GUIDELINES FOR

SURFACE WATER MANAGEMENT

IN THE CITY OF BERGEN

CONTENT

1 INTRODUCTION

Traditionally the regulation of run-off (precipitation and melt water) in urban areas was based on transporting the water as fast as possible into closed pipeline systems. This practice was intended to provide good urban environments and to provide security against floods, but often resulted in:

1. Increasing surface run-off in quantity and intensity
2. Increasing flow velocity with risk of erosion
3. Both lowering of the groundwater level and damage to vegetation and building structures.
4. Emission and spreading of surface water pollution (heavy metals and toxins)
5. Degradation of the ecological environment (reduction of biodiversity)

With urbanisation the amount of impervious surfaces increases at the expense of natural permeable soils, vegetation and trees. Natural ditches and waterways are replaced by pipes, marches, wetlands, ponds, etc. are drained. The natural infiltration, retention, absorption and evaporation of precipitation is significantly reduced which leads to an increase of surface run-off from the environment. The natural/original water balance and groundwater level are changed and the dry weather run-off (baseflow) is reduced. Often, also the natural drainage systems are removed or get reduced in capacity. Even small scale urbanisation (>10% impervious surfaces) influences the local water system and leads to a reduced water quality with negative consequences for the ecosystem, the water temperature, the sedimentation and the fish life.

The development of new areas and additional building in existing developed areas will give an increase of surface run-off by continuous use of traditional surface run-off solutions. In many places it can lead to overload of the surface water systems with even more flood events and water nuisance, increasing contamination, more constructions at higher expense, damage to settlements, water shortage for vegetation etc. as a result.

A future-oriented and sustainable surface water management should be based on retention practises and reducing/infiltrating surface water run-off by means of local surface water management. Adequate surface water management in urban areas can be achieved by solutions that maintain the natural water balance in the area as much as possible (natural situation). Sustainable land use with a hydrological oriented land use planning and the use of a sett of well functioning and integrated management methods are sufficient to minimise the effects of human intervention in the original hydrological situation.
This is in line with the content of EU's Water framework directive, which, among other things, describes the following:

Environmental aims:
The aim is that all fresh water, coastal water and groundwater are of good quality before the end of 2015. This means that in chemical, biological, and hydro morphological terms, the water quantity and water bodies, shall not differ too much from the conditions that would exist if the water body had not been influenced by human activities.

Management
Watershed management shall be introduced. This means that all water within a watershed and all activities that can influence the qualitative or quantitative state of the water will be monitored, independently of municipality-, province- or state boundaries.

Together with Bergen's management plan for waterways' new guidelines for surface water management will put increased focus on run-off and water quality and contribute to the use of better solutions and better resource management.

The European landscape convention points out that nature- and culture reserves must be preserved better during/by planning and management.

Existing legislation
Issues that are related to surface water management are regulated by several laws. The most important are the Water Resources Act and the Pollution Control Act, Plan- and building Act and Neighbouring law.
The directive framework for water will also have a large significance for which requirements have to be set to surface water management.

The Water Resources Act §7 the second paragraph reads:
Development and other land use should preferably take place in a way that precipitation still can infiltrate in the soil. The watershed authorities may order that measures are taken for better infiltration in the soil, if this can be achieved without unreasonable costs.
Here the municipality is given the authority to issue orders concerning measures that give better infiltration in the ground, if this can be achieved without unreasonable costs.

The Pollution Control Act regulates the responsibility for damage caused by the waste water system. *The owner of the system is responsible without regard to the guilt for the damage that a wastewater system poses because the capacity is insufficient or because maintenance has been inadequate.*

Further, it is so that if the pipe originally had sufficient capacity, but measures in the watershed have increased the run-off over the capacity, basically the owner of the sewer system is responsible even if other parties have implemented the measures. However, in these situations the responsibility may be slackened in the meantime.

The Plan- and building Act requires the municipality to oversee that plan- and building legislation is kept. It is the municipality's responsibility to consider the surface water situation regarding to floods, erosion and safety. Such considerations must be included in land-use planning. Municipal master land use plans, regulation plans and construction plans must fulfil the legislation requirements as mentioned above. In the regulation plans risk areas and flood risk areas shall be indicated and development without special measures shall not be allowed. Also the impact on areas downstream a new development shall be considered.

In recent years, in the municipality of Bergen, a large effort is made in the development of new waste water facilities. An important task ahead will be to reduce the waste water overflow from the sewage network to the recipients. Large supply of surface water to the sewage drainage network leads to capacity problems for the sewage network with overflows as a result.

The future indicates an increased building concentration in populated areas and development of new areas around and in the city. This, together with an expected growth in annual precipitation the coming years will lead to increased surface water run-off and an increased load on both surface water pipelines and sewer networks in areas with a combined sewer system. An increase in urbanization leads to an increase of pollution of surface water, i.e. increasing pollution in the watersheds. This future scenario must be faced with a prioritization of solutions that reduce surface water run-off from the environment and/or that reduce surface water inflow to the pipeline network.

Clean surface water is an important resource in the urban environment and the community and must to a greater extent be used as a positive element in land use plans, construction plans etc.

2 PURPOSE OF SURFACE WATER GUIDELINES

This document will be guidance for anyone planning, designing or building facilities where surface water regulation is part of the development project.

