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STUDY ON RAINWATER TREATMENT SYSTEMS IN PORT AND MARITIME COMMERCIAL AREAS

Considering the objectives of the EU WFD and using the example of German legal standards and technical regulations (new and existing buildings)

Version 1

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1. Introduction

The European Community's Water Framework Directive (EU WFD) serves as a regulatory framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater. It stands for an integrated water protection policy in Europe. The EU-WFD sets goals to protect and improve the condition of aquatic ecosystems as well as to gradually reduce priority substances and stop the discharge / release of priority hazardous substances.

The implementation of the EU Water Framework Directive with the achievement of its targets requires, among other things, a more detailed consideration of rainwater discharges. In Germany, rainwater treatment is regulated by the DWA-A 102 worksheet "Principles for the Management and Treatment of Rainwater Runoff for Discharge into Surface Waters".

The aim of this study is to examine the need for treatment of the rainwater discharges from port facilities and connected port handling and logistics areas as well as maritime industrial and commercial areas in accordance with DWA-A 102. The areas of the overseas port of Rostock are used as an example in this study. Within this framework, technical solutions are to be assigned to the various land uses, partly with concrete examples from manufacturers of treatment plants.

2. Legal bases and regulations

The natural resource water is used in very different ways. On the one hand, water serves as the basis of life for people; on the other hand, water is used by people in a wide variety of ways. For example, goods are transported on water, it is used to extract raw materials, energy and products, and pollutants and heat are discharged in bodies of water. In addition, water bodies are used for leisure activities. Economic and ecological interests often compete here. In order to uphold the balance between the interests of use and to protect the water resource in the public interest against excessive use, a balanced management of water is necessary. The provisions of the water protection law are responsible for the establishment of this balance.

The term water protection law encompasses all regulations that serve to protect water. The core regulations include the Federal Water Act and the Surface Water Protection Ordinance at the federal level. At the state level, the federal regulations are put into concrete terms and converted into state laws. In order to apply the laws technically to specific measures, technical rules and standards have been developed.

In order to implement comprehensive water protection, not only the national level is sufficient, but the coordination and bundling of measures at the European and international level is necessary. Cooperation within the EU as well as worldwide is therefore essential for effective water protection. With the Water Framework Directive, a tool was created in 2000 that defines, regulates and controls overriding goals relating to water protection.

The following table lists the most important legal bases in the context of water protection and rainwater treatment and is clearly shown in Figure 1:

EU	▪ Water Framework Directive (EU WFD) ▪ Marine Strategy Framework Directive (MSFD) ▪ Drinking Water Directive ▪ Priority Substances Directive
National	▪ Federal Water Act ▪ Surface Waters Ordinance ▪ Groundwater Ordinance ▪ Ordinance On Installations for Handling Substances Hazardous to Water
State	▪ State Water Act (or State Water Law from Mecklenburg-Vorpommern)
Technical Rules and Standards	▪ DIN standards ▪ DWA-A 102 (Discharge of Rainwater), DWA-A 138 (Infiltration) and other DWA-Publications / Guidelines ▪ Other regulations

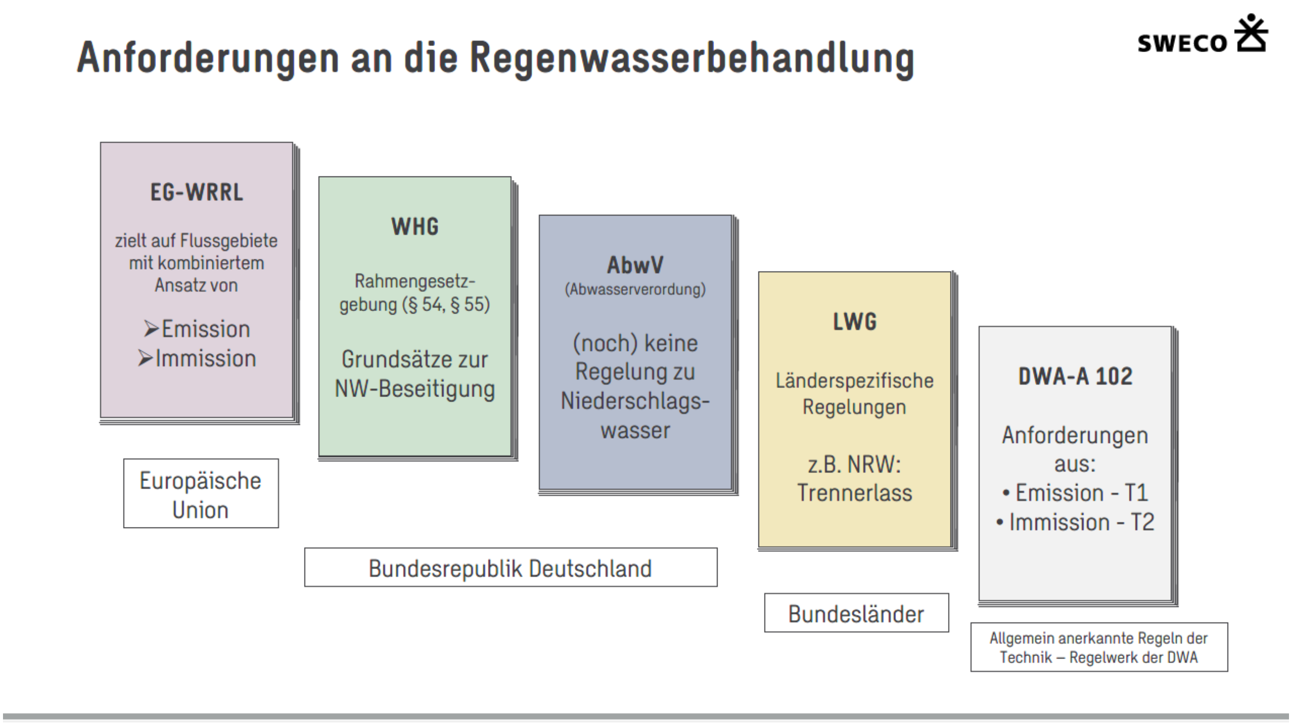

Figure 1: Legal basis in the context of rainwater treatment (Sweco GmbH: The future of rainwater treatment with a special focus on the quantity due to heavy rain events)

The most important legal bases are presented in the following sections.

2.1. EU WFD

2.1.1. Water Framework Directive (EU WFD)

With the Water Framework Directive of the European Community, which came into force on December 22, 2000, a regulatory framework was created for Community measures in the field of water policy. One of the central considerations for establishing the European Water Framework Directive is that water is not a common commodity, but an inherited good that must to be protected, defended, and treated accordingly. The primary objective is to protect and achieve good ecological status for all water bodies, i.e. inland surface waters, transitional waters, coastal waters, and groundwater, in the European Community.

The objectives of the directive are set out in Article 1 and can be summarized as follows:

- Preventing deterioration as well as protecting and improving the status of aquatic ecosystems
- Promoting sustainable use of water resources
- Reduction of discharges, emissions and losses of priority and priority hazardous substances
- Reduction of groundwater pollution
- Mitigating the effects of floods and droughts

The following environmental objectives were specified for surface waters in Article 4, which put the existing objectives in concrete terms:

- Good ecological and chemical status in 15 years (by 2015)
- Good ecological potential and good chemical status for heavily modified or artificial waters in 15 years (by 2015)
- Prohibition of deterioration

The deadlines can be extended until 2027.

A coordinated management of river basins or river basin districts is necessary to achieve these goals. The tasks involved can be grouped into three overriding areas of responsibility:

- Inventory (current state)
- Determination of goals (target state)
- Definition of the measures to achieve the goals (program of measures)

The individual member states themselves are responsible for fulfilling the tasks arising from the directive. A central aspect of coordination is the preparation of management plans and programs of measures for the river basin districts.

The management plan is the central element for the implementation of the EU WFD. Its content is regulated in Annex VII of the Water Framework Directive. A management plan must be drawn up for each river basin district every six years, called River Basin Management Plans. The management periods resulting from this can be seen in Figure 2 in the "Timetable for the implementation of the WFD objectives".

Figure 2: Timetable for the implementation of the WFD objectives (https://www.stalu-mv.de/mm/Themen/Wasser-und-Boden/Umsetzung-der-Europaeischen-Wasserrahmenrichtlinie-WRRL/)

For each river basin, programs of measures are drawn up to accompany the management plans, which list all measures that are necessary to achieve the goals of the WFD. Like the management plans, the programs of measures must be updated every six years. The established measures are to be implemented in the following management period.

The EU WFD was transposed into national law through an amendment to the Water Resources Act in June 2002. All federal states have also adapted their water laws to implement the directive. The Water Resources Act is explained in more detail in Chapter 2.2.

The chemical status according to the EU Water Framework Directive is determined regardless of the type of water. To assess the good chemical status, 45 priority substances were specified in the Water Framework Directive (the subsidiary Directive 2013/39/EU). The priority substances in the field of water policy are listed in Annex X of the EU WFD. In Article 16 of the WFD, strategies against water pollution by priority substances are set out, these include, for example, immission-related environmental quality standards (limit values) as well as emission-related restrictions. This was further specified in Directives 2008/105/EC and 2013/39/EU. For the priority hazardous substances, discharges and emissions must be completely stopped by 2020 at the latest so that they no longer occur in water bodies in the long term. Chapter 2.2.2. describes the directives on priority substances and their implementation in German law with the Ordinance on the Protection of Surface Waters (OGewV) in more detail.

2.1.2. Marine Strategy Framework Directive (MSFD)

The European Marine Strategy Framework Directive (MSFD, 2008/56/EG), which came into force on June 17, 2008, creates the regulatory framework for the necessary measures by all EU member states in order to achieve or obtain a good status of the marine environment in all European seas by 2020 at the latest. All European countries bordering the sea have committed themselves to implementing this overarching goal in their respective sea regions by developing and implementing national strategies. The schedule of the guideline was the legal implementation into national law (Federal Water Act) by 2010, the assessment of the current state of the seas and the determination of environmental goals by 2012 and, based on this, the development of monitoring and action programs by 2014 or 2015.

The description of the good environmental status was carried out by using eleven so-called qualitative descriptors, of which the following are mainly relevant for port and maritime commercial areas (Annex 1):

- D5 Eutrophication of the seas
- D8 Pollutants in the sea
- D10 Marine litter
- D11 Discharge of energies, underwater noise

In addition to the descriptors, a large number of indicators, characteristics and pressure factors (Annex 3) were and are used to assess the state of the sea. For port and maritime commercial areas, contamination by hazardous substances (see priority substances), systematic and / or intentional release of substances or physical damage (change in siltation, e.g. through the openings of pipelines) are, among other things, of particular importance.

In Germany, based on the descriptors, seven overarching national environmental goals were specified, such as UZ 2 "Oceans without pollution by pollutants" and UZ 5 "Oceans without pollution by litter". (see program of measures)

In the "MSRL Program of Measures for Marine Protection in the German North Sea and Baltic Sea", measures were drawn up that are assigned to the respective environmental goals. Measures listed in Annex 2 that are relevant for operators, owners or lessees of port and maritime commercial areas include:

- Construction and expansion of wastewater treatment plants and industrial wastewater treatment plants
- Measures of natural water retention
- Measures to eliminate or reduce emissions, discharges and losses of priority hazardous substances
- Measures to prevent or protect against the adverse effects of pollution from populated areas, transport and construction of infrastructure
- Interdict of TBT and other substances hazardous to the marine environment and measure in the course of the implementation of the industrial emissions directive
- Specifications for port reception facilities, waste logs and waste management plans

2.2. National Legislation

2.2.1. Federal Water Act (WHG)

The Federal Water Act (WHG), which originally dates back to 1957, forms the main part of German water law or water protection law and was established for the purpose of "protecting water bodies as a component of the natural balance, as the basis of human life, as a habitat for animals and plants, and as a usable resource, through sustainable water management". (§1 WHG) Like the EU WFD, the WHG also applies to surface waters, coastal waters and groundwater.

With the 7th amendment of the Federal Water Act of June 18 2002, the EU WFD was transposed into federal law and with the new version of July 31 2009, the reorganization of the Federal Water Act according to the requirements of the European Water Framework Directive was completed. The basic management concept of the EU Water Framework Directive for surface waters can be found in Paragraphs 27 to 31 of the Federal Water Act. The goals for surface waters, such as good ecological status or potential and good chemical status, including deadlines and permissible exceptions, are regulated here.

The aim of the Federal Water Act is to create the legal prerequisites for the orderly management of surface and underground water in terms of quantity and quality and to control the human impacts on water bodies. Waters are to be safe guarded as a component of the natural balance and as a habitat for animals and plants. They should be managed in such a way that they serve the public good as well as the benefit of individuals in harmony. Impairments and adverse changes with regard to the water balance and water characteristics are to be avoided, and to be prevented by protective measures or compensated. Overall, a high level of protection for the environment is to be ensured through sustainable water management.

The main contents of the Federal Water Act are:

- Uses of water bodies and the permission and authorization to use them
- Water maintenance, development and supervision

- Regulation of water protection areas, therapeutic spring protection areas and floodplains
- Handling of substances hazardous to water

According to Section 54 of the Federal Water Act, the water (rainwater) that drains and collects from precipitation from the built-up or paved surfaces is wastewater. According to § 57 of the Federal Water Act, a permit for the discharge of wastewater may only be granted "if the amount and harmfulness of wastewater is kept as low as is possible under compliance with the relevant state-of-the-art procedures and if the discharge is compatible with the requirements for the water properties and other legal requirements. "

In Section 3 No. 11 WHG (Federal Water Act), the state of the art is described as "the level of development of advanced processes, facilities or operating practices that makes it certain that a measure is practicable to limit emissions to air, water and soil, to ensure plant safety, to ensure environmentally compatible waste disposal, or otherwise to avoid or reduce impacts on the environment in order to achieve a generally high level of protection for the environment as a whole. "

According to Section 60, the wastewater facilities shall be built, operated and maintained in such a way that the requirements for sewage disposal are met. They may only be constructed, operated and maintained in accordance with the generally recognized rules of technology.

Special regulations apply to facilities for handling substances hazardous to water (§ 62f WHG), which are intended to ensure that the facilities do not cause any adverse changes to the properties of the water. In the Federal Ordinance On Installations for Handling Substances Hazardous to Water (AwSV), the requirements for the installations and the procedure for classifying substances hazardous to water are specified. The AwSV is discussed in more detail in Chapter 2.2.4.

2.2.2. Surface Waters Ordinance

As already described in Chapter 2.1, one of the basic objectives of the EU WFD is the reduction of discharges, emissions and losses of priority and priority hazardous substances. Priority substances are substances that pose a significant risk to or through the aquatic environment. Of these substances or groups of substances, those classified as "priority hazardous substances" should be completely eliminated from the aquatic environment.

The quality standards for priority substances were established and the classification into priority and priority hazardous substances was carried out with the directive 2008/105/EC (published on December 24, 2008), the so-called priority substances subsidiary directive of the WFD. The implementation into German law took place through the enactment of the Surface Waters Ordinance (OGewV) on July 25, 2011. The list of priority substances was expanded to 45 with the directive 2013/39/EU, published on August 24, 2013. In some cases, the environmental quality standards (EQS) were tightened considerably for this purpose.

Priority substances include, for example, heavy metals, polychlorinated biphenyls, poorly degradable chlorinated hydrocarbons and active ingredients in pesticides.

According to Section 1 of the Surface Waters Ordinance, the ordinance serves the protection of surface waters and the economic analysis of uses of water. It regulates the detailed aspects of the protection of surface waters on a nationwide basis and contains regulations for the categorization, typification and delimitation of surface bodies in accordance with the requirements of the WFD.

Furthermore, as already described in the previous paragraph, the OGewV implements the EU requirements on environmental quality standards, on quality requirements for analytics and on intercalibration into national law. Among other things, it formulates requirements for the inventory of pollution and the chemical and ecological status or potential, for example by defining river basin-specific environmental quality standards.

Appendix 8 OGewV regulates the 45 priority substances that were adopted in the Surface Waters Ordinance in 2016. Appendix 8 is divided into two tables: the first table "Substances of chemical status" contains information about the listed substances, such as the CAS number (international designation standard), whether the environmental quality standard of the substance has been revised or whether it is a priority hazardous substance. Table 2 “Environmental Quality Standards” lists the environmental quality standards for each substance for the various types of surface water. The environmental quality standard is the value or concentration of a substance that must not be exceeded.

