment (despite the protective measures put in place under Article 3(1) of the Major Accidents Ordinance) is to be presumed as a scenario covered by Article 3(3) of the Major Accidents Ordinance. The extent of the flooding and the measures to be taken then need to be examined individually in each case (cf. Section 7, ‘Detailed hazard source analysis’).

[2] I.e. above the levels assumed for the dimensioning of flood defences, cf. Section 7, 10, 13 and Annex I.

However, hazard sources that can reasonably be excluded may also be so improbable that they are beyond human experience and incalculable. No precautions are to be taken to protect installations against these exceptional major accidents.

The general level of knowledge about natural hazard sources, such as flooding and precipitation, is continuing to develop against the background of climate change. What is undisputed is that the hydrological balance in the atmosphere will change and the probability of heavy precipitation will increase as the global temperature rises.[3] Attention is to be paid to these new findings when natural hazard sources are assessed.

Against this background, the German Strategy for Adaptation to Climate Change (DAS) states that, at establishments where hazardous substances are present in larger quantities and could be released if extreme events occur, the safety requirements in place hitherto and safety management systems are to be reviewed and adapted as necessary so that they are consistent with the progress made in scientific knowledge and the operators' obligations pursuant to the Major Accidents Ordinance.[4]

As far as compliance with operators' general obligations is concerned, attention is to be paid to the determination of significant flood risk by the authorities pursuant to Article 73 of the Federal Water Act. For this reason, as the foundations for the hazard source analysis (cf. Sections 6 and 7), attention is to be paid to the (flood) hazard and risk maps pursuant to Article 74 of the Federal Water Act that are to be prepared by the authorities responsible for water management, which will be drawn up for watercourses with potential, significant flood risk by the end of 2013 and will be updated regularly every six years.

Operators of establishments that are subject to the basic obligations set out in the Major Accidents Ordinance have to pay attention to changes in (flood) hazard maps when updating their concepts for the prevention of major accidents (Article 8(3) Major Accidents Ordinance), and during the systematic audit and review of concepts for the prevention of major accidents and safety management systems (Annex III(3)(g) Major Accidents Ordinance).

Operators of establishments that have to produce a safety report have to review this report pursuant to Article 9(5) of the Major Accidents Ordinance at any time when new facts require this or in order to take account of recent developments in what is known about the assessment of hazards. This includes developments in what is known about environmental hazard sources and the influences upon them exerted by climate change. Irrespective of this provision, appropriate reviews are required at least every five years.

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[3] IPCC, *Fourth Assessment Report: Climate Change 2007 (AR4)*, Cambridge University Press, 2007, http://www.ipcc.ch/.

[4] German Strategy for Adaptation to Climate Change, adopted by the German federal cabinet on 17 December 2008, http://www.bmu.de/klimaschutz/downloads/doc/42783.php.

3. Scope

This Technical Rule on Process Safety is valid for establishments covered by Article 3(5a) of the Federal Immission Control Act that fall within the scope of the Major Accidents Ordinance. However, it is recommended that this Technical Rule on Process Safety also be applied to all other installations that require licensing under the Federal Immission Control Act where there is a danger of hazardous substances being released.[5]

This Technical Rule on Process Safety is valid for hazard sources that result from

1. floods caused by waters (flooding or storm surges), including the failure of flood defences,
2. drainage flooding, e.g. caused by heavy precipitation or backup from sewers, and
3. rising groundwater.

The hazard sources snow loads, ice loads, hailstorm, ice avalanche, rockfall and landslide are also directly or indirectly connected with precipitation and flooding. No reliable information about these hazard sources was yet available for assessment purposes when this Technical Rule on Process Safety was being elaborated. As a matter of principle, operators must also take these hazard sources into consideration pursuant to Article 3(3) of the Major Accidents Ordinance.

4. Definitions

The following definitions are to be taken as the basis for the application of this Technical Rule on Process Safety.

4.1. Flooding (including surface water flooding)

Flood (high water flooding) is the temporary surface water flooding of land that is not normally covered with water by surface waters or by seawater that penetrates into coastal areas (Article 72 Federal Water Act).

Surface water flooding occurs when *surface waters* such as rivers, streams or lakes rise and flood their immediate environs as a consequence of thawing snow, locally intensive precipitation (heavy rainfall) or prolonged precipitation over large areas, with dams, bank areas or built structures being undermined, or debris, sludge and floating debris being deposited on the flooded areas.

[5] This Rule refers below to 'establishments' when requirements derived from the Major Accidents Ordinance only apply to establishments. Otherwise, the term 'sites' is used when requirements are to be applied to establishments and their application is recommended for other installations that require licensing.

The term *drainage flooding* denotes above all situations where drainage systems outside buildings flood (see DIN EN 752 (2008).

The effects of surface water flooding and drainage flooding on sites are essentially the same.

In this Technical Rule on Process Safety, *flooding* therefore means *any abnormal level of water above ground level* outside built installations or above the lowest floor level of built installations. I.e. *flooding within the meaning of this Technical Rule on Process Safety includes surface water and drainage flooding*.

4.2. Hazard source

A hazard source (hazard root) is the origin of a hazard from which destructive effects may ensue.

4.3. Environmental hazard sources

Environmental hazard sources are influences that affect a site from beyond its boundaries and may result in an impairment of the functioning of safety-relevant parts of an establishment or an installation.[6] This Technical Rule on Process Safety is limited exclusively to the natural hazard sources mentioned in Section 3.

4.4. Hazard source analysis

Hazard source analysis within the meaning of this Technical Rule on Process Safety is the first step in a comprehensive process in which hazard sources and their causes are identified. Hazard source analysis determines hazard sources without assessing or appraising them. Environmental hazard sources are examined by the hazard source analysis undertaken within the framework laid down by this Technical Rule on Process Safety in order to ascertain whether they could affect a site.