Surface water management within a larger area usually involves multiple parties. The challenge is to maintain a comprehensive planning, design and maintenance of facilities at all levels, responsibilities and authority levels. The work must be coordinated and responsibilities distributed between the various parties (local, district, various local government bodies, builders / developers, planners, contractors)

Comprehensive surface water management is important to safeguard a number of factors:

• Safety of citizens (life, health, economy)
• Avoid flooding and ensure that flood water is diverted into designated areas (temporary flood routes) away from buildings so they cause minimal damage.
• Ensure that flood risk areas are not developed
• Ensure the best possible water quality for surface water (groundwater, rivers, and lakes).
• Reduce the overflow from the waste water system.
• Protect the vegetation areas within urban areas
• Make good use of the existing waterways in the design of new urban areas. Avoid replacing streams with pipes.

There are requirements as to which plans must/shall be made and what these should contain, which solutions are to be prioritized, etc. Good surface water management requires effective, reliable and cost-acceptable solutions. The choice of solutions must be adapted to each project based on local conditions.

All parties must ensure that the necessary expertise within the various aspects of surface water management is present in the planning and project implementation.

When it comes to the theoretical basis, calculation methods, etc. the planner/developer/ project owner must ensure that they have sufficient relevant knowledge.

3 STRATEGY

The Master plan for the sewage- and water environment focuses on a comprehensive surface water management. The goal is to ensure adequate and well functioning surface water solutions that take into account security, safety, environment and aesthetics.

The surface water system shall divert precipitation (rain and snow) in a safe, environmentally adapted and cost-effective manner so that citizens' health, safety and economic interests are safeguarded. The surface water should be used for the benefit of residents. The water should be made more visible and available in developed areas/urban areas, and reestablishment /opening of closed waterways will be a priority where it can be implemented within reasonable limits.

Planning of surface water management must be coordinated with land use planning, that is, principles or solutions for the management of surface water should be considered and determined in the land use plans (City master plans, / larger land use plans / regulation plans). This can be achieved by the preparation of separate plans for surface water management; master plans, principal plans, pilots, flood-/drainage plans etc. Coordination opportunities between surface water management and green area development, road plans etc. shall be exploited.

When developing new areas and rebuilding inn developed areas, surface water management must be planned and executed in such a way that the water does not cause damage or disadvantages for the lower areas. No new point outflow of surface water should be established that overburden downstream surface water systems (pipes, streams, rivers). For projects that lead to increased surface run-off and increased water flow to the rivers, specific approval is required by means of an application. If new projects (street works, rearmament of the squares and spaces, new buildings, etc.) within developed areas / urban areas solutions that reduce the drainage of clean surface water to a drainage network must be prioritized. Water flooding routes should not be obstructed by new measures.

Goals for surface water management in the City of Bergen:

Solutions for surface water management that do not cause harm to the environment, buildings and structures shall be used. Local surface water management shall be used whenever possible.

Priorities:

1.	In populated areas surface water shall as far as possible be taken care of at the source so that the water balance is maintained approximately equal to the natural state (maintain natural groundwater level, infiltration, retention and waterways). Proportion of impervious surfaces is to be minimized
2.	Contaminated surface water that can not be allowed to a specific recipient must either be treated locally, or be diverted to a smaller sensitive recipient or led to municipal wastewater treatment plants.
3.	Separation of surface water from the effluent in the existing combined sewer system should always be considered in connection with the change and renewal of waste water pipelines, street renewal, etc.
4.	Measures must be taken at the source of contamination (reduce pollution production through appropriate choice of materials for buildings, good street cleaning, good procedures for emptying the sand trap / street grates, keep contaminated and non-contaminated surface water separated, ...)

Solutions that deviate from the above shall be considered in particular.

4 PLANNING AND IMPLEMENTATION

4.1 General

The road towards a future-oriented and sustainable surface water management must be, among other things, governed by the requirements for the preparation of adequate plans, both on a general level and at detailed level. Plans shall be prepared and anchored in the municipality's overall goals and priorities. The keyword is hydrological oriented land use planning, where the requirements for surface water management are based on the overall plans. These requirements must be included in the provisions of regulation.

Planning levels:

Planning areal	Catchment	Planning level/-type
Watershed	Entire watershed	Municipal plan/master plan surface water/watershed
Area	Parts of watershed	Principal plan/surface water plan/ watershed plan
Locally	A smaller area within the watershed	Regulation plan/ development plan
Plot	A plot in the watershed	Development plan/ construction application

The above table provides an overview of the different levels of a comprehensive planning of surface water solutions. Surface water problems must be treated specifically within each planning level.

During the preparation of overall plans, such as the municipal land management plan, the responsible planning department must assess the need for any "surface water plans".

Costs relating to plan preparation and implementation of surface water measures shall initially be covered by the developer / landowner. To ensure a comprehensive planning and implementation within larger plan-/developing areas, municipal participation in financing can in some cases be necessary. This may partly apply to the preparation of overall plans in an area where several plans are developed, and for the establishment of larger central surface water plants (clean ponds, etc.).

The municipality may in the treatment of applications for building permits for single measures (new buildings, extensions and modifications) require special solutions for surface water management.

4.2 The overall plan

Central plans at this level are the municipal master plans and municipal partial plans, such as green plans, master plans for sewage and water, land use plans and theme plans. Such plans must set framework conditions for the development and use of the green areas and waterways in the municipality and provide guidelines for surface water management within the region or the sub-areas. Requirements for surface water management should be included in the plan provisions.

As special circumstances to be considered regarding to the planning work that have an impact on surface water management there can be mentioned flood zones, flood routes, water quality in urban water systems / recipients, vegetation belts / green areas and areas connected to surface water purposes (water cleansing areas/ponds, retention-/infiltration basins etc.)