The priority substances must be measured when they enter the water. Compliance with the EQS must be monitored if there are discharges or inputs of these substances in the catchment area of the measuring point representative of the surface water body. The annual mean value is always monitored, and the environmental quality standard is therefore abbreviated as JD-UQN (annual average environmental quality standard). For some pollutants with high acute toxicity, a maximum permissible concentration (ZHK-EQS) has also been specified, which must not be exceeded by the maximum value of the pollutants. An additional standard for biota has also been established for substances that are highly accumulated within the food chain.

There are only two classes for the chemical status of waters: if the standards are met, the status is “good”, otherwise “not good”. The “good chemical status” as an environmental target applies to both “natural” as well as “artificial” and “heavily modified” water bodies. The environmental quality standards of the chemical status take into account the protection of aquatic organisms and human health.

In addition to the EU-wide environmental quality standards that determine the chemical status of a water body, river basin-specific pollutants are assessed as a part of the ecological status classification. In Germany, environmental quality standards have been specified for 67 pollutants in Annex 6, "Environmental Quality Standards for River Basin-Specific Pollutants for the Assessment of Ecological Status and Ecological Potential" of the Surface Waters Ordinance. The environmental quality standard is tested on the basis of annual mean values.

2.2.3. Groundwater Ordinance

As for surface water, the Water Framework Directive is trend-setting for groundwater protection in the EU. The main goal for groundwater is to protect, improve and remediate it, so that a “good status” is ultimately achieved for all groundwater bodies. For groundwater, this target is defined as good quantitative and good chemical status. The quantitative status is good if, among other things, the long-term mean annual groundwater abstraction does not exceed the usable groundwater supply. That is, when there is a balance between the formation and withdrawal of groundwater. In addition, the groundwater level must be so high that surface waters and land ecosystems dependent on water are not endangered.

In order to specify the criteria for assessing the chemical water quality, the Groundwater Directive (2006/118/EC) was issued on the basis of Article 17 of the WFD. For the first time, this guideline contains specific threshold values for assessing good chemical status (they are largely based on the limit values of the Drinking Water Directive (98/83/EC)). It also contains criteria for realizing the so-called trend reversal. This requires identifying, assessing and reversing significant and persistent human-induced trends in groundwater degradation from water bodies already classified as vulnerable and which probably cannot achieve the good status without additional measures.

A new Groundwater Ordinance was passed in October 2010 to implement the Groundwater Directive into national law. The ordinance establishes criteria for the description, assessment, classification and monitoring of the groundwater status and implements the trend reversal in German law. In addition, measures are to be taken to prevent or limit the entry of pollutants into the groundwater. A deterioration of the groundwater status should be prevented.

The benchmark for assessing the good chemical status in accordance with the Groundwater Ordinance is based on the European quality standards for nitrate and pesticides (generic term for plant protection products and biocides). It is also based on threshold values for arsenic, cadmium, lead, mercury, ammonium, chloride, sulfate and trichloroethene and tetrachloroethene, which have now been standardized across Germany.

Measures or actions must not be permitted as a matter of principle if inputs of particularly dangerous substances (cf. Appendix 7) are to be expected. Deviations from this may only be made if the pollutants are introduced in such small quantities and concentrations that an adverse change in the groundwater quality is excluded. Inputs of other pollutants may only be permitted if an adverse change in the groundwater can be ruled out and no significant and sustained upward trend in pollutant concentrations in the groundwater is to be expected. (Paragraph 13 GrwV)

Accordingly, the operators of plants or owners / leaseholders of areas are obliged to prevent discharges of hazardous substances or to limit them in accordance with the limit values, both in the case of discharge into surface water and into groundwater.

2.2.4. AwSV, hazardous waste, extinguishing water retention

On August 1, 2017, the "Ordinance on facilities for handling substances that are hazardous to water " (AwSV) came into force to specify the requirements for handling water-polluting substances according to Section 62 WHG. It has replaced the previously applicable state ordinances (VaWS) and fully adopted the regulations of the "Ordinance for the Determination of classes hazards to water" (VwVws). For example, a uniform regulation has been created that applies at the federal level and no longer allows any discretionary powers for the federal states. The aim is to increase soil and water protection, to achieve greater safety and to ensure the health of local residents. Roughly speaking, substances hazardous to water should no longer get into the environment and plants that handle with substances hazardous to water must meet specified requirements. The operators must therefore implement the applicable obligations from the AwSV.

In principle, the AwSV applies to all systems that handle with substances hazardous to water. Exceptions to this are systems for handling waste water and systems that fall under a "minor limit". Above-ground systems with a maximum volume of 220 liters of liquid substances or a maximum mass of 200 kg of gaseous or solid substances are exempt from the requirements of the regulation (regardless of the water hazard class). This only applies outside of flood and protection areas (water, medicinal water). Further exceptions exist for commercially used storage containers with a volume of up to 1,250 liters: the organizational and technical requirements do not apply to them under certain conditions.

The AwSV defines three water hazard classes (slightly hazardous to water, obviously hazardous to water, highly hazardous to water) as well as the classification "generally hazardous to water" and "not hazardous to water". The safety data sheet usually provides information on the water hazard class. Annex 1 AwSV provides detailed specifications for self-classification: Companies must report the classification of substances to the Federal Environment Agency, which decides on the final classification. For mixtures, the classification must be documented; the competent authority can check the documentation. Substances and mixtures that have already been classified by or on the basis of the previous VwVwS are considered classified. The classification is the basis for a risk-oriented safety-related equipment of the plant.

In the event of a fire, systems that handle with substances hazardous to water produce not only the water-polluting substances themselves, but also combustion residues, which can be considerably more hazardous to water than the products that have escaped. Most extinguishing foams and their residues are classified as at least water hazard class 1 (WGK 1). According to Section 20 AwSV, all systems must therefore be planned, constructed and operated in such a way that, in the event of a fire, substances hazardous to water, extinguishing, sprinkling and cooling water and combustion products with water-polluting substances can be retained in accordance with the generally recognized rules of technology. The responsible water authorities decide whether companies have to build fire-fighting water retention; however, the building law authorities decide how large these are.

The fire fighting water retention guidelines were replaced by the AwSV, so that there are currently no generally applicable official regulations for calculating the required volumes for fire-fighting water retention. To be retained in the event of a fire, a new annex (Annex 2a) of the AwSV is intended to provide practical information on determining the volumes required for the liquids. Here, retention volumes for substances hazardous to water, incidental extinguishing water depending on the area of the fire, and rainwater, if systems are located outdoors, should be taken into account.

The AwSV also places requirements on the drainage of systems and associated areas. (§ 19) Rainwater which is contaminated with substances hazardous to water must be disposed as waste water or as waste and must never be discharged into the rainwater sewer system. In principle, all systems regulated by the AwSV, the restraint systems must be impermeable to liquids and may not have any drains. In the event of unavoidable ingress of rainwater, drains are only permitted if they are only opened after prior determination that the rainwater does not contain any substances hazardous to water. The second paragraph is mainly applicable for areas of port and maritime industrial areas:

"In the case of bottling or handling facilities where the ingress of rainwater is unavoidable, the rainwater, which may be contaminated with substances hazardous to water, can be discharged into a sewer or body of water, in derogation of Paragraph 1 and Article 18 Paragraph 2, if

1. the substances hazardous to water released in the event of a breakdown are retained and

2. the discharge of the contaminated rainwater corresponds to the water law requirements and local discharge conditions."

In addition, the competent authority decides on the type of retention of substances hazardous to water. The authority also decides on the disposal of rainwater if the access of rainwater to the retention facility is unavoidable or the control of rainwater runoff before opening it would only be possible with disproportionate effort.

Section 29 (special requirements for handling facilities for intermodal transport) and Section 30 (special requirements for facilities for loading and unloading ships and facilities for refueling watercraft) are also relevant for port and maritime commercial areas. If substances hazardous to water are transshipped at transshipment facilities for intermodal transport, i.e. reloading into loading units or road vehicles, the concrete or asphalt surfaces must be paved in such a way that rainwater cannot escape on the underside. The rainwater that occurs is to be disposed of as waste water or as waste. Furthermore, handling facilities for intermodal transport must have emergency areas or facilities that are impermeable to liquids. Loading units or road vehicles from which substances hazardous to water are leaking can be parked on these. Rainwater from such areas must also be removed as wastewater or waste.

According to Section 30, several requirements must be met when loading and unloading unpackaged liquid substances hazardous to water and when refueling watercraft. The requirements aim to minimize the risk of escaping substances hazardous to water. These include, for example, that when loading and unloading in pressure mode, breakaway couplings must be used that close automatically on both sides, or that in suction mode it must be ensured that in the event of damage to the suction line, the connected containers cannot run empty due to the lifting effect. Bulk materials are to be loaded and unloaded in such a way that the entry of solid substances hazardous to water into surface waters is prevented by suitable measures.

Waste that is classified as hazardous according to the European Waste Catalog (EWC) or the Waste Catalog Ordinance (AVV) poses a risk to health and to the environment and must therefore be specially removed and stored. Hazardous waste is also stored, accumulated or transshipped on port and maritime commercial areas. Many of these wastes or substances are also classified as hazardous to water, so they must be stored in secure containers over catch basins. If waste containers are not placed in a collection tray, the floor must be impermeable to liquids and designed as a tray. Furthermore, the floor must not have a drain. As a rule, a roof over the storage area is required. When handling and interim storage of hazardous waste, the law on hazardous substances and the law on hazardous goods also apply in addition to the waste law. Hazardous waste may only be transported from the waste producer to an approved recycling or disposal facility with official approval.

For better understanding, the transport of waste and hazardous goods should be briefly explained at this point, as well as the sub-items parking, interim storage and storage. Transport means the change of location of e.g. goods, people or animals by means of transport from one place to another. Alongside storage and transhipment, transport is one of the three main processes in logistics. Transhipment is the change of the means of transport and storage is the bridging of time when goods are only needed at a later point in time. In the area of hazardous goods law or hazardous substance law, storage begins at the end of the next calendar day. Parking is the accommodation / placing of a transport item that is not immediately used or moved to an otherwise unused location. The time between parking and the start of storage can be referred to as interim storage. Intermediate storage also occurs when goods to be transported are temporarily stored until further transport TRGS 510 applies if dangerous goods are stored at the same location for less than 6 months. The measures to be taken depend on the storage class of the hazardous substances and their storage quantity. For storage longer than 6 months, the AwSV must also be implemented in addition to the TRGS 510. Criteria for the measures according to AwSV are the water hazard class of the storage facility and the stored quantity.

2.3. Technical regulations

Among others, the following technical regulations are used in Germany for the drainage of port and maritime commercial areas:

- DWA-A 100: Guidelines for integral urban drainage
- DWA-A 102 / BWK-A 3: Principles for the management and treatment of rainwater runoff for discharge to surface water
- DWA-M 117: Dimensioning of rain retention spaces
- DWA-A 118: Hydraluic design and verification of drainage systems
- DWA-M 119: Risk management in municipal flood prevention
- DWA-M 153: Recommended action for dealing with rainwater (since Dec. 2020 replaced by DWA-A 102)
- DWA-M 179: Recommendation for the planning and operation of decentralized systems for rainwater treatment
- DWA-M 165: Rainwater, runoff and dirt load models in urban drainage, Part 1: Requirements

In the next chapter, the DWA-A 102 is explained in more detail due to its great importance for rainwater treatment in Germany.

3. Application of regulations to land use using the example of the seaport of Rostock

3.1. DWA A102

The DWA-A 102 was published in white print by the DWA (German Association for Water Management, Sewage and Waste) in December 2020. The worksheet is titled "Principles for the management and treatment of rainwater runoff for discharge into surface waters" and is structured as follows:

- Part 1: General
- Part 2: Emissions-related assessment and regulations
- Part 3: Immission-related assessment and regulations
- Part 4: Water balance for the management of rainwater
- Part 5: Hydromorphological and biological methods for immission-related assessment

So far, the first two parts of the DWA-A 102 have been published in white print and the third and fourth parts as a draft (as of September 2021). This study deals exclusively with the first two parts.

The series of worksheets and information sheets deals with the water management issues of water protection with a special focus on rainfall-related urban runoff. For this purpose, it contains emission and immission-related principles and specifications for dealing with precipitation-related urban runoff, both in separate and combined sewer systems. The overriding goal of the series is the environmentally friendly handling of precipitation-related runoff from settlement areas, with particular regard to the EU Water Framework Directive for surface waters. This particular attention is paid for achieving and maintaining the good chemical and good ecological status.

DWA-A 102 Part 2 deals with the emission-related assessment and regulation in the context of the treatment of rainwater runoff for discharge into surface waters. It applies to both rainwater in the separate and combined sewer systems. If industrially and commercially influenced rainwater is covered by the scope of application of an annex of the Waste Water Ordinance (AbwV), the respective origin-specific requirements of the AbwV are decisive for the discharge. In this study, such areas or such rainwater will not be discussed further.

- The regulations are primarily aimed at application in the following cases:Drainage-related new development
- Urban development and / or drainage over-planning
- Review and verification of existing systems for the treatment o rainwater and combined sewers
- Identification of suitable measures within the framework of programs of measures according to the EC WFD for the elimination of identified deficits of the water condition, caused by rainy runoff

When considering the material emissions, the accumulating effects of water inputs are in the foreground. The filterable substances (AFS) were selected for the evaluation of the pollution of rainwater. A restriction was made to the fine fraction of the solids from 0.45 µm to 63 µm, referred to as AFS63. The selected solids fraction exhibits a greater homogeneity in the composition and also captures a majority of the pollutants adsorbed onto the solids, such as heavy metals and organic pollutants.

3.1.1. Determination of catchment areas

The catchment areas must be determined as precisely as possible to consider the rainwater runoff. The DWA- A 102 therefore divides the areas into three different types. A distinction is made between non-paved surfaces, paved non-connected surfaces and paved connected surfaces. In the context of the worksheet, non-paved areas, such as green spaces, are considered to have no impact on runoff. For the area determination and evaluation, only the connected paved areas are relevant.

Depending on the issue, a differentiated or lump-sum area determination is necessary for the water management assessment. The differentiated assessment of individual areas is recommended if there is a higher demand for accuracy. In this case, the area is assessed in terms of runoff effectiveness and runoff pollution. In other cases, a general survey of the data at the discharge point may be sufficient. To calculate the runoff effectiveness, the water balance parameters: Direct runoff, groundwater recharge and evaporation, are considered. In the developed state, they should deviate as little as possible from the undeveloped reference state. The aim is to improve the overall water balance of the settlement areas towards the reference state and to reduce overall emissions as much as possible.

3.1.2. Pollution categories

The DWA-A 102 part 2 assigns pollution categories to rainwater, namely category 1 (lightly polluted rainwater), category 2 (moderately polluted rainwater) and category 3 (heavily polluted rainwater) on the basis of various criteria such as the land use, the risk of damage and the material pollution.

Zielgewässer	Gering belastetes Niederschlagswasser (Kategorie I)	Mäßig belastetes Niederschlagswasser (Kategorie II)	Stark belastetes Niederschlagswasser (Kategorie III)
Oberflächen-gewässer	Einleitung grundsätzlich ohne Behandlung möglich	Grundsätzlich geeignete technische Behandlung erforderlich	
Grundwasser	Versickerung und gegebenenfalls Behandlung gemäß Arbeitsblatt DWA-A 138		

Figure 3: Graphical representation of the pollution categories according to DWA-A 102 (DWA-Regelwerk/BWK-Regelwerk, Arbeitsblatt DWA-A 102-2/BWK-A 3-2: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. & Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau e.V.; Hennef und Aachen 2020)

The precipitation water of category 1 can be basically discharged into surface waters without treatment. The discharge of the pollution categories 2 and 3 may only take place after prior suitable technical treatment. For this reason, mixing of the different pollution categories should be avoided, especially mixing of pollution category 1 with categories 2 and 3. The Category 3 rainwater is often contaminated with material pollution. Therefore, various treatment measures should be examined.

The DWA-A 102 determines the fine fraction of the filterable substances (AFS63) as a reference parameter and thus regulates the material load of the discharge of rainwater into surface waters. The area-specific material discharge for the discharge of rainwater into surface waters is tolerable up to 280 kg / (ha * a). A higher area-specific material removal (up to 530 kg / (ha * a) = category 2, up to 760 kg / (ha * a) = category 3) requires suitable technical treatment. Thus, the target size or the permissible area-specific material discharge is: 280 kg / (ha * a). Rainwater runoff in treatment category 1 therefore has a calculated area-specific material discharge of 280 kg / (ha * a).