4.5. Analysis of hazards and threats

When hazards and threats within the meaning of this Technical Rule on Process Safety are analysed, the effects of environmental hazard sources on a site are studied. Where the risks are unacceptable, measures are to be developed in order to reduce these risks to an accepted degree.

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[6] Cf. *Abschlussbericht: Arbeitskreis "Richtwerte für sicherheitsrelevante Anlagenteile (SRA) und sicherheitsrelevante Teile eines Betriebsbereiches (SRB)"*, KAS-1, Commission on Process Safety, Bonn, 2006.

4.6. Disturbance of normal operation when flooding occurs

Where safety-relevant parts of installations are not designated to be operated under the influence of flooding, even if they are suitable for operation under these conditions (e.g. containers installed with antiflotation features), the disturbance of normal operation cannot be excluded when flooding occurs on the terrain of the site (incl. any establishment subject to the Major Accidents Ordinance).

Normal operation is disturbed in this way under the following circumstances in particular:

1. The stability and/or integrity of safety-relevant parts of establishments and installations where particular substances are present is immediately threatened.
2. The functioning of safety-relevant parts of establishments and installations is threatened.
3. Safety-relevant operating procedures or organisational work processes cannot be carried out or can only be carried out under difficult conditions, e.g. due to limitations on the accessibility of parts of establishments and installations.

4.7. Protection concept

A protection concept within the meaning of this Technical Rule on Process Safety includes the development of suitable measures to prevent or mitigate the effects of major accidents caused by environmental hazard sources that become active.

4.8. Protection aims

Protection aims within the meaning of this Technical Rule on Process Safety are set in order to preserve human health, the environment and property from the adverse consequences of a release, fire or explosion of hazardous substances due to an environmental hazard source that becomes active, e.g. flooding. Where installations require a licence under the Federal Immission Control Act, it must be guaranteed pursuant to Article 5(1) of the Federal Immission Control Act that

1. harmful effects on the environment and other hazards, significant disadvantages, and significant nuisances to the general public and the neighbourhood cannot be caused; and
2. precautionary action is taken against harmful effects on the environment and other hazards, significant disadvantages and significant nuisances, in particular measures consistent with the state of the art.

As far as establishments are concerned, it must be guaranteed that the characteristics and operation of an establishment's installations are consistent with the state of the art of safety technology.

5. Systematisation and structure of the Technical Rule on Process Safety

The operator's obligations within the meaning of the Major Accidents Ordinance may be fulfilled with regard to the hazard sources examined in this Technical Rule on Process Safety by taking the following four steps:

1. **hazard source analysis**, in which it is scrutinised what hazard sources could affect the site singly or in combination,
2. **analysis of hazards and threats**, in which it is scrutinised whether major accidents may occur as a result of effects on safety-relevant parts of an establishment or installations,
3. **drafting of a protection concept**, in which precautions to prevent major accidents are specified,
4. **examination of 'major accidents despite precautions',** which leads in particular to the specification of measures to mitigate the effects of major accidents.

(Cf. the systematic approach depicted in **Figure 1**).

The point of departure is a hazard source analysis in which the possible hazard sources are determined. Initially, a simplified hazard source analysis only identifies events in qualitative terms at the location (incl. establishments) that are possible (cannot reasonably be excluded) within the region. In a detailed hazard source analysis, further information is drawn upon in order to determine the possible hazard sources more accurately.

The next step is to identify the safety-relevant parts of the establishment and installations that are threatened.

Depending on their safety relevance and the possible effects of a major accident, protection aims are to be specified, and a protection concept elaborated that allows these protection aims to be achieved.

Subsequently, hazard sources that can reasonably be excluded (major accidents despite precautions) are studied. It may not be possible to prevent the occurrence of such accidents but, irrespective of the precautions taken to prevent major accidents under Article 3(1) of the Major Accidents Ordinance, additional precautions are to be taken to mitigate their effects (Article 3(3) Major Accidents Ordinance).

This does not apply for hazard sources that are so improbable that they are beyond human experience and incalculable. No precautions to protect installations are to be taken against these exceptional major accidents.

When plans are made for emergencies, onsite alarm and emergency plans are amended, and information is communicated both for the purposes of external alarm and emergency planning, and pursuant to Article 9(1)(5) of the Major Accidents Ordi-

nance (information concerning the siting of new activities, etc.), suitable consideration is also to be given to the results from the examination of the major accidents despite precautions discussed above.

Hazard source analyses and analyses of hazards and threats are to be taken into consideration in concepts for the prevention of major accidents and, are to be included in safety reports together with studies of the ´major accidents despite precautions` discussed above.