4.3 Principal plan surface water

Within a drainage area, a framework/principal plan must be prepared for surface water management. The plan forms the basis for further engineering of surface water management in each development area or building project. The principal plan shall ensure the requirements and priorities as stated in the overall plans and the community's Water and drainage standards. In a principal plan the following should be considered and evaluated

- Topography
- Ground/soil conditions and vegetation
- Areas of vegetation that are vulnerable to groundwater changes
- Areas and recipients that are vulnerable to pollution
- Areas that are suitable for infiltration, retention, cleaning ponds, etc.
- Natural drainage patterns
- Existing flood routes
- Municipal sewage and surface water system

In the principal plan, among other things, changes in drainage patterns, flooding routes, assessed contamination levels in surface water, recipient judgement, requirements for water quality, requirements for solutions for surface water management at the project level and location of any "combined areas" for surface water measures must be indicated.

4.4 Project Plan / detail plan

Utilization of opportunities for infiltration, retention, purification, use of water as an aesthetic element in a building project requires a holistic approach in the early stages of the project. Before an area is planned or rehabilitated the measures for surface water disposal need to be clarified and the surface water plan shall be prepared as part of the development plan. The plan must ensure the requirements and priorities as stated in the overall plans, the principal plan and the municipality's Water and drainage standards. All development plans should account for surface water management, also each and every house that is to be built.

A project plan should include:

- Run-off patterns (infiltration, retention and recipient).
- Flood routes
- Detailed plan for infiltration, retention and diversion.
- Measures against pollution of land and recipient (purification of surface water)
- Possible connection to municipal networks, stating the amounts of discharge (peak run-off)

Documentation of the calculation of water quantity and design of surface water facilities shall be submitted. Likewise the grounds/reasons for the choice of solutions shall be submitted.

4.5 Operations- and maintenance plan

Operational responsibility for the facility must be clarified before construction. The municipality would normally be responsible for operating systems that are wholly or partially owned by the municipality. In the case of a private facility the operational responsibility will lay at the owner of the property that the facility was originally built for.

To ensure the necessary maintenance some operational instructions should be prepared containing the following:

- Map of facility
- Description of the plant's function.
- Guidelines for operation and maintenance.
- Rules and standards for changes in the area that affect run-off and the surface water system (to be known by all the land buyers / landowners / homeowners / ...)

It is important that, subsequently, no measures are taken that will reduce the infiltration area or change the drainage from the area.

4.6 Construction plan.

For construction projects where there is a risk of pollution of surface water/ recipients in the construction phase or where the measures in the construction phase can affect the run-off conditions, plans for the management of surface water in the construction phase shall be drawn. Discharge to vulnerable recipients should be avoided. Pollution potential from unstable/erosive exposed slopes, location of mass deposits, practices and locations of fuel storage/refuelling, oil change etc. must be considered in relation to surface water management.
It is important that working processes are planned well and that potential environmental problems are taken into account early in the planning process.

In a construction plan it may be appropriate, among other things, to include requirements for:

- Protection of vegetation and infiltration areas / permeable surfaces
- Protection of watercourses and / or groundwater
- Measures to prevent erosion and sediment transport / sedimentation

- Measures to reduce run-off volumes / -peaks in the construction phase
- Measures against pollution from facility operation
- Waste management in the construction phase

Internal control and monitoring is an important part of the process and the builder must make demands to the contractor on a contract basis (tender documents, Health, Environment and Safety plan). Quality assurance systems are to ensure smooth implementation of construction work and that the current plans, requirements and policies are followed.

5 CALCULATIONS OF SURFACE WATER QUANTITIES

5.1 General

This chapter discusses the calculation of water quantity for both surface water systems and combined sewer systems.
Drainage systems are initially designed for peak run-off, while interceptive systems, spillways/overflows, retention facilities, infiltration facilities, etc. are designed for partial/average/base run-off.

In the design of the surface water- and combined sewer systems one must take into account possible future changes in:

- Linked areas (extended catchment area)
- percentage impervious surfaces (increased urbanization)
- climate (the expected higher rainfall)

The planning and design of facilities should always be evaluated for risk and consequence of events that exceed the dimensions of the run-off.

For relatively small and simple catchments, surface water quantities can be calculated using the rational method. As standard an upper limit of 50 ha (500 000 m2) for the use of the rational method is chosen. If the field / fields have irregular terrain and / or significantly different concentration times or run-off coefficients, the use of alternative methods must be considered (time-area method, the summation curve method).

For larger catchment areas (A> 50 ha) hydrological EDB-computer models shall be used. Such models must also be used for areas less than 50 ha, where there are special circumstances, complex watersheds or where the consequences of miss design will be large. This must be clarified in the early planning phase through contact with the Water and sewerage-department by means of a plan assessment / pre-discussion.

Generally surface water systems and combined sewer systems are to be designed in accordance to the CEN EN-752 standards. The Water- and sewage standards prevail over CEN EN-752
All calculations shall be performed by personnel with adequate expertise in the field.

Calculations of water quantities, storage capacity, infiltration capacity, etc. shall be documented and enclosed with the application for approval.

5.2 Recurrence interval (z)

One must distinguish between the recurrence interval for the design flow for filled pipelines and for the design flow that will lead to back flow to terrain-, street-, basement level.

In open areas where flooding has relatively small consequences, the dimensioned rainfall frequencies can be used. There, the drainage system shall be designed for full conduction, i.e., so that back flow does not occur at the dimensioned recurrence interval / rainfall frequency.