It does not contain any classification for areas for handling substances hazardous to water or areas that fall within the scope of the Ordinance on Installations for Handling Substances Hazardous to Water (AwSV). If there are sub-areas in the planning area for which separate regulations for dealing with rainwater apply, mixing of the rainwater from these areas with unaffected sub-areas should be avoided as far as possible. In this way, the most accurate, substance-specific treatment possible can be achieved.

Annex 1 lists land uses in accordance with table A.1 DWA-A 102 "Allocation of pollution categories for rainwater from built-up or paved areas according to type of area and land use", which can generally be found in port and maritime commercial areas.

3.1.3. Balancing of the substance discharge

The proportions of different area types for the considered discharge point or catchment area are available from the area determination. Using an area-weighted load balance with the area-specific values for the material removal, a resulting material removal can be determined. If this material removal exceeds the permissible value of 280 kg / (ha * a), which is always the case when connecting areas of pollution categories II or III, treatment measures are required.

The required efficiency is also decisive for the selection of treatment measure. This is calculated from the determined resulting material removal and the permissible material removal. If the inflow to the treatment plant is limited, the untreated volume flow passing the plant must be included in the balancing of the resulting substance discharge after the treatment, thus requiring an increased efficiency of the treatment measure. This is shown in Figure 4.

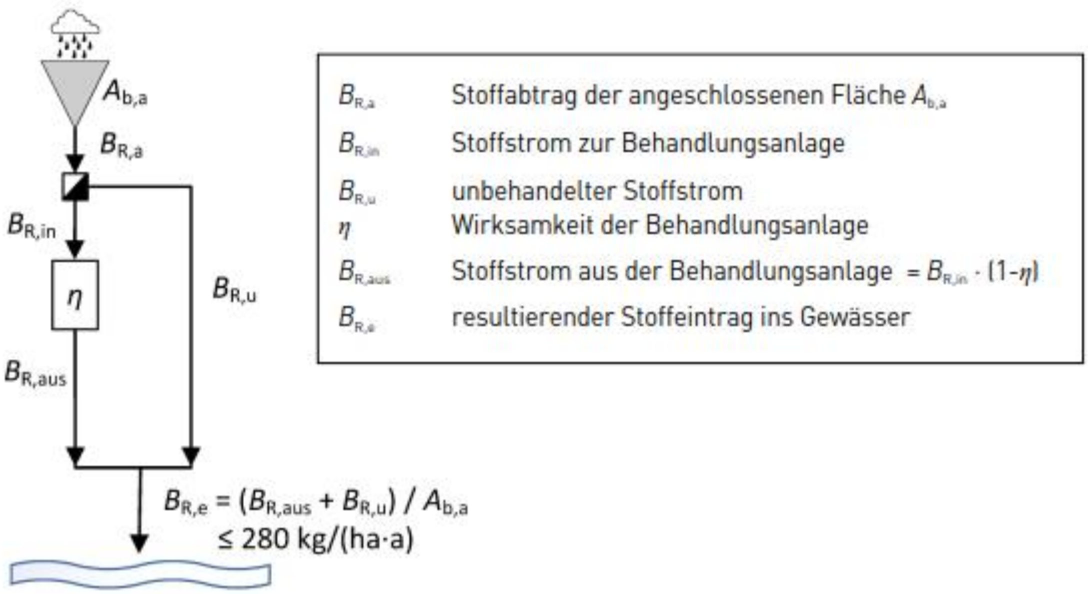

Figure 4: Schematic diagram for balancing the resulting material discharge for treatment plants with inflow limitation according to DWA-A 102 (DWA-Regelwerk/BWK-Regelwerk, Arbeitsblatt DWA-A 102-2/BWK-A 3-2: Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. & Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau e.V.; Hennef und Aachen 2020)

If runoffs from the areas with primarily dissolved material pollution is discharged into the system under consideration after substance-specific pretreatment, the remaining material pollution must be assessed according to category I in order to avoid arithmetical dilution effects in the balancing of the material removal. Without pre-treatment, the material pollution of these areas is balanced according to their pollution category and considered when determining the required substance retention.

3.1.4. Systems for the treatment of rainwater

According to the derived target value for the discharge into surface water, the substance input by precipitation water from polluted areas is to be limited or the runoff has to be treated before it is discharged into a water body. The necessary retention of substances in rainwater can take place in decentralized and centralized treatment plants. The effectiveness of the substance retention with respect to AFS63 is decisive for the proof of sufficient treatment. In this context, the separation of solids also means that a proportion of the pollutants (e.g. heavy metals, PAHs) attached to the solids is retained.

The mechanisms of action of solids retention and the function of decentralized and centralized treatment plant types are discussed in Section 4.

3.2. Rostock port

3.2.1. Rostock Port GmbH

The port of Rostock is owned by the Federal state of Mecklenburg-Vorpommern and the Hanseatic City of Rostock. Rostock Port GmbH represents the interests of the owners. Its main tasks are the administration, development and maintenance of the port infrastructure and the leasing of land as well as the rental of real estate for settlers in the industrial area Rostock seaport and the provision of services and utilities. In addition, Rostock Port is the sole operator of the ferry and cruise port.

The Rostock seaport consists of 4 piers and other ports. The following table shows the piers and harbours with the simplified use and / or with some of the substances handled there. Figure 5 shows the port map of the Rostock overseas port.

PIER 1	Ferry, RoRo and combined transport terminals
PIER 2	General cargo terminal (including cement, non-ferrous metals, steel products, wind turbines, large pipes)
PIER 3 WEST	Coal, building materials, ores, heavy cargo
PIER 4 OST	Fertilizers, grains, heavy goods
PIER 4	Malting, grains, building materials, heavy goods
OIL PORT	Oils and fuels (e.g. diesel, gasoline, heating oil)
CHEMICAL PORT	Liquid fertilizer, ammonia
CRUISE PORTS	Not included in the study

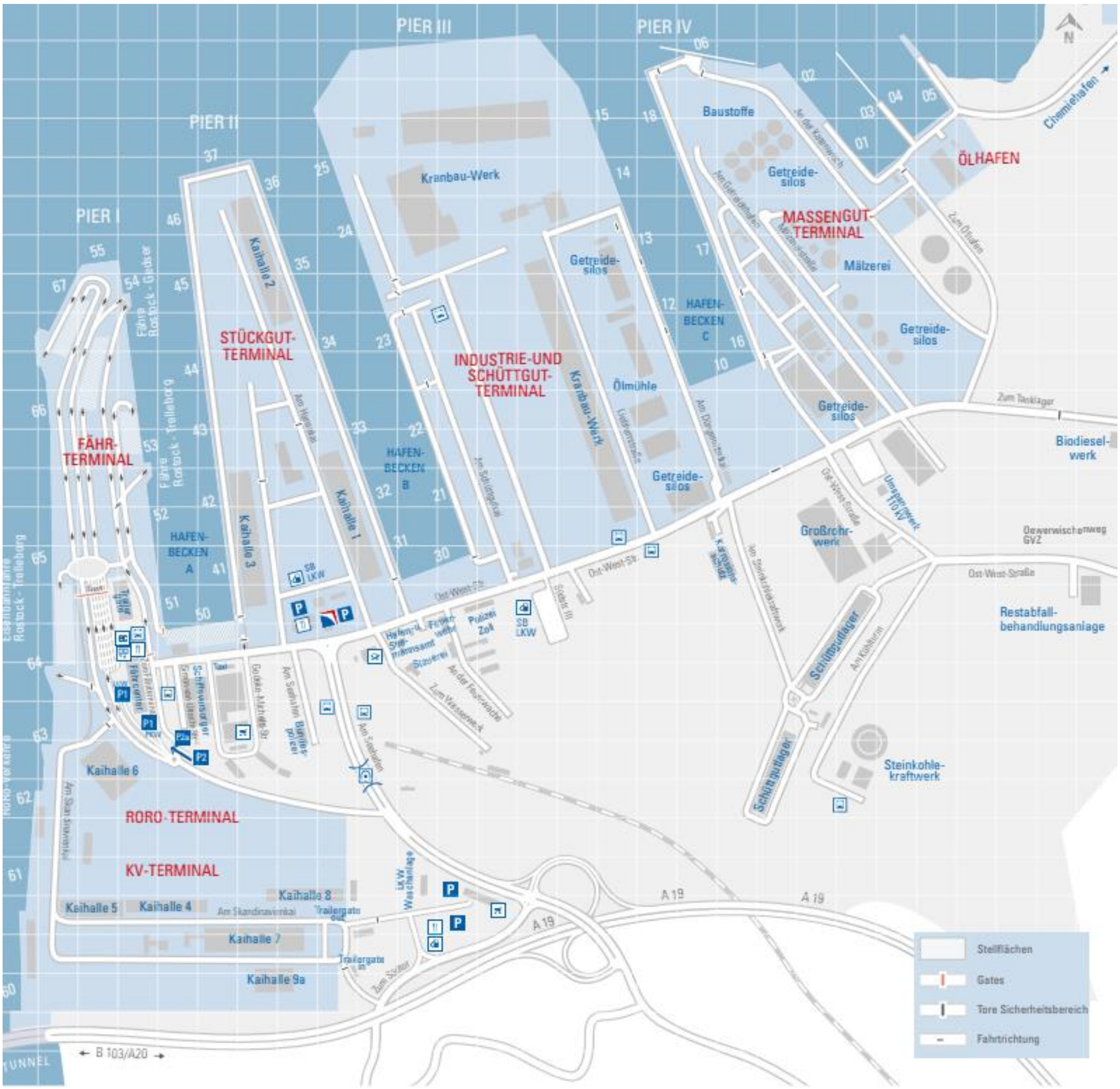

Figure 5: Port map of Rostock overseas port 2021 (Überseehafen Rostock auf einen Blick 2021: Rostock Port GmbH (2021); Faltbooklet_A-Z_DE-210415-LowRes.pdf (rostock-port.de))

The drainage in the port of Rostock takes place in a separate sewer system, which means that there are separate sewers for wastewater and rainwater. Since this is also expected for other port and maritime industrial areas, this study only deals with the treatment of rainwater in the separate sewer system.

The accumulating rainwater is discharged into the Unterwarnow River or the Breitling River via a large number of existing outfalls. Existing treatment plants are mainly coalescence separators and sedimentation basins.

For those areas where water-polluting substances are handled or where there is an increased risk of damage, the tenants of the areas are responsible for a treatment concept. In this study, this will only be discussed marginally.

3.2.2. Warnow

The rainwater from the areas of the Rostock seaport is discharged exclusively into the Warnow, more precisely into the Unterwarnow or Breitling. The Warnow is a 155-kilometer-long river in Mecklenburg-Vorpommern, which drains a catchment area of 3324 km^2 when it flows into the Baltic Sea in Rostock-Warnemünde. According to Article 3 Paragraph 1 Clause 2 of the WFD, the Warnow belongs to the Warnow / Peene river basin district (RBD).

At the Mühlendamm weir in Rostock, the Warnow flows into the Unterwarnow; the typical character of a flowing watercourse is no longer present in the Unterwarnow and Breitling area. Here, the characteristics of a coastal water body with rapidly changing water levels and currents determine the further outflow of the Warnow water into the Baltic Sea. As part of the inventory according to the EU WFD in 2004, the Unterwarnow water body was assigned to WFD type B2, mesohaline inner coastal waters. In the 2013 update, the Unterwarnow was designated as a heavily modified water body (HMWB). The main reason for this was very high material pollution as well as pollution from ports, shipyards, shipping and contaminated sediments. The assessments carried out during the inventories for the 1st and 2nd management periods of the EU WFD (2009 to 2015 and 2015 to 2021) came to the conclusion that the Unterwarnow water body only achieved the insufficient potential.

For the Unterwarnow water body, a less stringent management objective was set in accordance with Section 44 in conjunction with Section 30 WHG (coastal waters), as it is not possible or disproportionately expensive to achieve the good potential.

Both the good ecological potential and the good chemical status were not achieved. The reason for not achieving the good chemical status is an exceedance of tributyltin cations (BT) both in the annual average and in the maximum permissible concentration.

The reason for the non-achievement of the goals are human activities in the form of historical material inputs from shipping traffic, sewage and agriculture as well as hydromorphological changes to the harbor basin and the shoreline structure. Thus, there is a lack of near-natural structures as a habitat for macrophytes, fish and macrozoobenthos, and reintroduction is also prevented due to historical and current substance pollution. The reason for the increased TBT content in the sediment is the use of organotin in antifouling paints on ships over many years.

Since the objectives cannot be achieved with short-term measures or measures can only be implemented with a disproportionately high level of effort, the moderate ecological potential and the good chemical status were defined as new management objectives. The management objective of good chemical status is linked to the expectation that the ban by the International Maritime Organization in 2008 on the use of TBT-containing ship paints, as well as biodegradation, will lead to a permanent undercutting of the limit and orientation values.

3.3. Special features of port and maritime industrial areas

Port and maritime commercial areas are of existential importance because they are centers for trade, industry and business, they are logistical service centers and are at the center of traffic flows. Thus, comparatively small areas experience a very high level of stress. The many different land uses (see 3.4) contribute to the fact that the port and maritime areas are not only subject to heavy use but also to a variety of stresses and that the rainwater is polluted in many different ways. In many ports or in the maritime commercial areas, water-endangering substances such as heavy metals, chemicals, microplastics or light liquids such as oil or gasoline are often handled, which means that additional caution is required when treating rainwater. In addition, there is often a high degree of sealing in these areas. Most of the surfaces are paved and therefore only a small proportion of the rainwater can be retained in the surfaces. The rainwater must therefore be properly and safely drained and treated in accordance with DWA-A 102. The proximity to surface water entails a variety of risks and exacerbates the situation in maritime areas. Thus, risks on the water side, such as floods, as well as risks on the land side, e.g. accidents or heavy rainfall, must be considered in the planning. These criteria contribute to the special features of port and maritime commercial areas and illustrate the need for rainwater treatment of these areas.

3.4. Land use

The following land uses exist mainly in the seaport of Rostock (information provided by the operator) and will be considered in detail in this study:

- Ferry and RoRo traffic (FRV)
- Building material handling / storage (BUL)
- Storage of large pipes (GRL)
- Vehicle loading (KFZ)
- Manufacturing, final assembly and storage of large crane systems (GKA)

In order to carry out a satisfactory classification of the areas in port and maritime commercial areas in the area specifications according to DWA-A 102, the following independent assumptions were made to better distinguish the uses:

- Small-scale division of use into land use categories as far as possible, so that the proportion of land and amount of precipitation requiring treatment is not excessively increased, or so that there is no lump-sum classification into too high pollution categories (according to DWA-A 102, all storage areas are assigned to pollution category III; the overriding land use in the port of Rostock is the handling and storage of materials, so without a small-scale division the majority of land would have to be assigned to pollution category III)
- Due to an increased risk of damages in port and maritime commercial areas, if it is not possible to clearly assign the use to an area group according to DWA-A 102, the use is classified into the worse area group
- Roof areas in the port of Rostock are to be assigned to pollution category I (D) exclusively after consultation with the operator and accordingly need not be considered further (exception: mixing of rainwater from the roof areas with rainwater from contaminated areas)
- No chemical treatment takes place on the ballasted track areas in the port of Rostock. However, no statement could be made about the frequency of use of the tracks. Due to the diverse use with frequent arrival and departure of trains, it can be assumed that all the area specifications of tracks are to be found in the port of Rostock or in port and maritime commercial areas.
- For parking lots and parking spaces, the worksheet uses the imprecise classification of low frequency (e.g. private parking spaces), moderate frequency (e.g. visitor parking spaces at companies and offices), high frequency (e.g. in shopping centers) and parking spaces within mixed-use , commercial and industrial areas where other particular impairments of the rainwater quality are to be expected (e.g. storage areas, access roads to quarries). The types of parking spaces are adapted to port and maritime commercial areas as follows:

  - Employee and visitor parking spaces → Moderate frequency → V2 (pollution category II)
  - Car parking spaces in the ferry area → depending on the frequency, due to the frequent change of vehicle, allocation to the higher exposure category → V2 (pollution category II) or V3 (pollution category III)
  - Truck parking spaces → Special impairments of the rainwater quality to be expected → SV or SVW (pollution category III)
- Adaptation of the area types in courtyard and traffic areas to port and maritime commercial areas as follows:
  - Access roads or roads mainly used by cars are to be classified according to the frequency of use
  - Loading and unloading points for trucks and heavy-duty transports are to be classified in pollution category III (V3 or SV or SVW) due to high pollution from tire wear, fuel and road dirt as well as high frequency (especially frequent arrivals and departures)
  - Remaining courtyard and traffic areas that are not in the immediate vicinity of storage areas and / or on which frequent arrivals and departures of trucks or heavy goods vehicles are not expected can be classified in pollution category II (V2), unless materials / substances hazardous to water are handled.
- All storage areas are to be assigned to pollution category III. Accordingly, clear boundaries should be drawn in the catchment areas to non-storage areas or areas on which the materials are not or only slightly handled, so that these areas can be divided into other area groups (predominantly V2 and V3)
- Canopies are considered to be extremely useful in port and maritime commercial areas, as they can often be used to reduce storage areas from pollution category III to category I.
- If runoff from areas with primarily dissolved material pollution is introduced into the system under consideration after substance-specific pretreatment, the remaining AFS63 pollution must be assessed according to category I in order to avoid computational dilution effects in the balancing of the material discharge.