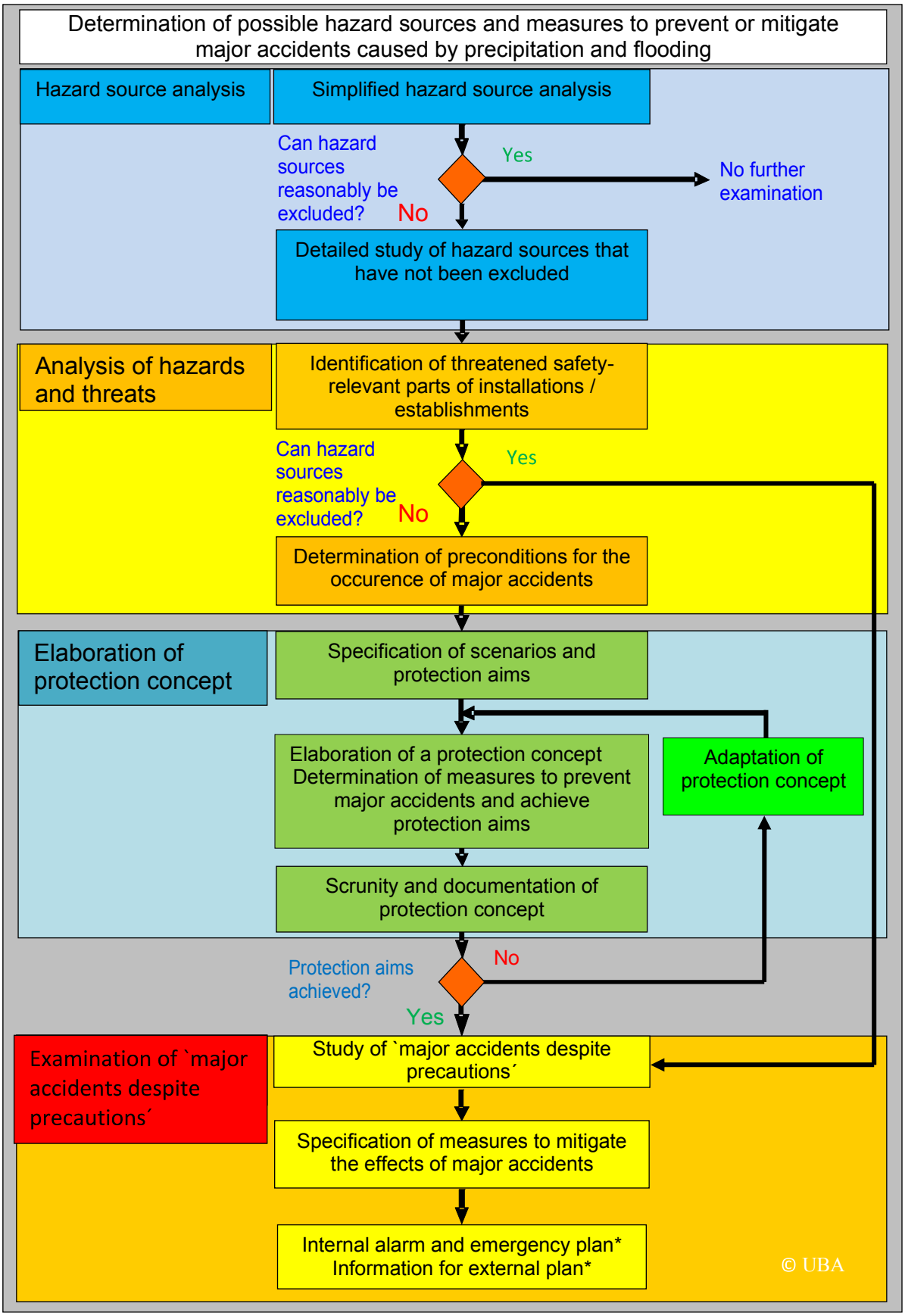

Figure 1: Flow chart for the optimisation of a protection concept
(*Where required pursuant to Article 10 of the Major Accidents Ordinance)

As a matter of principle, it is the case that flooding always occurs if the inflow of water is significantly greater than the runoff of water. For this reason, potential inflow routes must be examined by the operator as well as runoff routes.