In urban areas and where flooding will cause significant impact, the normally dimensioned flood frequencies shall be used. In such cases, calculations are preferably performed with the use of computer models (see Chapter 5.3).

The following recurrence interval must at least be used for rainfall frequency / flood frequency:

Dimensioned rainfall frequency (recurrence interval) (Once in *n* years)	**Area type**	**Dimensioned flood frequency (recurrence interval) (Once in *n* years)**
2 years	Undeveloped (Open)	10 years
10 years 20 years	Residential area - Open - Closed	20 years 30 years
20 years 30 years	City centre/Downtown - Open - Closed	30 years 50 years

Flood routes should be designed for a capacity at least equal to a 100-year flood recurrence interval.

The above values are minimum values. Higher recurrence intervals must be used where damage potential is huge. If the flooding will result in substantial costs or serious consequences a recurrence interval must be used longer than shown in the table above. The same can be said if the costs of using higher recurrence intervals are low.

Special structures such as for flood prevention, river culverts, critical tunnels and similar structures require normally a recurrence interval higher than indicated above. A 100 year recurrence interval is often used for the design of such systems. Selection of the recurrence intervals and the basic design features must be considered in particular.

5.3 Area / catchment area > 50 hectares

For basins larger than 50 ha and for smaller basins with complicated drainage conditions or where the consequences of dimensioning failures are large, computer based simulation models shall be used to estimate surface water quantity and for the design/dimensioning of the surface water system.

For larger areas / catchments specific water resources models are required. For urban areas drainage models of type MIKE URBAN (MOUSE) or equivalent can be used.

CEN EN-752 recommends that the level of protection against flooding is considered separately. The drainage system is to be designed first as smaller plants; afterwards a simulation model is used to verify that insurance against flooding is in accordance with the recurrence interval dimensions of the flood frequency.

Dimensioning should be achieved by long historical time series of precipitation, evaporation and temperature, i.e. 20 years time series or longer, through considered in a calibrated simulation model for the drains. The maximum estimated floods of the pipe network system shall then be used to estimate flood frequency and / or frequency of the back flow over a given level in the drainage pit (flood frequency analysis).
Bergen municipality aims to develop a set of rain events, based on long precipitation series, which can be used to design/dimension and asses the capacity of the sewerage network. Until these are available the Water and sewerage department can be contacted for further review of what rainfall data should be used for the model. The Water and sewerage department has time series of precipitation (short-term rainfall data) for Bergen and for Sandsli for the period 1982-2003.

If it is not possible to run the calculations with a calibrated model, the Water and sewerage department can be contacted to get information about the current set of parameters for the field that is to be calculated. I.e. to make use of parameter sets from another calibrated field that has similar characteristics as the field to be calculated.

Together with the model, in addition to precipitation data, there may also be a need for evaporation- and temperature data. Evaporation varies with wind conditions, temperature, precipitation and the type of surface. The evaporation in Bergen is normally highest in the period May-July. Evaporation has little effect on run-off over a shorter time and can be neglected for the design of piping networks.

However, often along with temperature data potential evaporation is used as input data in the modelling of surface water run-off. When evaporation data / temperature data are needed, the Water and sewerage department can be contacted.

5.4 Area / catchment area <50 hectares

5.4.1 The rational method, basic equation

The rational method can be used in the calculation of surface water quantity and design of surface water-/combined sewerage network for small, homogeneous catchment areas (A <50 ha).

Rational method equation: $Q = C * i * A$

C: dimensionless run-off coefficient.
i: rainfall intensity (from relevant IDF-curve)
A: catchment area (acres, ha)

With use of the rational method, the procedure for calculating the surface water quantities at a point is as follows:

1 Estimate a reasonable value of t_s (3-15 minutes or more for larger areas).
2 Estimate a reasonable value of the water velocity in pipes (use the Colebrook equation).
3 Calculate the time $t_l = l / v$ in the pipe.
4 Calculate the concentration time t_c and set this equal to rain duration.
5 Select the recurrence period z, for example 10 years.
6 Enter the requested IDF-curve with a duration equal to t_c, and Z, and read the corresponding rain intensity I.
7 Calculate the amount of water $Q = C * i * A$
8 Find the pipe diameter using a friction formula, for example the Colebrook equation. Find the water velocity using the partial drain contents diagram and compare this with the value estimated under point 2
9 If there is a large gap between estimated and calculated value, repeat the calculations.

5.4.2 Supplying area

The catchment area must be determined. Map study must be supplemented with field inspection; particularly in areas with little gradient. Trenches and canyons can have a major impact on the catchment area boundaries. Conditions that may affect the area size must be considered, for example measures for interception of partial areas, future connection of new areas etc.

5.4.3 Runoff coefficient

The run-off coefficient depends on the permeability and surface characteristics, the gradient circumstances, the rainfall intensity and rainfall duration.

The run-off coefficient can be used as indicated in the table below, but should be considered with regard to local conditions. Among other things, the share of impervious surfaces, land size, land gradient conditions and ground conditions should be taken into account. The table lists normative values for the run-off coefficient (C).