In the following sub-chapters, some land uses in the Rostock port with regard to the DWA-A 102 and other regulations will be discussed in more detail.

3.4.1. Ferry and RoRo traffic

Areas that are used for ferry and RoRo traffic are mainly traffic areas, parking lots and parking spaces as well as railway tracks. Usually there are no storage areas here and loading and unloading of trucks does not take place here either.

Track systems are assigned to the appropriate area group and load category depending on their superstructure (ballast or slab track) and their frequency of use (gross register tons per day and track). Nothing further is known about the traffic in the Rostock seaport, but it can be assumed here that there are track sections that are used frequently throughout the year, i.e. are heavily frequented, as well as sections that are usually used very rarely. It can therefore be assumed here that all area specifications for tracks can be found in the Rostock port or in port and maritime commercial areas.

A differentiation of the areas in traffic areas and parking spaces is not completely possible in the ferry and RoRo area, at least in the area for cars. Pure access roads are to be classified according to their frequency of use, but due to their location in commercial and industrial areas, at least exposure category II. Parking spaces that are used exclusively for cars are also to be classified according to their frequency of use, but due to the high number of vehicles, exposure category III should be selected here .

Traffic areas and parking spaces, on which mainly trucks and heavy goods vehicles are transported, are generally assigned to exposure category III. The main reason for this is that a particular impairment of the rainwater quality is to be expected, e.g. due to tire wear or soiling of the vehicles. The escape of fuel or oil cannot always be completely ruled out.

Traffic areas on which cars and trucks are expected to drive on and off frequently, e.g. in the access area for ships, are also assigned to load category III due to the high degree of tire wear.

In the ferry area can also be paths that are only used for cyclists and pedestrians. If other traffic areas are encapsulated, these are assigned to exposure category I (VW1) and therefore do not require treatment. The same applies to roof areas, as described above.

3.4.2. Storage and transshipment of bulk goods, minerals and organic substances

The storage and transshipment of various goods in the Rostock port or in port and maritime industrial areas are summarized under this point. Significant bulk goods are e.g. coal, building materials (chips), fertilizers, paper and grain. Mineral and organic materials are also stored and handled. When it comes to storage, a distinction must be made between covered and open storage. As explained in the previous chapters, roof areas (depending on the materials used) often do not require treatment. Thus, the rainwater to be treated can be greatly reduced with canopies.

Material-related rainwater treatment, e.g. for storing coal or storing building materials, will not be discussed here. The specifications of the relevant authority are decisive for this. Frequently, solid and light material separations are already planned for storage and transshipment areas, possibly linked to further treatment and control points. (cf. Bavarian State Office for the Environment) According to DWA-A 102, the following applies to areas with a primarily dissolved load after substance-specific pretreatment: In order to avoid calculated dilution effects in the balancing of the substance removal, the remaining load AFS63 is to be rated as Category I. Here, however, it must be ensured that if this water is mixed with the rainwater from other areas after that, the rainwater supplied is also assigned to Category I or has already been treated, or if this is not the case, the entire rainwater must be treated again.

Discharge is not permitted when reloading of substances hazardous to water. It is possible here to convert the drainage during handling to a drainage-free retention facility in accordance with AwSV and then dispose of the leaked and collected substances. Discharge, depending on the bulk material and regardless of the treatment, should not be permitted even if the transshipment points are not cleaned sufficiently or adequately. (cf. Bavarian State Office for the Environment)

If no substance-specific rainwater treatment is provided by the authorities for the handling and storage areas, these are, however, according to DWA-A 102 of the area group SV / SVW, i.e. courtyard and traffic areas within mixed, commercial and industrial areas on which other special impairments of the Precipitation water quality is to be expected or assigned to load category III. Accordingly, clear boundaries should be drawn in the catchment areas to non-storage areas or to areas where the materials are not or only slightly handled, so that these areas can be divided into other area groups (mainly V2 and V3).

Streets and parking lots are to be classified according to traffic. Load category II is to be expected for pure employee parking spaces. Excluded from the classification based on traffic are roads and areas on which trucks drive on and off frequently. (e.g. waiting area in front of transshipment) These areas are assigned to exposure category III.

3.4.3. Automobiles (new vehicles)

In the case of parking spaces for new motor vehicles, a lower pollution of the rainwater can be assumed compared to parking spaces for used cars or parking spaces in the ferry area. If the areas are cleaned regularly, parking spaces for new motor vehicles can be assigned to load category II. However, the arrival and departure points of the transport vehicles/trucks are assigned to load category III.

3.4.4. Steel prodeucts (metals)

A significant use of space in the port of Rostock is the storage, final assembly and handling of steel products such as large pipes and crane systems. Storage takes place both on covered and open areas. Rainwater from roofed areas does not usually require treatment here either.

As already mentioned in chapter 3.3.2. described above, storage and handling areas in commercial and industrial areas are generally assigned to exposure category III. An exception to this is rainwater, which has already been cleaned by a substance-specific treatment plant. This can be assigned to load category I after cleaning.

On areas for the final assembly of large pipes and crane systems, an increased accumulation of metal scrap and the smallest metal particles (e.g. chips) from drilling or sawing processes is to be expected. The respective products must be collected, stored and disposed of accordingly in order to prevent discharge into the water body via rainwater. Surfaces for final assembly should be cleaned regularly in this regard. According to DWA-A 102, areas for final assembly are to be classified as areas on which other impairments of rainwater quality are to be expected, and accordingly in exposure category III.

Furthermore, metal parts are preserved and derusted on these surfaces. Preservation generally leads to substances becoming more resistant to physical, chemical or biological degradation. In the case of steel products or metals, the treatment is intended to prevent corrosion. The surface of the material must first be prepared for the preservation, usually it is blasted with blasting gravel. In this way, processing aids are completely removed. The material is then spray coated. Lacquers, oils or grease are used as coatings. Steel or metals can be derusted using various methods. These are e.g. the mechanical treatment of the material, e.g. blasting with grit or treatment with steel brushes, treatment with rust removers, e.g. hydrochloric acid, or treatment with rust converters. The material is often first treated mechanically and then with rust removers or rust converters. Both during the preservation and derusting of steel products or metals, waste products can be released or substances are used whose entry into water bodies must be prevented. Mixing with rainwater should therefore be prevented as far as possible (e.g. roofing). If this is not possible, the accumulating rainwater must not be discharged into the rainwater sewage system, but must be treated separately as waste water.

Iron is classified as a non-water-polluting substance. No limit value for iron was specified in the Surface Water Ordinance, but there is an orientation value here. This is 1.8 milligrams per liter. Accordingly, in areas where iron products such as steel are handled, attention must be paid to the amount of input or the concentration in the water body. If the values are higher, additional measures to retain the metal are necessary.

Streets and parking lots are to be classified according to traffic. Load category II is to be expected for pure employee parking spaces. Excluded from the classification based on traffic are roads and areas on which trucks drive on and off frequently. (e.g. waiting area in front of transshipment) These areas are assigned to exposure category III.

3.4.5. Overview of land uses

The table below lists those area specifications according to Table A.1 DWA-A 102 "Assignment of load categories for rainwater from built-up or paved areas according to area type and area use" that are used in the Rostock port. The area specifications are assigned to the superordinate area uses in the Rostock port where they are found with high probability.

AREA SPECIFICATION (ABBREVIATION)	Pollution category (BK)	Use of the Rostock port
D	BK I	FRV, BUL, GRL, KFZ, GKA
GLEISANLAGEN (BG1, BG2, BG3, SG)	BK I bis BK III	FRV, BUL, GRL, KFZ, GKA
VW1	BK I	FRV, BUL, GRL, KFZ, GKA
V2	BK II	FRV, BUL, GRL, KFZ, GKA
V3	BK III	FRV, BUL, GRL, KFZ, GKA
SV/ SVW	BK III	FRV, BUL, GRL, KFZ, GKA

In principle, all listed area specifications according to DWA-A 102 can and do apply to all area uses in the Rostock port. Accordingly, the consideration is made below after the area specification.

3.5. Area evaluation using examples in the seaport of Rostock

In order to clarify the assignment of areas in port and maritime industrial areas to the area specifications and load classes according to DWA-A 102, which was dealt with in the previous chapters, this is to be carried out here using 2 examples from the Rostock port. At this point, the area-related survey and evaluation as well as the determination of the required substance retention should be discussed. Treatment options will be determined later. (see chapter 5.1)

3.5.1. Pier 1 – Ferry Terminal

Pier 1 of Rostock seaport is used exclusively for ferry and RoRo traffic. (See Chapter 3.3.1) The catchment areas of the discharge points of the pier and those areas that are treated by a coalescence separator are known from previous projects. Rainwater from areas that are treated by a coalescence separator can be assigned to pollution category I. The total area of Pier 1 considered here is approximately 21 ha. The area cleaned by coalescence separators is approximately 2.7 ha.

Statistical evaluations of the traffic volume from 2016 resulted in an average traffic volume (DTV) of approx. 1800. Accordingly, area group V2 or pollution category II can be assumed for the traffic areas that are used by trucks and cars together or exclusively by cars. Parking spaces for cars are also assigned to pollution category II in this example.

Pollution category III is assumed for the following areas:

- Traffic areas and parking lots for trucks
- Approach area for ships

To a lesser extent, there are roof areas and areas for cyclists and pedestrians. (pollution category I)

The proportions of the exposure categories are estimated for the calculation.

- Areas with coalescence seperator (BK I): 13 %
- Other areas in pollution category I: 7 %
- Areas of pollution category II: 30 %
- Areas of pollution category III: 50 %

The following scenarios are to be examined below:

1. Consideration of the entire Pier 1 with the shares assumed above (joint treatment of all areas)
2. Consideration of the entire Pier 1 with the shares assumed above, separate discharge of rainwater from areas of pollution category I
3. Consideration of a single discharge point (both with and without separate discharge of rainwater from areas of pollution category I)

3.5.1.1. Scenario 1

Appendix 2 table 1 lists the area-related survey and evaluation of all areas of Pier 1.

The sum of the resulting material loss from all areas is 12495 kg/a. The area-specific material removal is thus 595 kg/(ha*a). On the other hand, there is the permissible area-specific material discharge of 280 kg/(ha*a). In order to achieve this, rainwater must be treated with an efficiency of 52.9%.

3.5.1.2. Scenario 2

Appendix 2 table 2 lists the area-related survey and evaluation of all areas of Pier 1 with a separate discharge, i.e. without considering the precipitation water from areas in pollution category I (areas with coalescence separators, footpaths and cycle paths).

The sum of the resulting material removal from the areas is 11319 kg/a. The area-specific material removal is thus 673.75 kg/(ha*a). On the other hand, there is the permissible area-specific material discharge of 280 kg/(ha*a). In order to achieve this, rainwater must be treated with an efficiency of 58.4%.

3.5.1.3. Scenario 3

In the two previous sections, the entire area of Pier 1 was considered. However, since not all areas are fed into the Breitling via a single discharge point, but via a large number of discharge points, each discharge point must be considered individually to determine the required fabric retention. The discharge point 111AUS01 considered here has a catchment area of 5.13 ha. 1.65 ha of that area are already being treated using a coalescence separator.

For this discharge point, the calculation should be carried out with and without a separate discharge of the rainwater from the areas in pollution category 1. It is also possible to treat only the areas of pollution category 1 or 2.

Since the proportion of areas with coalescence separators for these discharge points is higher than for the entire pier (here approx. 34%), the proportions for the other land uses were adjusted.

In Appendix 2, Table 3, the area-related survey and evaluation of all areas of the discharge point 111AUS01 of Pier 1 is listed.

Without a separate discharge of the rainwater from the areas in pollution category 1, the resulting material loss totals 2696.4 kg/a. The area-specific material removal is accordingly 525.61 kg/(ha*a), so that treatment with an efficiency of 46.7% is required for discharge into the water body.

Annex 2, Table 4 lists the area-related survey and evaluation of all areas of the discharge point 111AUS01 Pier 1 with separate discharge, i.e. without considering the precipitation water from areas of pollution category I (areas with coalescence separators, footpaths and cycle paths).

With separate discharge of the rainwater from the areas in pollution category 1, as in scenario 2, there is an area-specific material removal of 673.75 kg/(ha*a) and a required efficiency of 58.4%.

If the rainwater from areas in pollution categories II and III is not mixed, but treated individually, an efficiency of approx. 47% is required for the rainwater from areas in BK II and an efficiency of approx. 63% for areas in BK III .

3.5.2. Pier 3 - Industrial and Bulk Terminal

The second example is Pier 3 in the seaport of Rostock. Compared to Pier 1, Pier 3 is characterized by a variety of different uses. Among other things, there is a coal site, storage and transshipment areas for bulk materials, grain mill (mainly rapeseed), transshipment, storage and processing as well as areas for storage and final assembly of large crane systems. There are also several employee parking spaces and access roads.

The estimated total area of Pier 3 is 66.5 ha. Approximately 22.5%, i.e. 15 ha of the area are covered and are therefore assigned to pollution category 1. Car parking spaces (employees and visitors) have an area of approx. 1.75 ha and are assigned to pollution category 2. All remaining areas correspond to storage or transshipment areas, areas for final assembly or access roads on which there is heavy truck traffic. All of these areas correspond to pollution category 3.

The following scenarios are to be examined below:

1. Consideration of the entire Pier 3 with the assumed proportions (joint treatment of all areas);

2. Consideration of the entire Pier 3 with the assumed proportions, separate discharge of rainwater from areas of pollution category I

3. Consideration of the areas for storage and final assembly of large crane systems and theoretical assumption of the increase in the proportion of roof areas

In the first two scenarios, it is assumed in simplified terms that all surfaces lead together via an introduction into the Breitling. In reality, as Pier 1, there are a large number of discharge points but nothing else is known. In reality, it can also be assumed in the third scenario that the areas do not discharge together via just one discharge point, but this is assumed here because of simplification and illustration.

3.5.2.1. Scenario 1

Appendix 2 table 5 lists the area-related survey and evaluation of all areas of Pier 3.

The sum of the resulting material removal from the areas is 42937.5 kg/a. The area-specific material removal is thus 645.68 kg/(ha*a). On the other hand, there is the permissible area-specific material discharge of 280 kg/(ha*a). In order to achieve this, rainwater must be treated with an efficiency of 56.6%.

3.5.2.2. Scenario 2

Table 6 in annex 2 lists the area-related survey and evaluation of all areas of Pier 3 with a separate discharge, i.e. without considering the rainwater from areas in pollution category I (roof areas).

With separate discharge of the rainwater from the areas in pollution category 1, there is an area-specific material removal of 752.18 kg/(ha*a) and a required efficiency of 62.8%, as in the scenario.

If the rainwater from areas in pollution categories II and III is not mixed, but treated individually, an efficiency of approx. 47% is required for the rainwater from areas in BK II and an efficiency of approx. 63% for areas in BK III .

3.5.2.3. Scenario 3

In the third scenario for Pier 3 of Rostock port, areas used for the storage and final assembly of large crane systems are to be examined more closely. In order to clarify the influence of roof areas in port and maritime commercial areas on the treatment of rainwater, the calculation for the assumption that the proportion of roof areas, e.g. due to the construction of a large warehouse, is increased, in addition to the calculation of the required material retention for the total area is shown.

The total area used for the storage and final assembly of large crane systems is approx. 30.5 ha. Of this, approx. 5.5 ha are currently covered (BK I) and approx. 0.5 ha are a parking lot (BK II). The remaining areas are assigned to pollution category III. The second calculation increases the covered area from 5.5 ha to 10 ha.

Appendix 2, Table 7 lists the area-related survey and evaluation of all areas of Pier 3 that are used for the storage and final assembly of large crane systems.

The area-specific removal of material here is 669.67 kg/(ha*a) and the required efficiency of the treatment is 58.2%. If the roof areas were discharged separately, area-specific material removal would be 755.4 kg/(ha*a) and the required efficiency 62.9%.