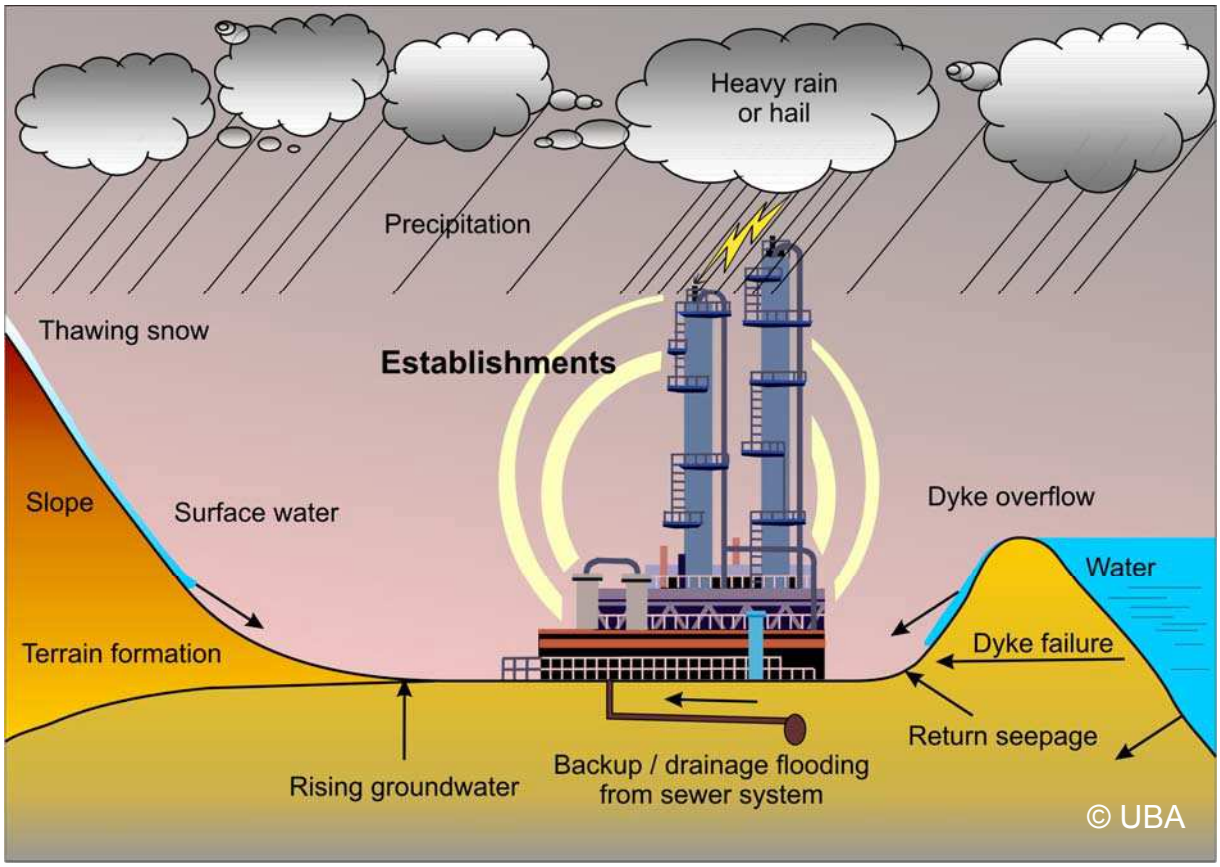

Figure 2: Potential inflows of water

A potential influx of water may accordingly be caused by

1. extreme precipitation,
2. water backing up from the sewer system (onsite/offsite),
3. surface water (lateral inflow due to terrain formation, e.g. at locations in depressions),
4. lateral inflow due to high water flooding or the failure of flood defences (dykes, gates), or
5. groundwater or return seepage.[7]

[7] The temporary presence of shallow water immediately behind a dyke that gathers as a result of percolation under the dyke due to the water pressure of the high water level in a river.

Potential runoff routes are depicted in **Figure 3**. Mention may be made of the following runoff routes:

1. surface runoff (due to terrain formation, harmless diversion of excess water along roads when extreme events occur),
2. seepage,
3. sewers (onsite/offsite) and
4. flood pumping stations (along waters).

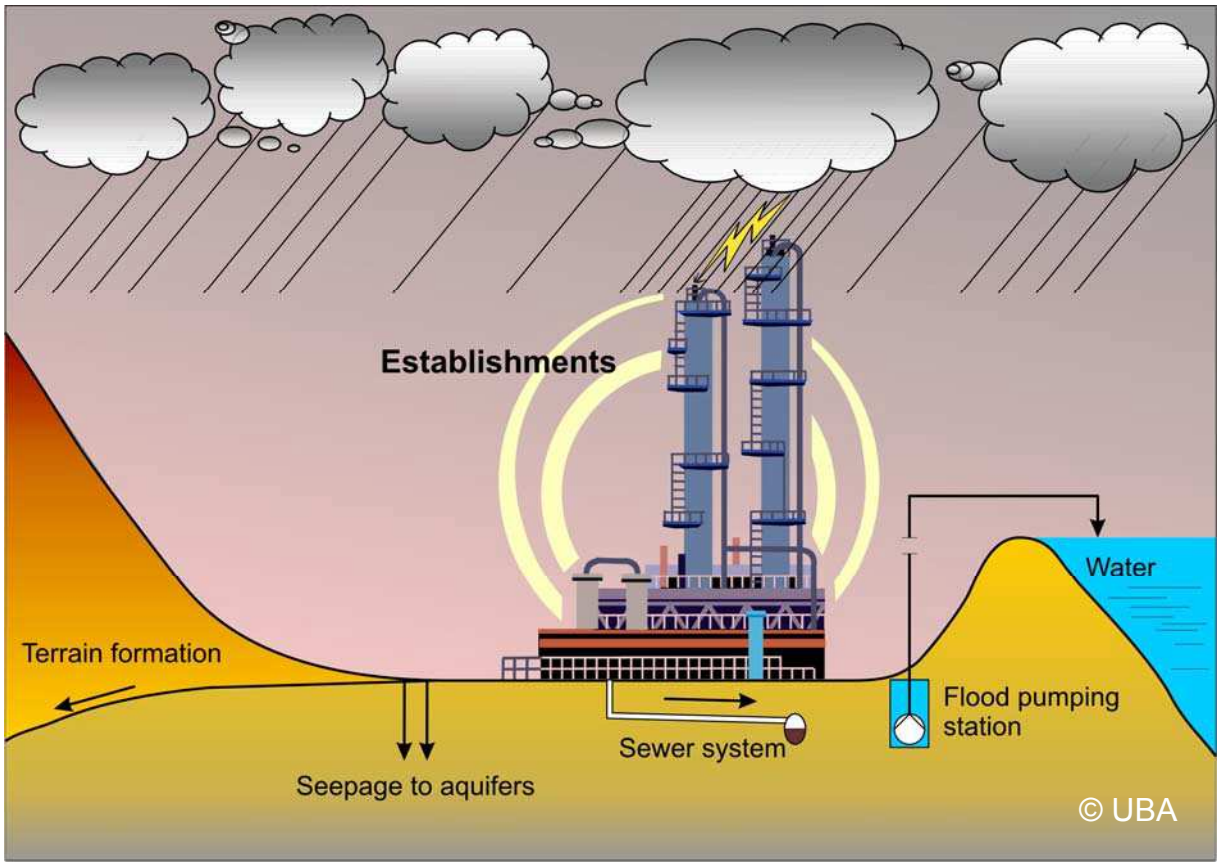

Figure 3: Potential water runoff routes

6. Simplified hazard source analysis

It is to be determined whether the hazard sources examined come into question as trigger events for major accidents or can reasonably be excluded – in which respect what is known about climate change is also to be taken into consideration.

The simplest possible and most easily comprehensible criteria are to be used to decide whether a hazard source can reasonably be excluded. Such criteria are set out in **Table 1** for river and coastal high water flooding, potentially combined with flow, flotsam and ice run.[8]

[8] Both the operator and the competent authority continue to have the discretion to undertake or demand further investigations in the individual case.