Impervious surfaces (roofs, asphalted squares/roads etc.)	0,85 - 0,95
Downtown area	0,70 - 0,90
Multi units-/apartment neighbourhoods	0,60 - 0,80
Single house areas	0,50 - 0,70
Gravel roads/-spaces	0,50 - 0,80
Industrial areas	0,50 – 0,90
Lawn, park, meadow, forest, cultivated land	0,30 - 0,50
Mountainous area without heath and forest	0,50 - 0,80
Mountainous area with heath and forest, stoned and sandy soils	0,30 - 0,50

For flat and permeable surfaces with large distance to the groundwater level the lowest values are used. For more steep and dense surfaces or where the groundwater table is just below surface the highest values are used. It must also be taken into account that at wintry conditions the surface can be frozen or icy which yields run-off corresponding to impervious surfaces.
If sub-basins have different run-off coefficients, the weighted average run-off coefficient should be calculated using the equation:

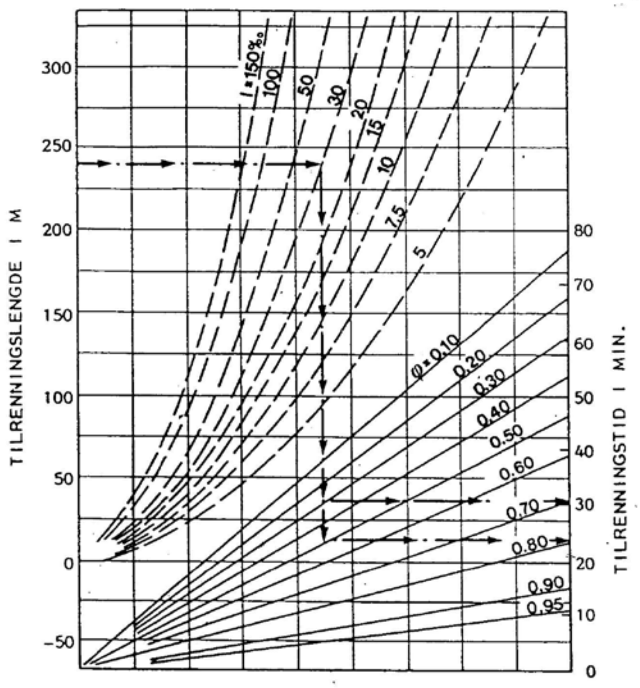
$C_{average}$ = (C1A1 + C2A2 + ... + CnAn) / (A1 + A2 + ... + An)

When selecting the run-off coefficient any future changes in land surface type must be considered. A future development may lead to an increased proportion of impervious surface and thus a higher run-off coefficient.

5.4.4 Concentration time
The duration of rainfall is normally sett equal to the time of concentration (t_c) for the basin: *"The greatest flow occurs normally for the rain that has a duration equal to the entire field concentration time"*

The concentration time is the longest time required for the water that falls on the catchment to travel from the most remote point in the catchment to reach the point of interest where the flow is measured /collected.

The concentration time (t_c) consists of sheet run-off time over plane surfaces (t_s) and the flow time in pipelines, open channels, ditches, etc. ($t_l = l / v$) The concentration time (t_c) can be determined with the use of nomograms and / or formulas. A diagram for calculating sheet run-off time for run-off on the surface is shown below.



Gitt: Tilrenningslengde 240 m, fall I = 30 ‰ ϕ er 0.30 og 0.50.
Tilrenningstiden blir hhv. 30 og 25 min

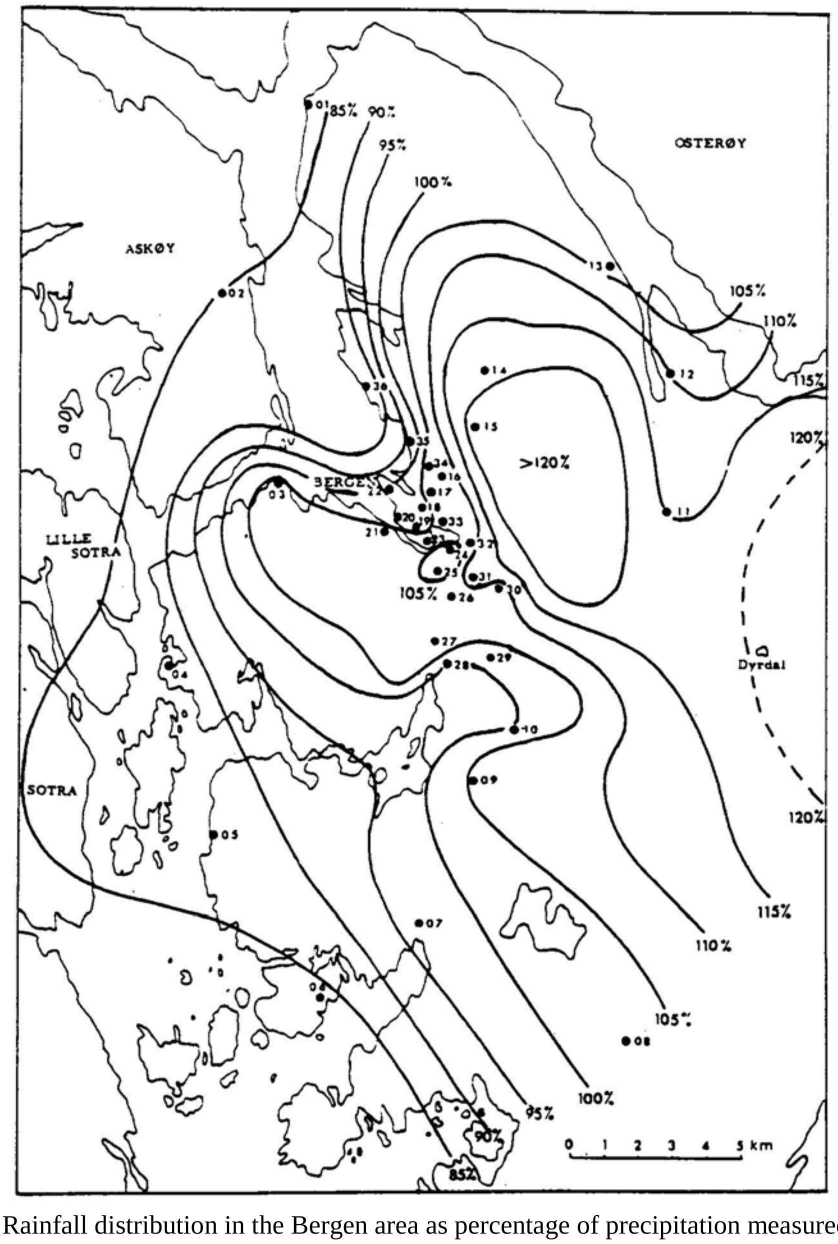
Figur 1.13 Nomogram for beregning av konsentrasjonstiden. (Etter "Design and Construction of Sanitary and Storm Sewers". American Society of Civil Engineers (ASCE). Manual of Practice. No 37, 1970.)