Appendix 2 Table 8 lists the area-related survey and evaluation of all areas of Pier 3 that are used for the storage and final assembly of large crane systems, with an increase in the area of the roof areas from 5.5 ha to 10 ha.

If the proportion of covered areas is increased, the area-specific material removal is 598.85 kg/(ha*a) and the required efficiency is 53.2%. If the rainwater from the roof areas were discharged separately, the area-specific material removal would be 754.4 kg/(ha*a) and the required efficiency 62.9%.

As already explained at the beginning under 3.4, treatment options for the aforementioned scenarios are determined in Chapter 5.1.

4. Treatment systems

4.1. Basic information

As described in Chapter 2.4, for areas of pollution categories II and III as well as for mixed areas, the runoff must be treated before discharge into the water, so that the substance input from rainwater is limited. A basic distinction is made between decentralized and centralized treatment systems for substance retention. The primary mechanisms of action here are sedimentation and filtration.

Sedimentation refers to the deposition or settling of particles under the influence of gravity and other forces. Sedimentation plants thus have a storage volume that contributes to the retention of substances when the stored volume is fed to further cleaning after the end of the event. Like sedimentation, filtration is also a mechanical separation process. To separate the substances, filtration uses a filter, whose filter material provides resistance to the particles of the mixture to be separated. Filters or filter materials in the context of rainwater treatment can either be topsoil (activated soil zone) during infiltration or technical substrates in road gullies or structures. In systems for filtration, in addition to the physical filtering effect, further cleaning processes such as sorption (organic and inorganic pollutants), ion exchange (e.g. heavy metal ions) or biochemical material turnover (e.g. mineralization of carbon compounds) occur, whereby additional material retention can be achieved.

Sedimentation systems according to DWA-A 102 are to be operated without permanent congestion. Accordingly, systems are to be emptied and cleaned at short, rainfall event-dependant intervals, to a wastewater treatment plant. This requires the rainwater treatment system to be connected to a wastewater system using technical equipment (e.g. pump).

In the following sub-chapters, the various types of centralized and decentralized treatment systems are presented and example systems from some manufacturers are shown. It should be noted here that in the case of manufacturer systems, it is often not possible to explicitly differentiate between centralized and decentralized systems. Some of the systems are available in different sizes with different degrees of efficiency and connectable areas, so that they can be used both for individual areas as a decentralized treatment system, but also in large versions for large catchment areas as a central treatment system.

4.2. Decentralized treatment

Decentralized treatment systems are located directly on the areas (e.g. individual properties or street sections) where the rainwater is to be treated. The runoff from these systems can either be fed into the groundwater via a downstream infiltration system or discharged into a surface water body. Thus, decentralized rainwater treatment measures appear to be particularly effective with regard to the overriding objective of urban drainage, to preserve the local water balance as much as possible.

In addition to the distinction according to their mechanisms of action, sedimentation or filtration, decentralized systems can be divided into systems with a soil passage and into commercially or industrially manufactured systems.

Systems with soil passages, including systems with soil passages as part of the treatment system, which can be individually planned and built, generally have a very high cleaning performance if the soil passage meets the requirements for swale infiltration or a retention soil filter basin. The requirements for trough infiltration are contained and regulated in worksheet DWA-A 138 and the requirements for retention soil filter systems in worksheet DWA-A 178. The filtration mechanism of action in soil passage starts from the active soil zone, i.e. the topsoil horizon that is alive with microorganisms and small animals. Treatment by soil-passage-systems is usually accompanied by infiltration and discharge of rainwater into the groundwater, and in the case of swale infiltration by a relatively large space requirement compared to technical systems due to the required storage volume in the swale. In heavily built-up and sealed areas, as is the case with port and maritime industrial areas, it is difficult to treat rainwater using systems with soil passages in existing areas. In the case of new planning and construction of such areas, early consideration and designation of areas for infiltration, in the form of surface or swale infiltration, can effectively treat rainwater as well as contribute to the local water balance through discharge into the groundwater. A space-saving alternative for infiltration can be the use of pipe trenches or infiltration trenches.

Systems that are commercially or industrially manufactured can be roughly divided into systems that supplement or replace a street gully and systems that combine several street gullies. There are a large number of different types and styles of systems on the market, differentiated according to the mechanisms of action and the combination of the two basic mechanisms of action. In principle, a distinction must also be made here between measures in existing buildings and those for new buildings. In the case of a new construction, the options are largely open if rainwater treatment is included in the planning at an early stage and the necessary space is made available. In existing buildings, on the other hand, the local boundary conditions are decisive, here it is often advisable to retrofit the road gullies, as this can eliminate the need for construction measures.

According to DWA-A 102, the following applies to commercially or industrially manufactured systems:

"For systems with building authority approval, the cleaning performance determined in the approval procedure for specified areas of application can generally be taken as the effectiveness of the substance retention. For plants with approval according to DIBt (2015), it can be assumed that the effectiveness of the substance retention with regard to AFS63 is sufficient to limit the resulting substance discharge to the mathematically permissible value, even for connected areas in pollution category III. The specifications made in the approval procedure for layout, area allocation and operation, in particular or limiting the connected areas, must be observed in the specific application. If, in the case of systems without building authority approval, the cleaning performance has been determined within the framework of a test or test comparable to DIBt (2015) by a test centre approved by the responsible water authority, this value can be used in the same way to assess their effectiveness. In addition, system-related specifications for arrangement, area allocation and operation are to be defined by the test centre or the water authority in individual cases. "

The following figure shows a typical existing situation with a decentralized treatment of rainwater of categories II and III.

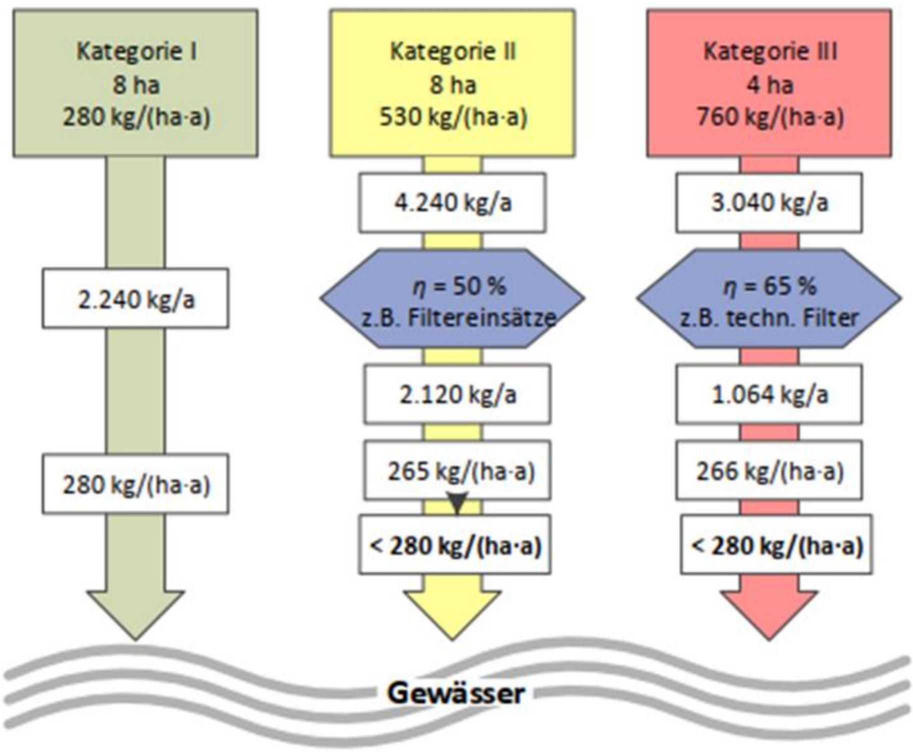

Figure 6: Schematic existing situation with a decentralized treatment of rainwater of categories 2 and 3 (DWA-Regelwerk/BWK-Regelwerk, Arbeits- und Merkblattreihe DWA-A/M 102 (BWK-A/M 3): Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. & Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau e.V. (2020): Grundsätze zur Bewirtschaftung und Behandlung von Regenwetterabflüssen zur Einleitung in Oberflächengewässer, Hennef und Aachen)

4.3. Centralized treatment

In centralized treatment plants, rainwater from larger drainage areas, either of a sub-area or the entire catchment area, is treated, which is fed via rainwater sewers. The Worksheet DWA-A 166 deals with the systematization of central treatment systems in the separation system. The DWA-A 102 distinguishes between the two generic terms for central treatment systems:

- Rainwater clarifier and inclined plate clarifier

- Retention soil filter

Rainwater clarifiers work on the principle of sedimentation and differentiated based on their mode of operation into permanently filled rainwater clarifiers with permanent impoundment and into non- permanently filled rain clarifiers, i.e. without permanent impoundment. The contents of rainwater clarification basins without permanent impoundment must be fed into the wastewater sewer system at the end of the rainfall. According to the DWA-A 102 worksheet, rainwater clarifiers and lamella separators should only be built for operation without permanent impoundment, since plants with permanent congestion run the risk of oxygen depletion and dissolution processes leading to an unfavourable condition of the water body. Density stratification due to increased use of road salt can also occur, which adversely affects the flow and sedimentation conditions in the basin.

Rainwater clarification basins without permanent impoundment are preferably designed as flow-through basins. Structural components are therefore an upstream basin overflow, an inlet and distribution structure, a throttled clarification overflow with a baffle and a drainage device into a wastewater or combined sewer. However, according to DWA-A 102, rainwater clarifiers of conventional design have relatively low sedimentation efficiencies for fine particulate solids (AFS63) or large structures are necessary for adequate retention. One option to increase the sedimentation effect is to install lamellas or tubes as lamella clarifiers.

“Inclined clarifiers are rainwater basins in which the surface effective for sedimentation is increased by up to five times the surface of the basin by means of mechanical equipment with lamellas or tubes in the sedimentation chamber. Thus, they are able to achieve comparable sedimentation efficiencies with a significantly lower volume than conventional rainwater basins, or significantly higher efficiencies with the same volume. With proper structural design, the particles' sedimentation paths are considerably shortened. "

Compared to rainwater clarifiers, inclined clarifiers have a significantly lower construction volume with comparable sedimentation efficiencies with additional technical equipment. Accordingly, the majority of the central treatment systems offered by manufacturers can be assigned as lamella separators and inclined clarifiers.

According to the DWA-A 102 worksheet, retention soil filter systems are particularly effective for treating polluted rainwater. In the separate sewer system, these consist of a preliminary stage for separating sand and gravel and a retention soil filter basin. As a rule, the soil filter basin should consist of an open earth basin designed as close to nature as possible. The planted bottom serves as the filter body. A drainage system is arranged under the filter body, which discharges the purified water in a throttled manner. A throttle in the drain can be used to control the residence time in the soil and thus the cleaning performance of the basin.

The efficiency of the solids retention with respect to AFS63 can be assumed to be 95% for the filtered volume flow in retention soil filter systems according to DWA A-102. An average efficiency of 50% can be assumed for the overflow.

Compared to rainwater clarifiers and inclined clarifiers, which are usually built underground, retention soil filter systems have the disadvantage of taking up space. The implementation of retention floor filters is particularly difficult in existing buildings, so sedimentation systems (rain clarification basins and inclined clarifiers) are ideal here.

In addition to these treatment measures, separation structures and storage systems can and are used to control the feed to the treatment systems.

The graphic shows a typical centralized treatment situation in which all the rainwater from various areas drain together into a rainwater sewer and is treated together. It should be noted in this graphic that the co-treatment of the areas of category I leads to a significantly lower required efficiency of the treatment system (in this case, lamella clarifier), but a larger volume of the treatment system is required in order to keep the untreated overflow low in the event of a rain event.

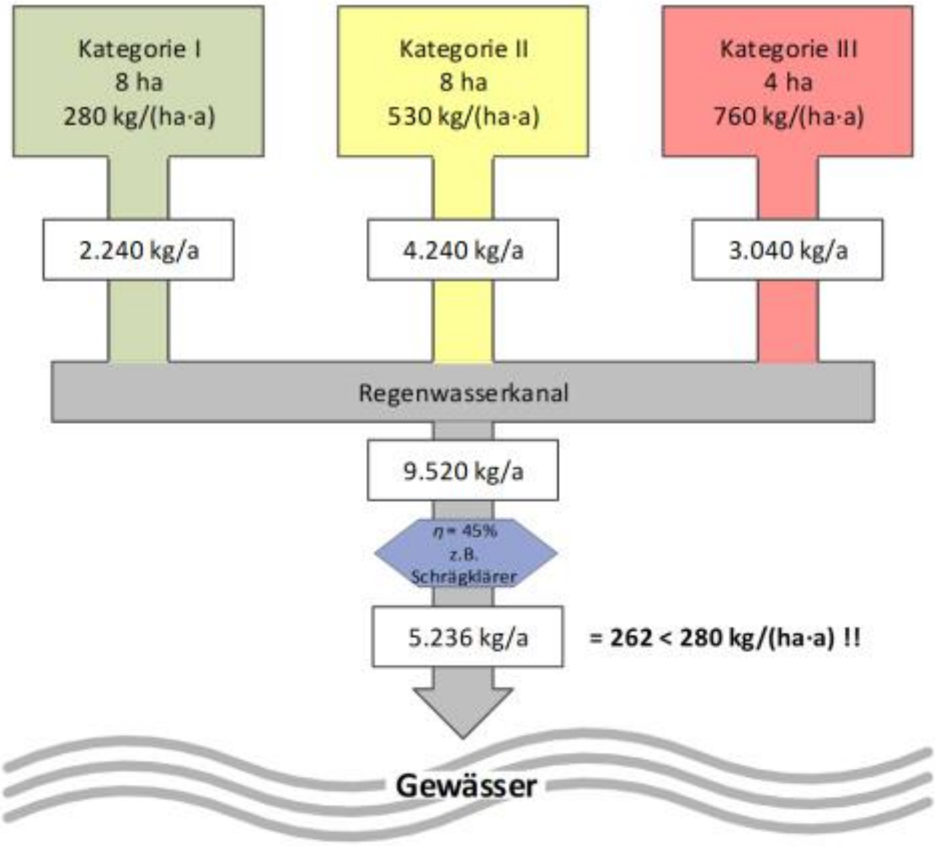

Figure 7: Existing situation with a centralized treatment of rainwater of all categories (DWA-Regelwerk/BWK-Regelwerk, Arbeits- und Merkblattreihe DWA-A/M 102 (BWK-A/M 3): Deutsche Vereinigung für Wasserwirtschaft, Abwasser und Abfall e.V. & Bund der Ingenieure für Wasserwirtschaft, Abfallwirtschaft und Kulturbau e.V. (2020): Grundsätze zur Bewirtschaftung und Behandlung von Regenwetterabflüssen zur Einleitung in Oberflächengewässer, Hennef und Aachen)

4.4. Types of treatment systems

In order to illustrate the various possibilities of rainwater treatment, different types of systems that can be used in port and maritime commercial areas are presented below. As an example, the manufacturer's plants of the described system type are listed and the general functioning of the system type is shown using a manufacturer´s system. At this point it is pointed out that there are a large number of manufacturers with certified systems on the market and only a few of these can be named in the study.

4.4.1. Road gully filter

Road gully filters include the mechanical parts that clean the rainwater directly on site and before it is discharged into the rainwater sewer. Accordingly, road gully filters are assigned to the decentralized treatment systems. The road drain filters are designed in such a way that existing road drains can also be retrofitted. Depending on the type of road drain, a distinction must be made between drain filters for dry drains and drain filters for road drains with wet sludge traps.

The system for dry drains usually consists of an insert, a coarse filter and a filter cartridge filled with a special substrate. The coarse filter is arranged at the top and is passed through first and serves to retain coarse matter in the surface runoff. The coarse material settles on the bottom of the coarse filter and the water passes through openings into the filter cartridge below. The dissolved heavy metals and organic substances carried along in the surface runoff are adsorbed in this. The filter substrate also usually has a very good oil absorbency. After the cleaning in the filter cartridge, the cleaned water flows through the existing drain into the rainwater sewer or into a body of water.

In the case of drain filters for road gullies, the coarse filter is not required due to the existing wet sludge trap to retain coarse matter. However, this requires a built-in part, usually in the form of a distributor cone, which directs the rainwater so that it flows past the insert and collects at the bottom of the road drain. As the water level rises, the rainwater flows through the filter cartridge filled with substrate. As with the system for dry drains, the dissolved heavy metals, oil and organic substances carried along in the water are adsorbed. The water purified in this way can then be discharged into the rainwater sewer through a drain installed at the top. An oil retention cartridge is also available as an option or retrofit kit. If there are still oil particles in the overflow water, they will be bound in the oil binder used.