Table 1: Criteria for selected environmental hazard sources

Hazard source	Criterion	Necessity and extent of hazard source analysis	
River or coastal high water flooding combined with flow, dynamic pressure, flotsam and ice run	Designated flood plain or area mapped on (flood) hazard or risk maps under Article 74 of the Federal Water Act*)	On the designated flood plain or within the mapped (flood) risk area	Detailed hazard source analysis
		Mapped, but outside (flood) risk area	No further examination required
Rising groundwater	Underground parts of installations[9] where hazardous substances are present (tank installations, pipelines)	Necessary	Detailed hazard source analysis
		Not necessary	No further examination required

No simple, general criterion can be cited that makes it reasonably possible to exclude the hazard source 'flooding' triggered by precipitation ('flash floods') outside mapped (flood) risk areas.

As has already been explained in Section 5.1, however, flooding only occurs when the inflow onto the site is greater than the runoff from it. Any appraisal must therefore be based on a calculation of inflow and runoff levels. The volumes of both flows may be influenced by the following factors:

1. the presumed precipitation intensity or total precipitation,
2. the topographical situation (hillside, depression, etc.) delineated using data on the elevation of the terrain (information source: digital terrain models or, alternatively, official contour maps, provided the date of the survey is taken into consideration,
3. surface sealing on and off the site (runoff coefficients),
4. bottlenecks in the area through which water runoff passes, e.g. caused by railway embankments, road overpasses or terrain formation,
5. the location of the site or installation in the vicinity of bridges or culverts whose runoff profiles may be clogged or damaged by flotsam or ice blocking and whose stability may be threatened,
6. the location of the site or installation on the banks of tidally influenced waters,
7. the efficiency of the onsite sewer (storm water or combined sewer), treatment and discharge systems, where applicable, and
8. the efficiency of the local authority sewer system in the environs of the establishment or installation (information source: body responsible for waste water disposal, e.g. local authority consortium, city/town civil works department or municipal utility company).

[9] 'Underground' within the meaning of water pollution control at installations (Articles 62 and 63 Federal Water Act), which places particular requirements on these installations.

7. Detailed hazard source analysis

Where hazard sources cannot reasonably be excluded, a detailed hazard source analysis is required. The following trigger events are to be assumed for the detailed hazard source analysis:

1. Events with medium probability (recurrence interval at least 100 years analogous to Article 74 of the Federal Water Act) and, where applicable, more onerous standards for the dimensioning of public flood defences (see below) as the foundation for measures to prevent major accidents (Article 3(1) Major Accidents Ordinance).
2. Penetration of water into the establishment as the foundation for measures to be taken on a precautionary basis in order to keep the effects of major accidents as small as possible (Article 3(3) Major Accidents Ordinance, cf. Section 13).

With regard to the foundations for measures to prevent major accidents, it is to be taken into consideration that the standards for the dimensioning of public flood defences may be based on events that occur more rarely than 100-year flooding. With regard to establishments that lie behind these defences, this means the operator usually does not have to take any inhouse precautions to prevent major accidents, provided the failure of the defences can be ruled out as a hazard source within the meaning of Article 3(1) of the Major Accidents Ordinance. However, if an establishment is directly contiguous with the water in question, the standards for the dimensioning of public flood defences are also to be applied to this establishment, because high water flooding could otherwise penetrate through the establishment into the hinterland. If the public flood defences have not been dimensioned, constructed or operated in accordance with generally recognised technological regulations, their failure cannot be excluded. The operator then has to take inhouse measures pursuant to Article 3 of the Major Accidents Ordinance; alternatively, they may contribute to remedial works on the public flood defences.

7.1. Part A: Flooding (water depth, flow, dynamic pressure, flotsam, ice run)

Where it has not already been possible for flooding and the hazard sources associated with them to be reasonably excluded on the basis of a simplified hazard source analysis, a detailed hazard source analysis involves the following steps:

1. Determination of the potential inflow routes with direction of flow
2. Determination of possible water levels dependent on the intensity of the event
3. Quantification of flow speeds
4. Estimation of the threat from flotsam or ice run
5. Estimation of the threat from erosion (undermining of buildings and parts of installations)
6. Estimation of the threat from the flotation of installations and parts of installations

It is necessary to quantify the flow speed in order to estimate the effects of dynamic pressure and flotsam.

7.2. Part B: Rising groundwater

In order to assess the threat from a rise in groundwater, information on the level of the groundwater table is to be obtained from the responsible water resources board or the local authorities. Frequently, the authorities also possess models that supply evidence about the changes in the groundwater table that are to be expected. A hazard source analysis essentially builds on this information and the foundation depths of safety-relevant parts of establishments and installations. Furthermore, the failure of pumps for the abstraction of groundwater – for instance due to a power cut – may be relevant if this could trigger a rapid rise in the groundwater level.

7.3. Consideration of climate change

The foreseeable consequences of climate change should be taken into consideration in the course of a hazard source analysis, even if uncertainties naturally attach to them. It is to be assumed that the changes to the climate that have already occurred will have an influence on the intensity and frequency with which at least some of the hazard sources discussed above become active.

In order to perform a detailed hazard source analysis, the operator has to collate information and data that may be based on various sources. Data that have been determined by means of statistical evaluations of historic events only take past events into consideration. Nevertheless, they initially offer a foundation for the performance of hazard source analysis.

With the global temperature rising as a consequence of climate change, the atmosphere's capacity to absorb water vapour will increase disproportionately. This gives reason to expect that the intensity and frequency of heavy precipitation will rise in line with the rise in temperature. It is therefore possible to argue the preconditions are in place for the probability of flooding to increase due to more frequent and intense heavy precipitation. By contrast, the data on the increases in volumes of precipitation are somewhat inconsistent. According to the emissions scenarios studied in 2007 by the IPCC, it is to be presumed that the volumes of precipitation in winter could be 0 % to 15 % higher over the period 2021-2050 than during the control period 1961-1990. Over the period 2071-2100, they could be 0 % to 40 % higher, while the regional volumes of precipitation may vary widely.