For an area a recharge time less than 3 minutes is never chosen.

In the assessment and selection of the concentration time or the dimensions of the rainfall duration the area layout and size must also be taken into account. For some areas the dimensioned rain duration will be shorter than the concentration time.

5.4.5 Precipitation (IDF-curve)

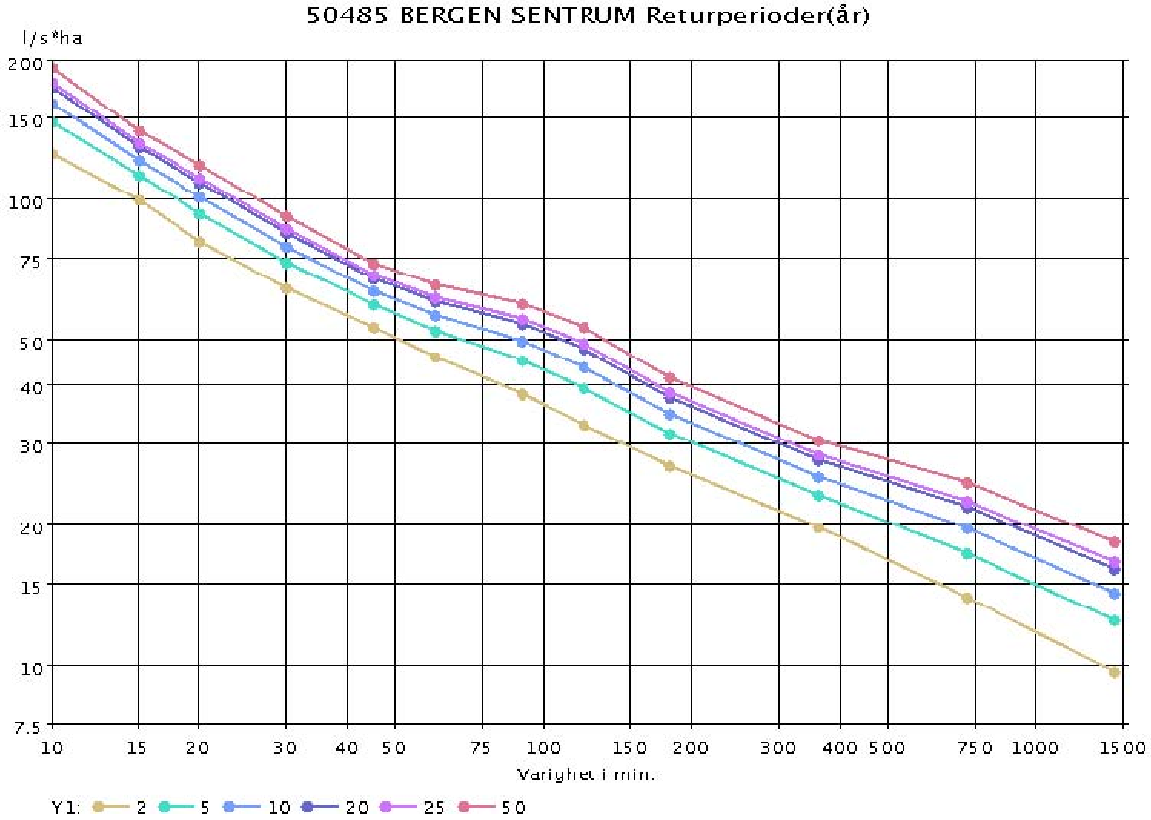
There can be large local variations in rainfall over both years and over short periods of time. As an example of annual variations a drawing is attached that shows the rainfall distribution in the Bergen area in 1947 (Færøyvik 1951). This must be considered when selecting and using rainfall data / IDF-curves, where there must be chosen a curve that is most representative of the area to be calculated. Also the variation in precipitation depending on elevation, terrain shape, etc. must be considered.