Depending on the size of the filter cartridge and the design of the system, areas up to 250 m2 can be connected to road gullies with wet sludge traps and up to 400 m2 for road gullies with dry drains.

The efficiencies for road gully filters with dry drainage are approx. 42%, so that they can only be used with mixed areas of pollution categories I and II. In the case of street gully filters for drains with wet sludge traps, the efficiencies are around 52%, so that they can be used for areas of pollution category II.

Depending on the location, i.e. the amount of coarse matter in the rainwater, the coarse filter or the wet sludge trap must be emptied 2 to 6 times a year. The filter substrate should be replaced annually.

The street drain filters from Funke Kunststoffe have established themselves on the market. The functionality of the INNOLET systems, which can be used for road gullies with dry drainage, and INNOLET-G, which can be used for road gullies with wet sludge trap, is shown in Figure 9. Another example is the Combipoint SSA separation road gully from ACO Tiefbau.

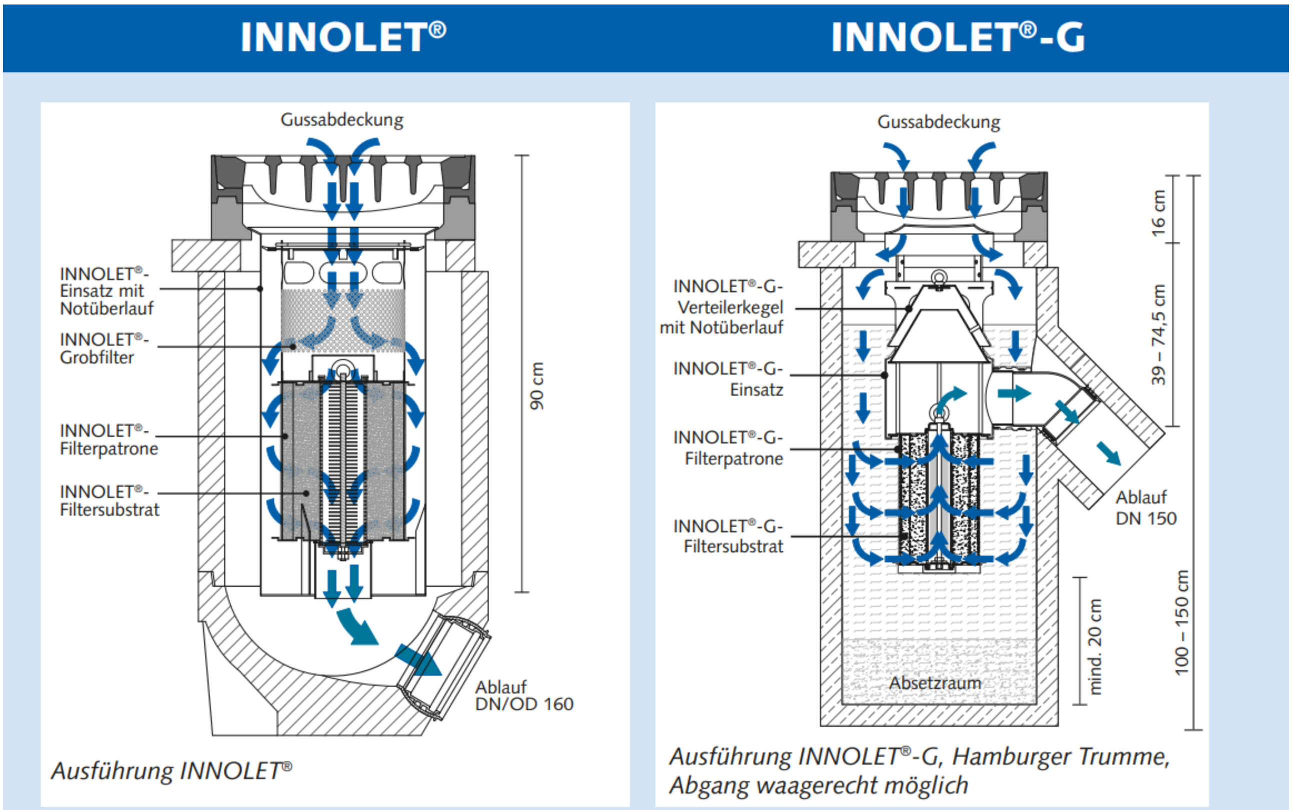

Figure 9: Functionality of the street drain filters INNOLET and INNOLET-G from Funke Kunststoffe GmbH (https://www.funkegruppe.de/fileadmin/pdf/Prospekte_DE/Funke-Kunststoffe-Innolet-Prospekt-04-2021.pdf) (28.09.2021)

4.4.2. Rainwater clarifier

The structure and operation of a rainwater clarifier have already been described in section 4.3. According to the DWA-A 102 worksheet, rainwater clarification tanks should only be built for operation without permanent impoundment.

For economic reasons, rainwater clarification basins are not dimensioned for the maximum inflow from the rainwater sewer system. The difference between the maximum inflow and the permissible load must be temporarily stored in a rainwater retention basin or discharged in a circuit past the facility to the water body. Rainwater clarification basins are dimensioned for a critical rainfall rate of 15 l / (s * ha) as recommended in DWA-A 102. The efficiency of a rain clarification basin compared to the AFS63, must include the proportion of precipitation water that is discharged into the water body via the basin overflow. According to DWA-A 102, this proportion can be assumed to be a flat rate of 10%. The minimum basin depth is 2.0 m.

The area that can be connected is flexible and depends on the required efficiency of the system as well as the selected surface feed or system size. The structural design of the basin is ultimately based on the DWA-A 166.

According to DWA-A 102, however, the sedimentation effect in simple rainwater clarification basins is quite low, that relatively large structures are often required. Instead, inclined or lamella treatment plants (see 4.4.3) are recommended.

4.4.3. Inclined plate clarifier / lamella clarifier

Inclined clarifiers, also called lamella separators or clarifiers, are sedimentation systems or rainwater clarifiers in which the sedimentation chambers are equipped with lamellas or tubes. The lamella or tube elements are arranged parallel to one another and the rainwater flows through them. The effect is that the sediments only have to sink through the small distance between the elements for a few centimetres, instead of the entire depth of the basin, as in the case of the rainwater clarifier. This results in a significantly better separation effect and this mechanical equipment can increase the surface area effective for sedimentation up to 5 times the surface of the basin. The plates or tubes are inclined to allow the sediments to slide down to the bottom of the basin.

According to DWA-A 102, inclined and lamellar clarifiers should also be set up and operated without permanent impoundment. As a result, such systems, which are usually built in monolithic construction and have the outlet in the upper area of the structure, have to be pumped out at the end of the rain event, i.e. when no more rainwater arrives at the system. This usually requires control technology and a pump to discharge the remaining water and sediments deposited on the ground, into the public sewer system.

There are different versions of inclined or lamellar clarifiers on the market. The area that can be connected depends on the size of the structure and the required efficiency for AFS63. The surface loading is usually specified by the system manufacturer. The connectable area can be up to 96,000 m2 for areas of pollution category II and up to 48,000 m2 for areas of pollution category III. Smaller systems, e.g. diameter DN 1000, have a connectable area of up to 3,000 m2. The efficiencies can be up to approx. 70%.

One example is the ViaKan lamellar clarifier from Mall Umweltsysteme or the sedimentation shaft from Funke Kunststoffe. Other sedimentation shafts that can be used are Sedised-C and Sedismart+ from ACO Tiefbau.

Figure 10 shows the ViaKan from Mall Umweltsysteme.

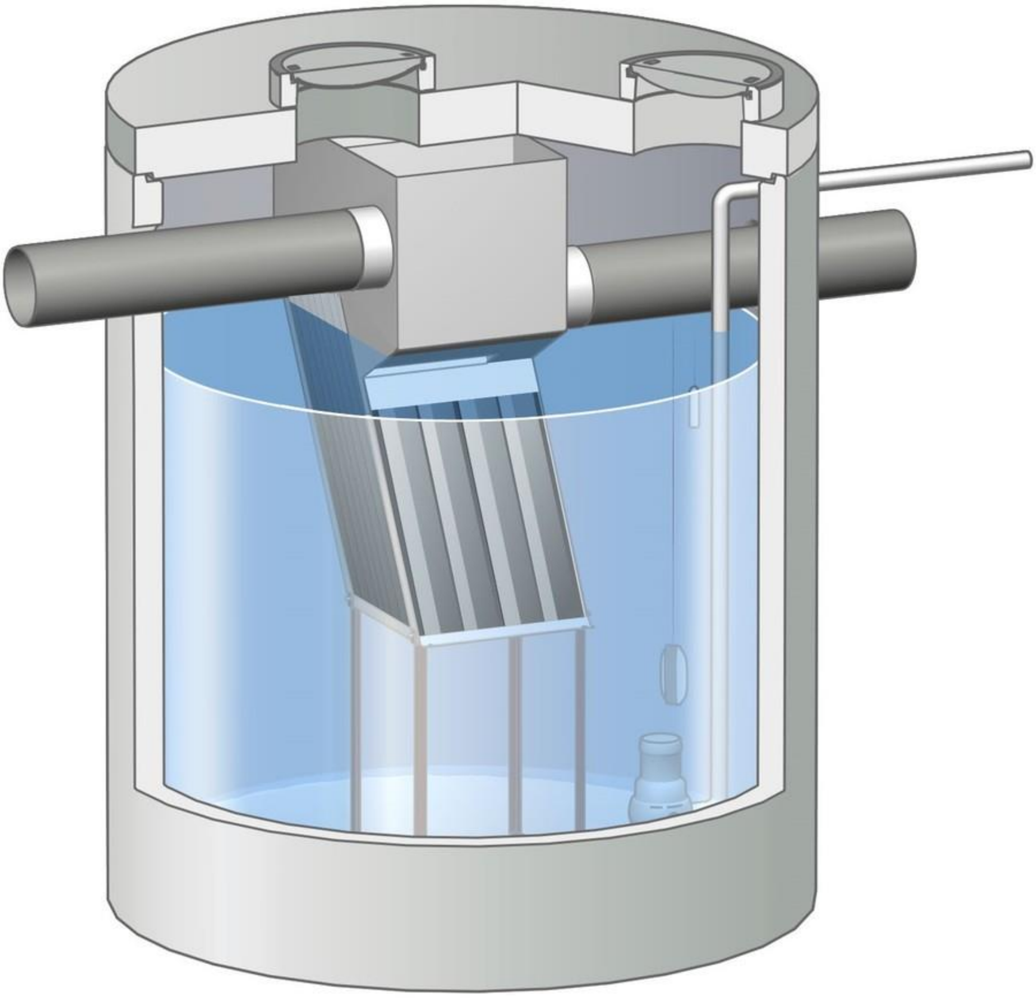

Figure 10: Representation of the Viakan of the company Mall Umweltsysteme (https://www.mall.info/produkte/regenwasserbewirtschaftung/regenwasserbehandlung/viakan-lamellenklaerer) (25.10.2021)

4.4.4. Pipe sedimentation system

Pipe sedimentation systems are not manufactured as a monolithic structure, like most sedimentation systems for rainwater treatment, but as a system in the form of a pipe. These systems can therefore be integrated into rainwater sewers relatively easily.

The sedimentation section is elongated in the form of a pipe between a start and a target shaft. The start shaft of the system is usually designed as a sludge trap, so that coarser contaminants are already deposited at this point. In the target shaft, light liquids are removed by a baffle wall. Pipe sedimentation systems are operated in a permanent state impoundment.

In the lower part of the sedimentation section there is a flow separator, e.g. in the form of a geometrically defined lattice structure, which contributes to a hydraulic separation. This creates a flow-calmed area in the lower cross-section of the pipe, causing the substances to settle through sedimentation. On the one hand, the flow separator prevents the re-discharge of sediment that has already settled (deposit protection) and on the other hand, it enables rapid sedimentation. This elongated and thin sedimentation space offers very short descent paths, flow straightening and prevents turbulence. Due to the counter-slope of the structure caused by its design, the settled sediment slides to the start shaft, from where it has to be pumped out at regular intervals.

The maintenance interval depends on the type of system and the connected area. The lesser the area is connected, the less often the system has to be serviced. The maintenance interval is between 1 and 4 years.

The total length of the sedimentation section depends on the type of system and can be up to 24 m. It is also possible to connect several pipe sedimentation systems in parallel to increase the connectable area. The connectable area of a single pipe sedimentation system can be up to 44,450 m2.

Pipe sedimentation systems from manufacturers are e.g. the SediPipe series from Fränkische Rohrwerke or the pipe sedimentation system from ACO Tiefbau.

Figure 11 shows the SediPipe L system from Fränkische Rohrwerke. The starting shaft is shown on the left, the sedimentation section with flow separator in the middle and the target shaft on the right.

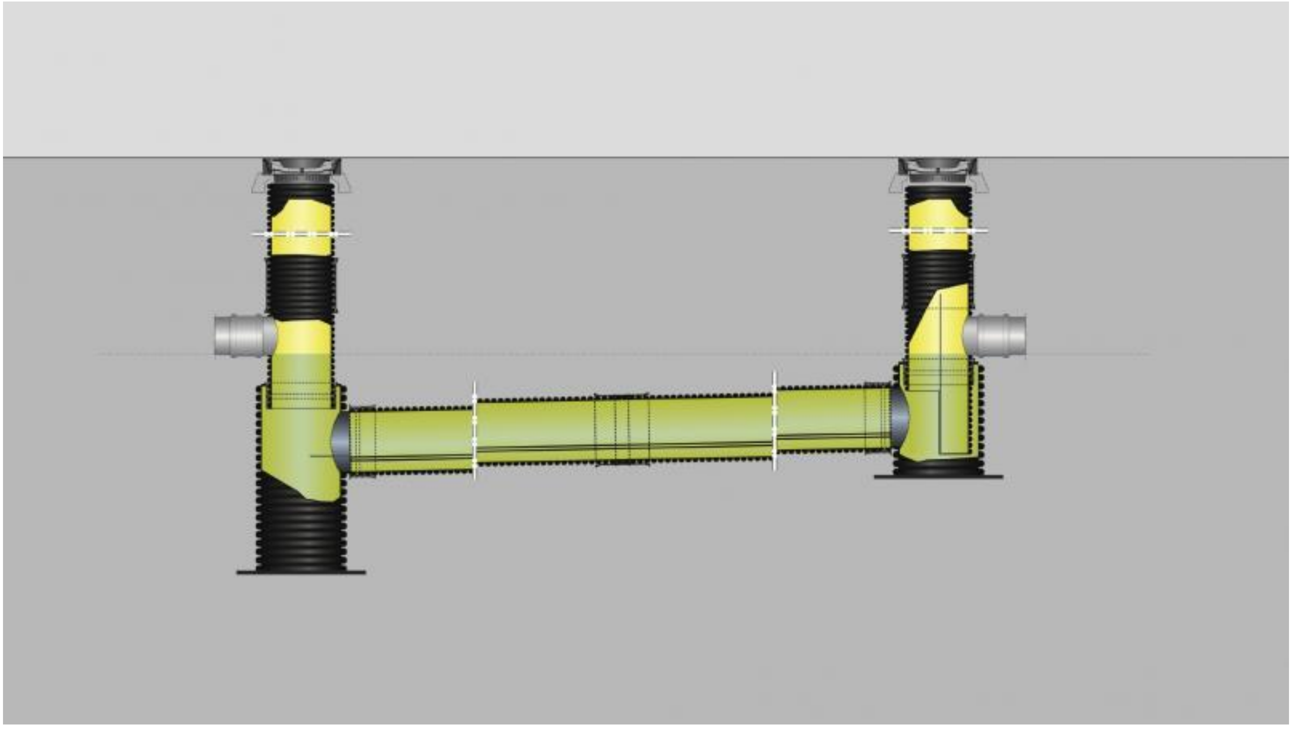

Figure 11:Representation of the SediPipe L of the company Fränkische Rohrwerke (https://www.fraenkische.com/de-DE/product/sedipipe-l) (25.10.2021)

4.4.5. Retention soil filter

Retention soil filters differ from the previously mentioned in that the retention soil filters cannot be built underground and the primary mechanism of action is filtration. Retention floor filters are vertical flow filter systems that are sealed against the subsoil. The retention space is located above the filter. The inflow is stored there, flows slowly through the filter layer vertically and is fed to an outlet structure through a drainage system. A throttle system at the outlet limits the discharge of the system and thus controls the residence time in the soil and thus the cleaning performance of the system.