In order to take account of developments in scientific knowledge about climate change as accurately as possible in the course of a hazard source analysis, the regional probability density functions for precipitation, etc. would have to be adjusted. However, given that such adjustments usually involve a great deal of effort and expense, the simpler approach of adding a standard factor to the historic data can be applied instead, even if this is not scientifically exact. Even though it has still not been possible for a climate change factor to be determined scientifically in each case, a standard climate change factor of 1.2 (cf. Annex I, 'Consideration of climate change') should be applied as a matter of principle when scenarios and protection aims are specified and a protection concept elaborated, provided the consequences of climate change have not already been taken into consideration by the competent authorities pursuant to Articles 72 to 81 of the Federal Water Act in their (flood) hazard maps or the authority responsible for the waters in question has not previously determined possible changes in runoff where high water floods take place due to climate change.

In order to take climate change into consideration, a factor of 20 % is to be added to

1. the peak heavy precipitation and
2. the high water flood runoff used to calculate the dimensions of flood defences,

provided the influence of climate change has not yet been taken into consideration in the data to be used as the basis for the analysis.

The climate change factor is a design variable that is used as a standard method for the consideration of potential changes in the climate in the period up to 2050 when protective precautions and measures are planned (cf. Annex I, 'Consideration of climate change'). It is not to be applied when decisions are taken as to whether a hazard source can reasonably be excluded or when scenarios are determined pursuant to Article 3(3) of the Major Accidents Ordinance (Section 13, 'major accidents despite precautions').

8. Determination of threatened safety-relevant parts of establishments and installations

The safety-relevant parts of establishments and installations of this kind are

1. installations and parts of installations where particular substances are present, and

2. installations and parts of installations with particular functions.

Threatened parts of establishments and installations within the meaning of this Technical Rule on Process Safety are safety-relevant parts of establishments and installations where a hazard or threat may arise due to a major accident (i.e. a hazard or threat on the site or a threat to the environment) when the relevant environmental hazard becomes active (i.e. when there is a threat from the environment). The set of the parts of establishments and installations to be protected is therefore dependant on the type of hazard source and its presumed intensity (e.g. water depth in m, flow speed in m/s, precipitation in mm/h).

Installations outside the establishment may also be safety-relevant. The possible effects of hazard sources on these installations must then be examined as well.

9. Determination of preconditions for the occurence of major accidents

When the preconditions for the occurrence of major accidents are determined, it is to be scrutinised whether a major accident could actually occur in the individual threatened parts of establishments and installations or whether the site would merely be disturbed, given the presumed nature of the hazard source in question and the intensity with which it would become active. For this purpose, it is to be studied how the hazard source that would become active could affect the safety-relevant parts of the installations and establishments threatened in the specific case.

The following approach is proposed:

1. determination of the effects on threatened parts of installations where particular substances are present,
2. determination of the effects on threatened parts of installations with particular functions (within installations),
3. determination of the effects on threatened installations where particular substances are present,
4. determination of the effects on threatened installations with particular functions inside and outside the establishment,
5. determination of the effects on the establishment.

At the latest when the last step is carried out, the consequences of the simultaneous effects of hazard sources on all parts of the establishments and installations on the site, and the interactions between them (effects on one installation/part of an installation trigger a major accident in another installation/part of the same installation) are to be examined.

10. Specification of scenarios and protection aims

On the basis of what is known about possible hazard sources (Section 7, ‘Detailed hazard source analysis’) and the possible hazards or threats to which they give rise (Section 9, ‘Determination of preconditions for the occurrence of major accidents’), scenarios to cover these hazard sources are to be drawn up and studied in detail. They serve to determine the effectiveness of precautions and measures taken under Article 3(1) and Article 4 of the Major Accidents Ordinance, ‘Requirements for the prevention of major accidents’, and their consistency with the state of the art of safety technology.

For the subsequent scrutiny of scenarios, attention is to be paid to the superordinate protection aims concerning the protection of people, the environment and property pursuant to Article 5 of the Federal Immission Control Act and Article 3 of the Major Accidents Ordinance, which are to be defined in concrete terms in relation to the hazard sources and the associated scenarios. In addition to this, attention is to be paid to the requirements of water pollution control at installations pursuant to Articles 62 and 63 of the Federal Water Act, in particular on flood plains.

The foundations for the specification of the concrete terms are the results of the hazard source analysis, from which information is derived about the intensity of a hazard source as a function of its probability of occurrence. Where the damage triggered by events of different intensities is known, the risks can be determined. These risks must be reduced to an accepted degree by defining the general protection aims in concrete terms.

An at least 100-year event should be taken as the basis for the specification of the protection aims. Attention is to be paid to the comments made in the second paragraph of Section 7 with regard to sites that are directly contiguous with waters. The consequences of climate change for the various hazard sources are to be taken into consideration additionally (see Annex I).

11. Elaboration of protection concepts for scenarios

Protection concepts are to be developed on the basis of the hazard sources that cannot reasonably be excluded, the hazards or threats that are identified, and the scenarios and protection aims. When protection concepts are elaborated, attention is to be paid to the requirement laid down in Article 3(4) of the Major Accidents Ordinance that they be consistent with the state of the art of safety technology.

When a protection concept is elaborated, the following points are of contributory significance as well as the intensity of an event:

1. the speed with which the event occurs,
2. the advance warning time (e.g. weather forecast and water levels) and
3. the parties' capacity to take effective action during the event.

This relates in particular to organisational measures, e.g. the removal of hazardous substances, and, in the case of flooding, the assembly of mobile flood defence systems or commissioning of drainage technology.

Every protection concept should include various safety precautions and measures (lines of defence) (**Figure 4**).