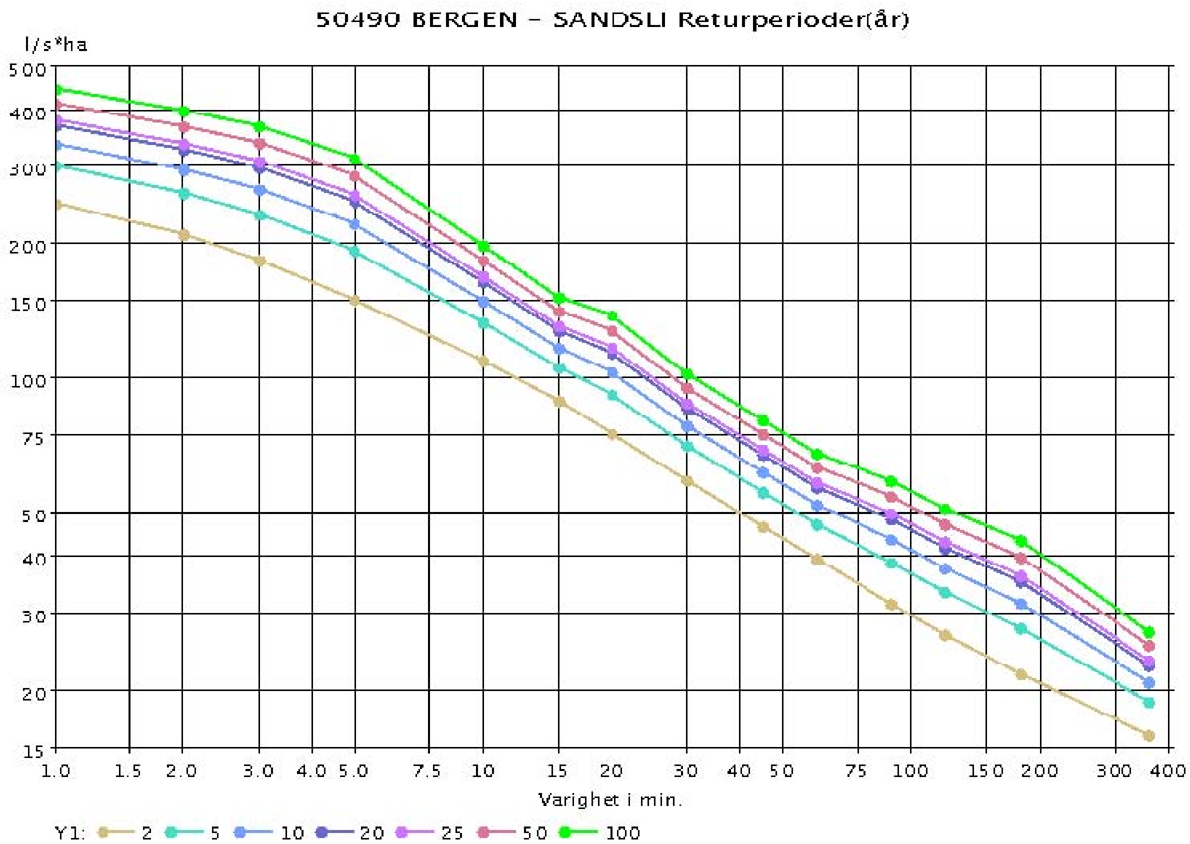
Rainfall distribution in the Bergen area as percentage of precipitation measured by Fredriksberg for the year 1947 (Færøyvik, 1951)

The latest updated curves for Bergen should be used. Attached er:

- curve for Bergen downtown area 1982- 2002
- curve for Sandsli 1982- 2002



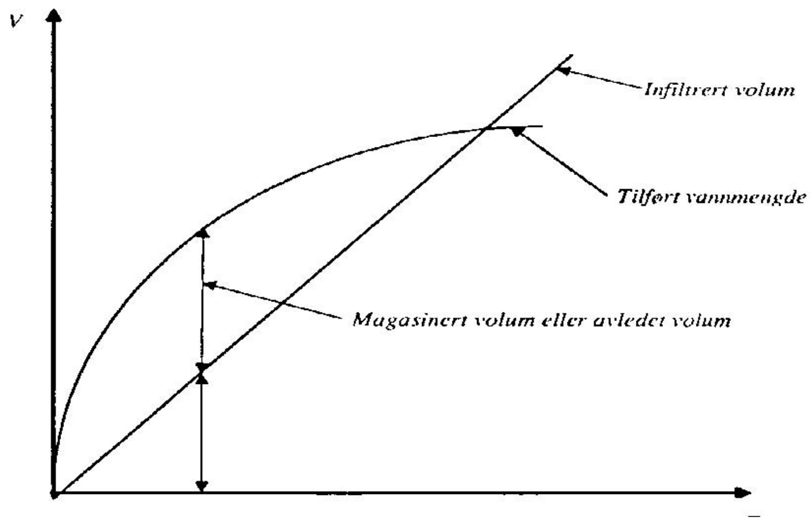
IDF-curves for Bergen – Florida 1982-2002



IDF-curves for Bergen – Sandsli 1982 – 2003

5.5 Design of storage volume (rain envelope method)

A retention basin temporarily stores a part of the water volume from a catchment; either all or part of the difference between the recharged and discharged water volume.
With use of graphical rendering of the recharged and discharged water volumes, one can find the necessary storage volume for a catchment with a selected / dimensioned recurrence interval. This principle is called the rain envelope method. Based on the IDF-curves one calculates the recharge volume for various precipitation durations and recurrence intervals (recharge envelope). The discharge envelope is determined by the outlet capacity and / or infiltration capacity of the retention basin. The necessary storage volume is determined by the maximum difference between the recharge envelope and discharge envelope.
Such calculations can also beneficially be conducted with computer models.



Recharged and discharged /infiltrated water volume as a function of time.