The chemical-physical and biological cleaning processes take place on and in the filter layer. The primary process is filtration, which results in almost complete retention of coarse and fine particulate matter and the substances bound to them. Other processes that take place are sorption and conversion.

As a rule, retention soil filters consist of open earth basins that are designed as natural as possible, with the filter surface planted with reeds, for example. In order to avoid premature colmation of the retention soil filter, a rainwater clarification basin must be installed upstream of it as a preliminary stage. The preliminary stage is used to separate sand and gravel. The preliminary stage and the retention soil filter together are called retention soil filter systems.

The pollutant concentration in the outflow water depends on the filter material, its particle size distribution, the thickness of the structure, the hydraulic load on the filter and the nature of the inflow. The systems can retain AFS almost completely in the partial flow. According to DWA-A 102, the effectiveness of the solids retention with respect to AFS63 for the filtered volume flow can be assumed to be 95%. For the overflow of the filter basin, an average efficiency of 50% can be assumed for the sedimentation effect with respect to AFS63 due to the generally low surface loading.

The design and verification of retention soil filter systems are carried out in Germany in accordance with DWA-A 178. Figure 12 shows a schematic cross-section through a retention soil filter basin.

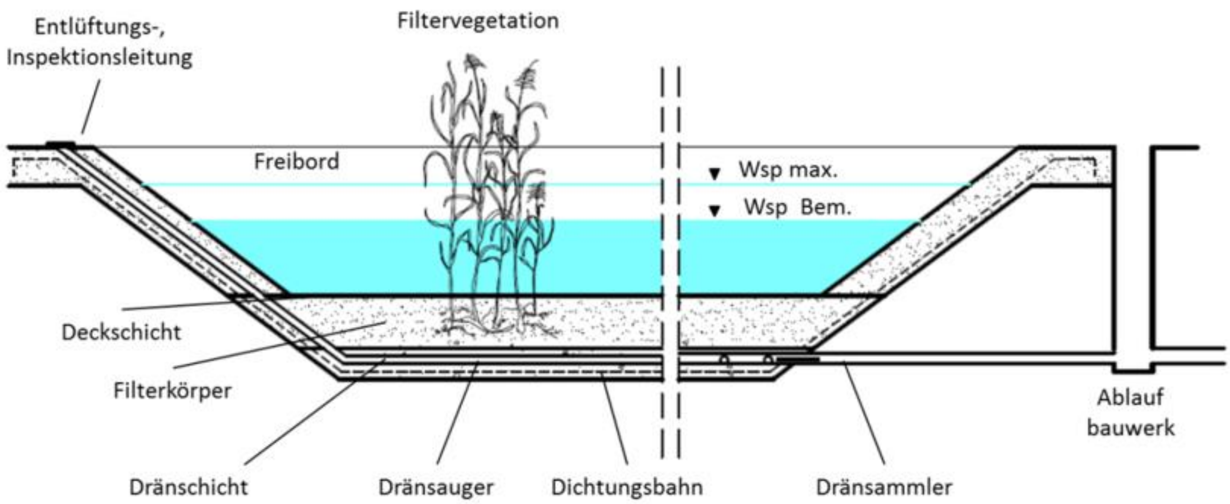

Figure 12: Schematic cross-section through a retention floor filter basin (DWA-A 178 Retentionsbodenfilteranlagen)

4.4.6. Summary of treatment systems

Chapter 4.4 shows that there is a wide range of different systems and types of systems. In general, the exact explanation and specification of the systems and the distinction between manufacturers' systems was dispensed with, in order to only provide an overview of the system types and their possible applications. The systems differ from one another in that they have different operating mechanisms with different efficiencies, different connectable areas, and different system sizes.

The manufacturers also offer combinations of system types and mechanisms of action, which will be discussed in more detail in Chapter 4.5.2. The advantage here is the increased retention of pollutants, with the disadvantage of a smaller connectable area.

Regular maintenance intervals are necessary for rainwater treatment systems so that their functionality with regard to the purification of rainwater can be guaranteed. In addition to the maintenance intervals prescribed by the manufacturers, regular checks and maintenance after (heavy) rain events are also considered useful. For port and maritime commercial areas, a person responsible for such inspections must be specified, since, as already described in Chapter 3.3, the number of residents in such areas is usually high and the responsibilities are often not clearly defined.

4.5. Possibilities for the retention of pollutants

According to Article 16 EU WFD and the Surface Waters Ordinance, concentrations (environmental quality standards) are specified which certain substances (priority and priority hazardous substances) must not exceed in the water. These substances are pollutants or groups of pollutants that pose a significant risk to the environment. These substances are to be gradually reduced in water, and the introduction, emission and loss of priority hazardous substances is to be ended.

According to the EU WFD, measures are to be specified in the management plans of the river basin districts that lead to a reduction in pollution. According to the management plan of the FGE Warnow / Peene (Dec. 2015), measures directly related to the source or at least close to the source are necessary to improve the pollutant situation. So far, the following relevant plans have been made for port and maritime commercial areas, which are to be continued or intensified:

- Mixed water and rainwater (discharge, treatment, retention)
- Industrial and commercial wastewater (optimization of the operating mode)
- Conceptual measures

In the program of measures of the management plan (chapter 7), the following measures are named, which are intended to reduce the material pollution from point sources and are relevant for port and maritime commercial areas:

- Optimization of the operation of systems for the discharge, treatment and retention of mixed water and rainwater
- Other measures to reduce substance inputs from mixed water and rainwater discharges
- Other measures to reduce substance inputs from industrial / commercial wastewater discharges

In addition to operational measures, such as reducing the occurrence / production / use of the substances, structural measures to retain such pollutants before they are discharged into the sewer system or into the receiving waters are also possible. On the one hand, so-called oil or light liquid separators have become established here; on the other hand, it is possible to technically expand the systems for rainwater treatment so that, in addition to their largely already existing retention effect against such pollutants, they also lead to a considerable reduction in pollutant discharges. These two possibilities are to be explained in the next two chapters.

4.5.1. Oil separator / light liquid separator

Oil or light liquid separators are used to treat rainwater that is contaminated with water-polluting light liquids such as oil, petrol or grease. These decentralized treatment systems are based on the principle of gravity. The contaminated rainwater flows into the system, which reduces the flow rate. Heavy pollutants sink to the bottom to the sludge trap and the light liquids collect on the surface of the water and a liquid film is created. This layer must be vacuumed at regular intervals. However, not all light liquids are recorded with this method. Smallest oil droplets (oil particles) still require another measure. The principle of coalescence was used for this. The so-called coalescence separators have an additional filter screen made of oil-attracting and water-repellent materials. As a result, the small oil particles collect on the filter insert, which is located directly at the drain to the channel and adhere to the filter. More and more particles and small oil droplets spread out on the filter and an oil film is formed until the oil film is too sticky. Individual drops separate from the filter and also float to the surface of water, where they are ready to be skimmed off. When the maximum oil storage volume is reached, a float prevents light liquids from getting into the drain.

A variant of this system is also the vortex separator. This is characterized by the fact that the contaminated water is fed through a spiral into the separator. Due to the centrifugal force, larger and heavier substances are pushed outwards and the light liquids remain in the center of the spiral. These can already collect here on an oil-attracting surface.

The figure below shows a typical structure of a light liquid separator (oil separator).

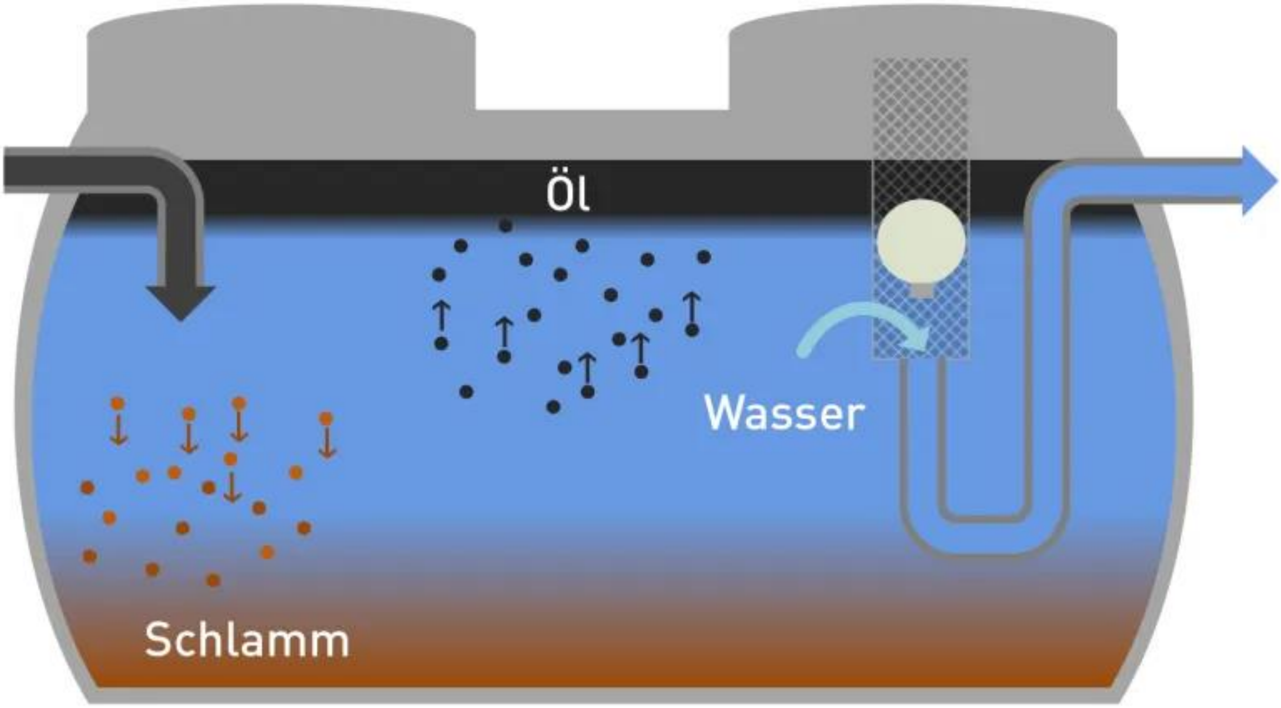

Figure 13: Representation of an oil separator (https://www.oko-tech-uws.de/wiki/oelabscheider) (01.10.2021)

4.5.2. Expansions of treatment systems

In addition to their rainwater treatment systems, most of the manufacturers' systems offer extensions for the retention of pollutants or substances hazardous to water, both on the system side, i.e. integrated in the system, and as an additional system. In this way, the general cleaning performance can generally be increased and light liquids can be separated out in the event of an accident.

Pipe sedimentation systems can either be equipped with a second flow separator arranged in the upper area of the pipe for oil separation or in the target shaft with an additional substrate stage, usually a substrate cartridge, which leads to the adsorption of pollutants. Such an additional cleaning stage, however, reduces the area that can be connected.

Street drain filters can be equipped with additional oil retention cartridges to retain oil and light liquids.

Variants are available for inclined clarifiers or lamellar clarifiers, in which a filter body is also installed. Thus, in addition to sedimentation, filtration and adsorption are also used here. Upstream or downstream solutions, e.g. of oil separators, are also possible and are offered as a compact system.

According to DWA-A 102, runoff from areas with primarily dissolved material pollution is introduced into the system after substance-specific pretreatment, the remaining material pollution AFS63 must be assessed according to category I in order to avoid arithmetical dilution effects in the balance sheet for the material removal. However, this must be viewed critically, as substance-specific treatment systems are often only built as emergency separators and therefore they do not have the capacity for continuous cleaning of rainwater.

If the handling of pollutants or substances hazardous to water (priority and priority hazardous substances), such as mineral oil hydrocarbons or heavy metals, is to be expected or known in higher quantities, an additional cleaning stage is generally necessary. Basically, in sedimentation systems for existing mineral oil hydrocarbons, upstream coalescence separators or oil separators and for existing heavy metals substrate filters are suitable.

4.6. Other measures of discharging in port and maritime commercial areas

Discharges from port and maritime commercial areas are subject to exceptional conditions that can affect rainwater management and treatment. In commercial and industrial areas, for example, there is a risk of pollutants escaping through accidents or non-intended use. Furthermore, there is a risk of flooding of the receiving water, meaning the water into which it is discharged, usually in port and maritime commercial areas and coastal waters. Due to such floods, the rainwater can only be released into the receiving water in a restricted manner and backwater can result. Likewise, without suitable measures, flooding can penetrate the rainwater sewer system up to the rainwater treatment systems. In addition, concentration controls and require monitoring are necessary for discharges from areas on which substances are handled, for which environmental quality standards must be complied in accordance with the Surface Waters Ordinance.

In order to prevent large quantities of pollutants from escaping or discharging into the water from the areas as part of an accident, either operational measures or measures that take effect in the event of an accident and intercept or neutralize the pollutants are necessary. Emergency containers, for example, in which the contaminated water can be temporarily stored and then fed to the existing treatment system or a mobile system for the treatment of contaminated water can be used as effective measures. A switchover shaft is required for this, in which either the water is fed into the tank or water out of the tank through shut-off valves or the inlet to the tank is usually closed, as well as measurement and control technology that signals that there is an accident , and the butterfly valves in the switchover shaft can be activated. Such systems can be activated manually or automatically. In both cases, however, it is essential that scenario plans for the procedure are drawn up and available for the occurrence of accidents.

Such emergency containers could also be used as additional storage space in the event of heavy rainfall or flooding in the receiving water. In addition, in port and maritime commercial areas with long-lasting floods, it may be necessary to provide pumps, e.g. arranged after the rainwater treatment system, to ensure that the cleaned rainwater is discharged without backwater in order to avoid damage to the treatment system. Backwater flaps have become established to prevent flooding from entering the rainwater system.

If the discharge for pollutants or priority substances is to be continuously monitored at regular intervals, the problem often arises in port and maritime commercial areas that the discharges are under water due to high water levels in the receiving waters, here usually coastal waters, and thus making sampling and control more difficult. As a suitable aid, existing manholes before the discharge can be used here, from which samples can be taken if there are no further inflows into the sewer after them and, for example, backflow valves prevent the penetration of water from the receiving water.

The detection of pollutants and trace substances in (waste) water is essential for the control of environmental and water technology systems. However, the standard sampling intervals are often too long for efficient control. As an alternative to this, there are molecular and pollutant sensors for field use in development. Due to their very low sensitivity, such substance-specific sensors are not in competition with laboratory analyzes, but rather should be used as reliable early warning systems for excessive concentrations of pollutants on site and integrated into the system. Depending on the question, different molecular species can be the focus.

5. Land use listing - treatment systems

In this chapter, possible rainwater treatment systems are to be assigned to the three pollution categories according to DWA-A 102. Annex 1 lists the area specifications that occur in port and maritime commercial areas.

According to DWA-A 102, areas of pollution category I do not require treatment. A mixing of such areas with areas of pollution categories II and III cannot be avoided, especially in existing buildings, so that in the comparison table, assuming a mixing ratio of the areas of 50:50, the mixing of pollution categories I and II as well as II and III are listed. The list of the mixing of areas of pollution categories I and III can be waived at this point, because firstly a mixing of these pollution categories should be avoided at all costs and, secondly, such a mixing would correspond to pollution category II.

In order to provide the respective rainwater treatment systems with connectable areas for an overview and usability, the data available from the manufacturers for their treatment systems were used for this. The following table lists the manufacturers' systems as well as building sizes (diameter = D, length = L, height = H; in m). If the manufacturers offer different system sizes, the largest system was selected.

PLANT TYPE	USED SYSTEM (COMPANY)	BUILDING SIZE
PIPE SEDIMENTATION SYSTEM	SediPipe L (Fränkische Rohrwerke)	D = 0,6 ; L = 24
INCLINED PLATE CLARIFIER /	A: ViaKan (Mall Umweltsysteme)	D = 5,6 ; H = 4

LAMELLA CLARIFIER	B: Sedismart+ (ACO Tiefbau)	D = 3 ; H = ca. 2,3
ROAD GULLY FILTER	A: Innolet (Funke Kunststoffe) B: Innolet-G (Funke Kunststoffe)	No extra structure necessary; suitable for road gully filters 0,3 * 0,5 or 0,5 * 0,5

A rain clarification basin is not listed here, as the efficiency of the system and the area can be determined by the system dimensions. However, areas with high pollution lead to very large constructions, so that the use of simple rainwater clarifiers is not recommended.