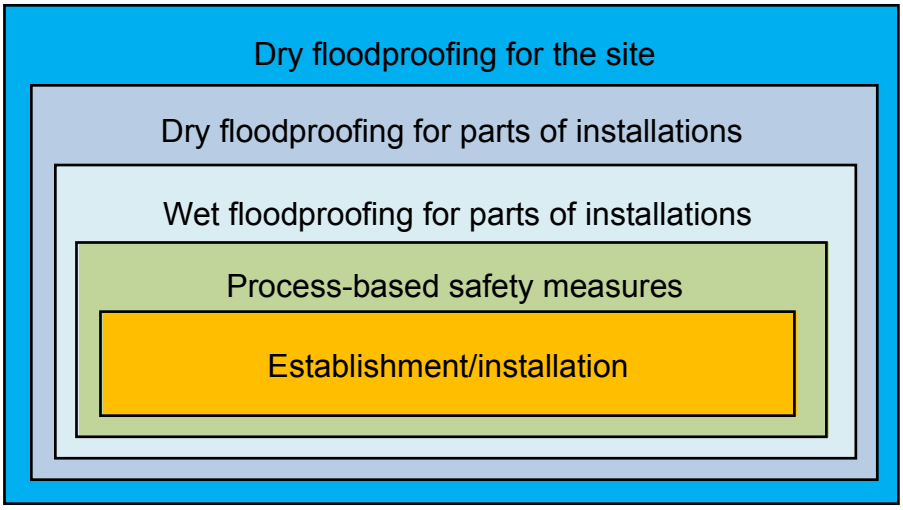

Figure 4: Safety precautions and measures (flooding)

12. Scrutiny of protection concepts

The protection concept developed pursuant to Section 11 is to be reviewed with a view to the achievement of the protection aims. In this respect, consideration is to be given to the probabilities of occurrence and intensities of the environmental hazard sources, and the probabilities of failure of the precautions and measures chosen to reduce risk.

If the chosen precautions and measures are not found to be sufficient, the protection concept in question is to be revised in order to incorporate further precautions and measures to provide for major accidents.

13. Determination of scenarios pursuant to Article 3(3) of the Major Accidents Ordinance (major accidents despite precautions) and scenarios for alarm and emergency planning

These scenarios are drawn up in order to determine

1. the measures required to mitigate the effects of major accidents that can reasonably be excluded pursuant to Article 3(3) and Article 5(1) of the Major Accidents Ordinance (major accidents despite precautions),
2. the information required for the elaboration of internal alarm and emergency plans pursuant to Article 10 of the Major Accidents Ordinance and
3. the information required for the drafting of external alarm and emergency plans pursuant to Article 9(1)(4) of the Major Accidents Ordinance.

Hazard sources that can reasonably be excluded may lead to major accidents despite precautions. The occurrence of such accidents may not be preventable but, irrespective of the precautions taken to prevent major accidents under Article 3(1) of the Major Accidents Ordinance, additional precautions are to be taken to mitigate their effects (Article 3(3) Major Accidents Ordinance). The relevant hazard sources may include e.g.:

1. the failure of precautions taken under Article 3(1) of the Major Accidents Ordinance and
2. flooding or precipitation that occurs more infrequently than the recurrence interval that is 'reasonably' to be presumed for precautions and measures to prevent major accidents.[10]

This means that, in particular where a substance may be released due to hazard sources that can reasonably be excluded, additional measures are to be taken in order to mitigate harmful effects on humans, the environment and property.

In particular, attention is to be paid to the following points when scenarios are set out:

1. parts of installations located at higher elevations may not have to be taken into consideration as a result of the exclusion of exceptional events;
2. environmental hazard sources, e.g. flooding, may have effects on several parts of an installation simultaneously and cause disturbances,
3. as a consequence, more than the largest coherent mass may be released in certain circumstances (leakage of several containers),
4. apart from the dispersion of substances in the atmosphere when events caused by flooding and precipitation occur, aqueous dispersion is to be presumed,

9. I.e. above the levels assumed for the dimensioning of flood defences, cf. Section 10 and Annex I.

5. it is to be assumed that the availability of the measures to mitigate effects provided for to date where there are environmental hazard sources will be limited in certain circumstances (access routes, etc.),
6. in addition to this, it is to be presumed that the availability of external personnel will be limited,
7. in addition to this, the extent to which a disturbance may trigger another disturbance at a different installation or a different part of the same installation is to be scrutinised.

14. Specification of measures to mitigate the effects of major accidents

According to Article 3(3) of the Major Accidents Ordinance, the operator has to take precautionary measures to fulfil their obligations in order to keep the effects of major accidents as small as possible.

Whether and to what extent the external environmental hazard sources examined in this Technical Rule on Process Safety permit measures of any kind to prevent the dispersion of contaminants must be scrutinised systematically in the individual case because, apart from the site affected, it is usually the immediate surroundings of this area that will be affected as well, and the hazard source, flooding in particular, may persist over a prolonged period of time.

15. Planning for emergencies, amendment of operational alarm and emergency plans, communication of information for external alarm and emergency planning

15.1. Planning for emergencies

Pursuant to Article 8(3) of the Major Accidents Ordinance, in the cases covered by Article 7(2)(1) to (3) of the Major Accidents Ordinance, the operator has to review and where necessary update the concept for the prevention of major accidents, including the safety management system on which it is based, as well as the procedures for its implementation. In consequence, this provision also relates to the planning for emergencies required pursuant to Annex III(3)(e) of the Major Accidents Ordinance.

15.2. Amendment of onsite alarm and emergency plans

Under Article 10 of the Major Accidents Ordinance, the operator of an establishment that is subject to extended obligations has to draw up an alarm and emergency plan and, under Article 10(4) of the Major Accidents Ordinance, has to test, review and

update the plan. Establishments with basic obligations may also be obliged to draw up plans of this kind by an order issued in the individual case (Article 1(2) in conjunction with Article 6(4) Major Accidents Ordinance).