The comparison table lists the required efficiencies for the pollution categories and the mix of pollution categories. On the basis of this, the connectable area for the manufacturer's systems was then determined or selected. In order to give an improved overview of the different types of systems, system properties are also given in the form of land use and the expandability for the retention of pollutants.

		Pipe sedimentation system	Inclined plate clarifier / lamella clarifier	Road gully filter	Retention soil filter
SYSTEM CHARACTERISTICS	Space consumption	Low to medium (underground)	Low to medium (underground)	Low	Large
	Can be expanded to include retention of pollutants	Yes	Yes	Yes	Yes / No[1]
APPLICABILITY OF THE RAINWATER TREATMENT SYSTEMS FOR THE POLLUTION CATEGORIES ACCORDING TO DWA-A 102	BK I u. BK II (η = ca. 31 %)	Yes	Yes (B ca. 30.000 m²)	Yes (A ca. 400 m² u. B ca. 250 m²)	Yes
	BK II (η = ca. 50 %)	Yes (ca. 10.900 m²)	Yes (A ca. 96.000 m² and B ca. 18.000 m²)	Yes (Only B ca. 250 m²)	Yes
	BK II u. BK III (η = ca. 57 %)	Yes	Yes (B ca. 9.500 m²)	No	Yes
	BK III (η = ca. 65 %)	Yes (ca. 4.900 m²)	Yes (A ca. 48.000 m² and B ca. 8.000 m²)	No	Yes

[1] Additional building necessary (e.g. oil seperator)

5.1. Plant assignment to examples in the seaport of Rostock

To repeat and summarize the results of the area-related survey and evaluation as well as the determination of the required substance retention from Chapter 3.4, these are listed in the table below.

PIER 1

	Area [ha]	Area-specific material removal [kg/(ha*a)]	Required efficiency [%]
SCENARIO 1	21,00	595,00	52,9
SCENARIO 2	16,80	673,75	58,4
SCENARIO 3 ALL AREAS	5,13	525,61	46,7
SCENARIO 3 WITHOUT AREAS BK I	3,20	673,75 all areas	58,4

PIER 3

	Area [ha]	Area-specific material removal [kg/(ha*a)]	Required efficiency [%]
SCENARIO 1	66,50	645,68	56,6
SCENARIO 2	51,50	752,18	62,8
SCENARIO 3 ALL AREAS	30,50	669,67	58,2
SZENARIO 3 WITHOUT AREAS BK I	25,00	755,40	62,9
SCENARIO 3 INCREASING THE ROOF AREA	30,50	598,85	53,2
SCENARIO 3 INCREASING THE ROOF AREA & WITHOUT AREAS BK I	20,50	754,40	62,9

A fundamentally suitable method for the treatment of rainwater is rainwater settling tanks. (cf. 4.3 and 4.4.2) The results from chapter 3.4 can be illustrated using the required tank size (tank surface). This shows that large constructions are necessary to clean rainwater and that rainwater settling tanks are therefore only used in rare cases to treat rainwater.

PIER 1

	Maximum allowable surface loading [m/h]	Required pool surface [m²]	Approximate dimensions (width x length) [m]
SCENARIO 1	2,76	411,04	10,6 x 39,0
SCENARIO 2	1,94	468,80	11,2 x 42,0
SCENARIO 3 ALL AREAS	3,80	72,92	4,5 x 16,5
SCENARIO 3 WITHOUT AREAS BK I	1,94	89,30	4,9 x 18,3

PIER 3

	Maximum allowable surface loading [m/h]	Required pool surface [m²]	Approximate dimensions (width x length) [m]
SCENARIO 1	2,20	1634,61	20,9 x 78,3
SCENARIO 2	1,34	2076,81	23,6 x 88,3
SCENARIO 3 ALL AREAS	1,97	835,49	15,0 x 56,0
SCENARIO 3 WITHOUT AREAS BK I	1,32	1024,23	16,6 x 62,0
SCENARIO 3 INCREASING THE ROOF AREA	2,71	607,46	12,8 x 47,8
SZENARIO 3 INCREASING THE ROOF AREA & WITHOUT AREAS BK I	1,32	835,70	15,0 x 56,0

Approximate dimensions given correspond to the internal pool surface area required; Here, the thickness and width of the walls of construction are not taken into account.

Example systems are to be determined in the following for scenario 3 of pier 1 and pier 3.

In principle, road gully filters can be used for areas in pollution category II. Combining this with rainwater in pollution category III would lead to a reduction in the required level of efficiency; If the cleaned areas of pollution category II were fed in separately with a street drain filter, the area connected to the treatment plant, which then only treats rainwater of pollution category III, would be reduced (the required efficiency for this would increase). Both would mean that a smaller treatment plant would be necessary, but with increased acquisition and maintenance costs for the road drain filters.

If there was no pre-treatment of the rainwater from areas in pollution category II and no separate discharge of the rainwater from areas in pollution category I, the following treatment systems would be possible for the determined areas and required efficiencies of the discharge point 111AUS01 of Pier 1:

- 5 pipe sedimentation plants SediPipe L 600 / 24 (diameter and length) (Fränkische Rohrwerke)
- Lamella clarifier ViaKan 80 (D = 5,6 m and H = 3,8 m) or two ViaKan 48 (D = 4,0 m and H = 3,4 m) (Mall Umweltsysteme)
- 3 lamella seperator Sedismart+ 3000 mm (diameter) (ACO Tiefbau)

If there was no pre-treatment of the rainwater from areas in pollution category II and no separate discharge of the rainwater from areas in pollution category I, the following treatment systems for the determined areas and required efficiency of the areas of Pier 3, which are used for the storage and final assembly of large crane systems, would come into question:

- Ca. 44 pipe sedimentation plants SediPipe L 600 / 24 (diameter and length) (Fränkische Rohrwerke)
- Ca. 6 Lamella clarifier ViaKan 144 (D = 5,6 m and H = 4,0 m) (Mall Umweltsysteme)
- Ca. 33 lamella seperator Sedismart+ 3000 mm (diameter) (ACO Tiefbau)

The large number of treatment systems required for the areas of Pier 3, which are used for the storage and final assembly of large crane systems, is due to the large catchment area (approx. 30.5 ha) and the high proportion of areas in pollution category III and the resulting required efficiency . Assuming that the proportion of roof areas is increased and rainwater from areas in pollution category I is discharged separately (Pier 3 – scenario 3 increase in roof areas & without areas BK I), the following systems would be possible:

- Ca. 42 pipe sedimentation plants SediPipe L 600 / 24 (diameter and length) (Fränkische Rohrwerke)
- Ca. 5 Lamella clarifier Viakan 144 (D = 5,6 m and H = 4,0 m) (Mall Umweltsysteme)
- Ca. 26 lamella seperator Sedismart+ 3000 mm (diameter) (ACO Tiefbau)

6. Summary and outlook

The legal bases and regulations of the European Union and Germany about water protection show clearly that the protection of the resource water is of immense importance for human and other living beings. The European Water Framework Directive created a framework for Community measures in the field of water policy. Because of management plans and measure programs for individual river basin districts, the primary goal of achieving a good ecological status for all waters should be achieved. An important step towards achieving the good ecological status is the reduction of discharges, emissions and losses of priority and priority hazardous substances. This can only be achieved through adequate treatment of rainwater.

Rainwater treatment in Germany is regulated by the DWA worksheet A 102 “Principles for the Management and Treatment of Rainwater Runoff for Discharge into Surface Waters”. For the evaluation of need for treatment and pollution of rainwater, the substances that can be filtered out were selected in the worksheet with limitation to the fine fraction of solids from 0.45 µm to 63 µm, designated as AFS63. The selected solid content has a greater homogeneity in his composition and includes a large part of the pollutants sorbed onto the solids, such as heavy metals and organic pollutants. On the basis of various criteria, rainwater is assigned to pollution categories I (slightly polluted rainwater), category II (moderately polluted rainwater) and category III (heavily polluted rainwater) for each area of origin, whereby category I rainwater can generally be discharged into surface waters without treatment. The discharge of rainwater II and III may only take place after suitable technical treatment. Correspondingly, a correct and precise allocation of the land use is extremely important in order not to excessively increase the proportion of rainwater to be treated.

To do justice to the peculiarities of port and maritime commercial areas, a satisfactory division of the areas must be made. The central aspect here is that the use should be subdivided into the area categories as small as possible so that the proportion of areas requiring treatment and amounts of precipitation are not excessively increased. The individual types of area also need to be more precisely adapted to port and maritime commercial areas, as this is only done superficially and not precisely enough in DWA-A 102.

Possible treatment systems for port and maritime commercial areas are pipe sedimentation systems, inclined or lamellar clarifiers, street drain filters and retention floor filters. However, since water-polluting substances for which environmental quality standards have been laid down are also dealt with on such areas, either system extensions for improved retention and separation of such substances, additional systems, such as oil separators, or systems for the temporary storage of heavily contaminated rainwater are necessary. This always involves measuring devices to ensure compliance with environmental quality standards. Rainwater treatment systems are available on the market in various designs and sizes, so that the right system and size can be selected depending on the degree of efficiency and the area to be connected.

When new areas are being developed, rainwater management should be considered at an early stage. With foresighted planning and design of the areas, for example, the runoff effective precipitation can be reduced by a low surface sealing and precipitation runoff loads can be reduced by clear delimitation of polluted and unpolluted areas.

Correct rainwater management and treatment is necessary to achieve the goals of the European Water Framework Directive and to protect our waters in the long term.

To illustrate the possibilities for rainwater treatment in port and maritime industrial areas, a further investigation was carried out in the form of a variant planning using the example of bulk material areas in the Rostock seaport. In addition to the exact area allocation in the land use according to DWA-A 102, this also includes explicit treatment options for the polluted rainwater.

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Attachment 1: Typical land use in waterfront and maritime industrial areas according to table A.1 DWA-A 102 "Classification of impact categories for rainwater runoff from tilled or fortified areas after area type and area use"

AREA USE	Area specification	Area group	Impact category
ROOF AREAS	All roof areas ≤ 50 m² and roof areas > 50 m² except of those falling under area group SD1 or SD2	D	I
	Roof areas with high shares (20 % to 70 % of total roof area) in materials, which lead to significant strains of water harming substances for rainwater runoff	SD1	II
	Roof areas with very high shares (> 70 % of total roof area) in materials, which lead to significant strains of water harming substances for rainwater runoff	SD3	III
RAILWAY TRACKS	Railway tracks with crushed rock superstructure on free distance and in station zone up to 100.000 BRT (brutto register tonnes)/(day*platform) except of those falling under SG	BG1	I
	Railway tracks with crushed rock superstructure in station zone > 100.000 BRT/(day*platform) as well as railway tracks with solid tracks up to 100.000 BRT/(day*platform) except of those falling under SG	BG2	II
	Railway tracks with solid tracks > 100.000 BRT/(day*platform) except of those falling under SG	BG3	III
	Railway tracks with operational strongly increased interferences of rainwater quality, e.g. because of high amounts of shunting, strongly frequented braking distances or due to the application of herbicides during vegetation controls	SG	III
COURT AND PATH AREAS, TRAFFIC AREAS AND OTHER AREAS WITH GREAT STRAIN	Foot and cycle paths	VW1	I
	Court and traffic areas in mixed, commercial and industrial areas with low car traffic (DTV ≤ 2.000), except of those falling under SV and SVW as well as parking places and storing positions with moderate frequencies	V2	II

	Court and traffic areas in mixed, commercial and industrial areas with medium or high car traffic (DTV>2.000), except of those falling under SV and SVW as well as parking places and storing positions with high frequencies	V3	III
	Court and traffic areas as well as parking places and storing positions in mixed, commercial and industrial areas, where particular strains of rainwater quality are expected, e.g. storage areas	SV / SVW	III

Attachment 2: Tables belonging to chapter 3.4 area assesment using the excample of Rostock Seaport

Table 1 - Pier 1 Scenario 1

AREA TYPE	Area [ha]	thereof		
		Category I 280 kg/(ha*a)	Category II 530 kg/(ha*a)	Category III 760 kg/(ha*a)
AREAS WITH COALESCENCE SEPARATOR	2,73	2,73	-	-
OTHER AREAS POLLUTION CATEGORY I	1,47	1,47	-	-
AREAS POLLUTION CATEGORY II	6,3	-	6,3	-
AREAS POLLUTION CATEGORY III	10,5	-	-	10,5
CUMULATIVE VALUES	21	4,2	6,3	10,5
PERCENTAGE	100 %	20 %	30 %	50 %
DEGRADATION [KG/A]	12495	1176	3339	7980

Table 2 - Pier 1 Scenario 2

AREA TYPE	Area [ha]	thereof		
		Category I 280 kg/(ha*a)	Category II 530 kg/(ha*a)	Category III 760 kg/(ha*a)
AREAS POLLUTION CATEGORY II	6,3	-	6,3	-
AREAS POLLUTION CATEGORY III	10,5	-	-	10,5
CUMULATIVE VALUES	16,8	0	6,3	10,5
PERCENTAGE	100 %	0 %	37,5 %	62,5 %
DEGRADATION [KG/A]	11319	0	3339	7980

Table 3 - Pier 1 Scenario 3

AREA TYPE	Area [ha]	thereof		
		Category I 280 kg/(ha*a)	Category II 530 kg/(ha*a)	Category III 760 kg/(ha*a)
AREAS WITH COALESCENCE SEPARATOR	1,65	1,65	-	-
OTHER AREAS POLLUTION CATEGORY I	0,28	0,28	-	-
AREAS POLLUTION CATEGORY II	1,2	-	1,2	-
AREAS POLLUTION CATEGORY III	2	-	-	2
CUMULATIVE VALUES	5,13	1,93	1,2	2
PERCENTAGE	100 %	37,6 %	23,4 %	39 %
DEGRADATION [KG/A]	2696,4	540,4	636	1520

Table 4 - Pier 1 Scenario 3 without areas of pollution category I

AREA TYPE	Area [ha]	thereof		
		Category I 280 kg/(ha*a)	Category II 530 kg/(ha*a)	Category III 760 kg/(ha*a)
AREAS POLLUTION CATEGORY II	1,2	-	1,2	-
AREAS POLLUTION CATEGORY III	2	-	-	2
CUMULATIVE VALUES	16,8	0	1,2	2
PERCENTAGE	100 %	0 %	37,5 %	62,5 %
DEGRADATION [KG/A]	2156	0	636	1520

Table 5 - Pier 3 Scenario 1

AREA TYPE	Area [ha]	thereof		
		Category I 280 kg/(ha*a)	Category II 530 kg/(ha*a)	Category III 760 kg/(ha*a)
ROOF AREAS	15	15	-	-
PARKING PLACES	1,75	-	1,75	-
AREAS POLLUTION CATEGORY III	49,75	-	-	49,75
CUMULATIVE VALUES	66,5	15	1,75	49,75
PERCENTAGE	100 %	22,6	2,6	74,8
DEGRADATION [KG/A]	42937,5	4200	927,5	37810

Table 6 - Pier 3 Scenario 2

AREA TYPE	Area [ha]	thereof		
		Category I 280 kg/(ha*a)	Category II 530 kg/(ha*a)	Category III 760 kg/(ha*a)
PARKING PLACES	1,75	-	1,75	-
AREAS POLLUTION CATEGORY III	49,75	-	-	49,75
CUMULATIVE VALUES	51,5	0	1,75	49,75
PERCENTAGE	100 %	0 %	3,4 %	96,6 %
DEGRADATION [KG/A]	38737,5	0	927,5	37810

Table 7 - Pier 3 Scenario 3

AREA TYPE	Area [ha]	thereof		
		Category I 280 kg/(ha*a)	Category II 530 kg/(ha*a)	Category III 760 kg/(ha*a)
ROOF AREAS	5,5	5,5	-	-
PARKING PLACES	0,5	-	0,5	-
AREAS POLLUTION CATEGORY III	24,5	-	-	24,5
CUMULATIVE VALUES	30,5	5,5	0,5	24,5
PERCENTAGE	100 %	18	1,6	24,5
DEGRADATION [KG/A]	20425	1540	265	18620

Table 8 - Pier 3 Scenario 3 with increase of roof areas

AREA TYPE	Area [ha]	thereof		
		Category I 280 kg/(ha*a)	Category II 530 kg/(ha*a)	Category III 760 kg/(ha*a)
ROOF AREAS	10	10	-	-
PARKING PLACES	0,5	-	0,5	-
AREAS POLLUTION CATEGORY III	20	-	-	20
CUMULATIVE VALUES	30,5	10	0,5	20
PERCENTAGE	100 %	32,8	1,6	65,6
DEGRADATION [KG/A]	18265	2800	265	15200