15.3. Communication of information for external alarm and emergency planning

Operators of establishments with extended obligations have to communicate the information required to draw up external alarm and emergency plans to the responsible authorities (Article 10(1)(2) Major Accidents Ordinance). Apart from the data that have to be included in the alarm and emergency plans in any event, the following information on environmental hazard sources that cannot be excluded is to be communicated additionally to the authorities:

1. the location of the establishment on a contour map,
2. a representation of the direction from which the hazard poses a threat (e.g. direction of flow),
3. the possible water depth in the establishment affected,
4. data on flow speed,
5. layout plans with side views and elevations,
6. the types and quantities of substances that are handled and their properties (hazardous substances inventory, expanded with data on the hold-up of major accident-relevant substances),
7. the location of the sewer system,
8. the locations and elevations of catch and retention basins,
9. the locations of groundwater wells and drinking water abstraction facilities, and
10. information on internal alarm and emergency planning for environmental hazard sources.

16. Documentation

The steps taken to date and their results, in particular the protection aims, protection concepts and their scrutiny, are to be documented.

17. Fulfilment of further obligations under the Major Accidents Ordinance

17.1. Requirements placed on the maintenance of precautions (Article 6(1)(1) and (2) Major Accidents Ordinance)

According to Article 6(1)(1) and (2) of the Major Accidents Ordinance, in order to fulfil their obligations, the operator has to inspect the construction and operation of safety-relevant parts of installations, and to constantly monitor and regularly service the safety technology of the installations at the establishment. The obligation to maintain installations includes the maintenance of precautions to prevent major accidents caused by environmental hazard sources and mitigate their effects. Maintenance work required by manufacturers' specifications or Technical Rules is to be carried out.

17.2. Information and training for personnel (Article 6(1)(4) Major Accidents Ordinance)

Incorrect behaviour is to be prevented by providing suitable operational and safety instructions and training for personnel (including relevant subcontracted personnel).

The training of personnel includes both the actions required to satisfy obligations under the Major Accidents Ordinance, e.g. to prevent major accidents and mitigate their effects, and actions to ensure the personnel's own safety when environmental hazard sources become active. In particular, reference is to be made to the hazards posed by a medium or high flow speed, even at low water depths, and by electric shocks when electrical installations and parts of installations suffer flooding.

Personnel are to be trained on the type, possible intensity and frequency of environmental hazard sources that cannot reasonably be excluded, and the behaviour required if they become active. The instructions must specify who is to ascertain the presence of an acute hazard or threat, how personnel are to be informed about the situation, and who has to take what action to prevent major accidents or mitigate their effects and ensure the safety of personnel. This applies for all personnel in the establishment, i.e. including personnel who work in parts of the establishment that are not safety-relevant.

17.3. Advice for responsible authorities and emergency services when a major accident occurs (Article 5(2) Major Accidents Ordinance)

According to Article 5(2) of the Major Accidents Ordinance, in order to fulfil their obligations, the operator of an installation has to provide the authorities and emergency services responsible for preventing hazards with immediate, comprehensive and expert advice when a major accident occurs.

When environmental hazard sources become active, this advice is not just to be provided to the authorities responsible for the enforcement of the Major Accidents Ordinance, but also to all authorities and emergency services responsible for or active in the efforts to prevent hazard sources from becoming active or mitigate the ensuing consequences. When the advice concerns flooding, this includes e.g. the water management authorities and water brigades.

When flooding occurs, it must be possible for the advice to extend in particular to the effects, behaviour and dispersion of the substances involved in waters.

Annex I Consideration of climate change

Principles:

For the purposes of adaptation, climate change is to be taken into consideration as follows:

1. A climate adaptation factor of 1.2 is applied to the trigger event intensities to be estimated for 2010 in order to take into consideration possible changes in the period up to 2050.
2. New installations that will be designed for the period up to 2050 or after 2050 should comply with the consequent requirements.
3. The climate adaptation factor does not have to be taken into consideration if it is intended to operate a planned new installation not until 2050.
4. As of 2050, the climate adaptation factor is to be considered in the lay-out of all installations.
5. A detailed hazard source analysis may provide grounds for the 1.2 factor to be varied in an individual case. This is possible in particular if the consequences of climate change are already taken into consideration on (flood) hazard maps or the authority responsible for the water in question has previously ascertained the possible change in the runoff from high water flooding due to climate change.
6. Should other developments in what is known about climate come to light in the period up to 2050, they will be taken into consideration when this Technical Rule on Process Safety is revised.

Requirements:

In particular, the need for adaptation to climate change is taken into consideration as follows:

Hazard source	Intensity to be estimated as of 2010	Intensity to be estimated for 2050
River flooding	Flood runoff (m^3/s), cf. Section 7	1.2 * flood runoff (m^3/s)
Flash flood events[11]	Flood runoff (m^3/s)	1.2 * flood runoff (m^3/s)
Storm surge events	Nominal height of dykes, etc. pursuant to designation	May subsequently be raised by up to 1 m[12]
Heavy precipitation	Peak heavy precipitation[13] for t = 100 a	1.2 * peak heavy precipitation for t = 100 a
Rising groundwater	Surface of terrain	Surface of terrain (climate adaptation factor not relevant)

[11] German: *Sturmflutereignisse*. For further comments on this term, see *Hinweise und Erläuterungen zum Vorentwurf der TRAS*.

[12] Cf. general coastal defence plans, e.g. the measures taken by the Lower Saxony Water, Coastal Defence and Nature Conservation Agency, http://www.nlwkn.niedersachsen.de.

[13] Cf. http://www.dwd.de/kostra.