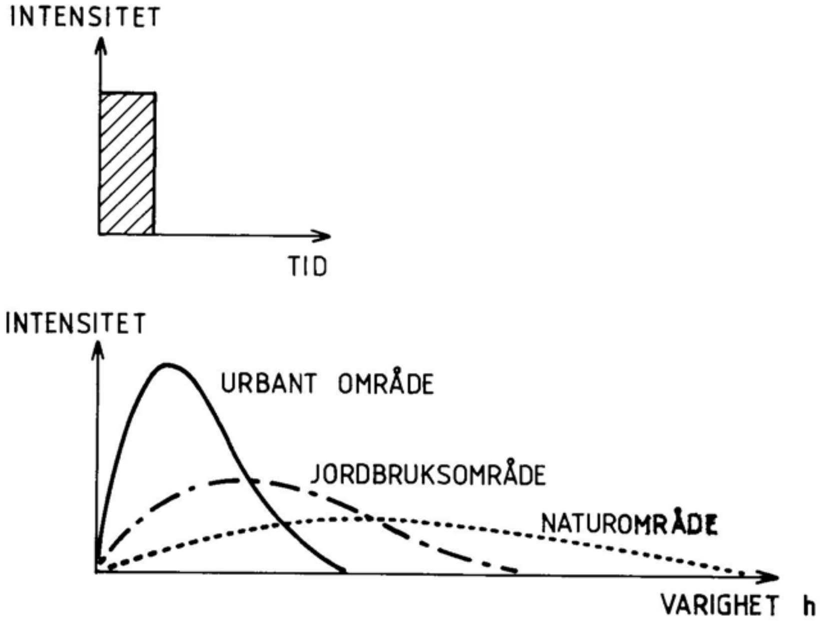
5.6 Design of interception pipeline constructions / overflow

Interception pipeline constructions are normally not designed for a capacity equivalent to the catchment's peak run-off from the upstream drainage system. It is assumed that the discharged water volume (overload volume) does not bring serious consequences downstream the overflow outlet. The over flow outlet should cope with the peak run-off from the upstream drainage system.

Such facilities shall be designed from a pollution point of view where the emission concessions/licenses and local environmental aims for water bodies shall be decisive when determining the dimensions of water volumes.
Where aims are lacking, the facility will be dimensioned in a way that the overload for an average year does not exceed 5% of the total recharge volume. This principal can be used for discharging the overload of adequate recipients in the sea. For vulnerable recipients stricter requirements for the overload are required. Measures to reduce the overload further, for example through over dimensioning of the network, will be implemented if the additional costs associated with such measures are low.

6 LOCAL SURFACE WATER MANAGEMENT

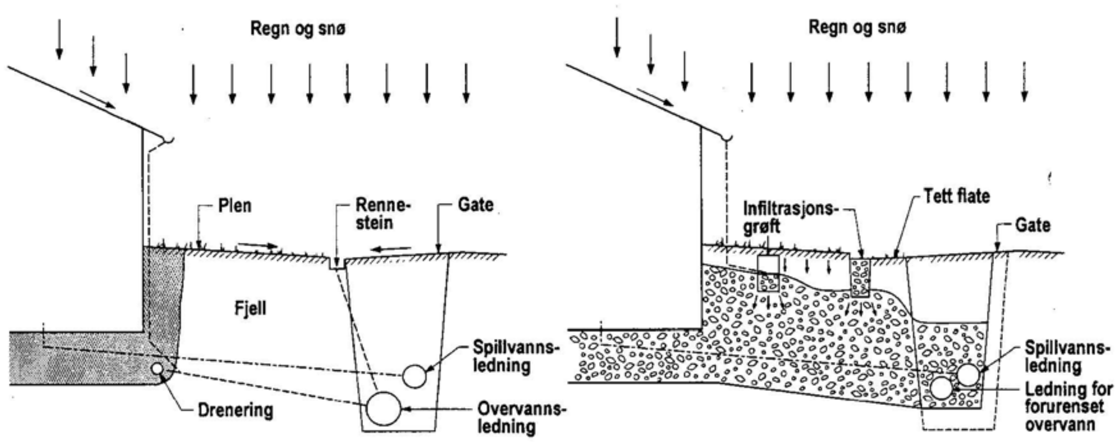
With urbanization the proportion of impervious surface is increasing at the expense of natural permeable soil, vegetation and trees. The natural infiltration, retention, absorption and evaporation of rainwater decreases highly and increases the surface run-off substantially, both in volume and intensity.



Adequate surface water management in urban areas can be achieved through solutions to maintain the natural water balance in the area (natural state) to the greatest extent possible. Such solutions are considered "Local surface water management". Adequate comprehensive solutions require a hydrological oriented land use planning.

The main elements of local surface water management are the infiltration and retention. With infiltration the water infiltrates directly into the ground, either through the soil surface or through various storages or ditches in the ground. With retention the water flows to a basin where it is retarded before it is supplied to the ground, a local recipient or drainage-/surface water drainage network.
Often combined solutions of infiltration and retardation in open / closed basins are used.
Local surface water management often involves a significant purification of surface water, depending on which solutions are used.

The City of Bergen has partly made use of small scale surface water management solutions within the so-called Sandsli basin and in the Lønningen Næringspark. The experiences with these constructions are good.



Et konvensjonelt avløpssystem *Sandsli-systemet*

Calculations and design of infiltration- and retention measures shall be performed by personnel with adequate expertise in the field.
For the design of facilities for local surface water management one should seek to achieve solutions that strengthen the area's visual character and that enrich the community by making the water more visible and use it as an architectural element. Running water is life-giving and can / should be used as an aesthetic element in gardens, parks, living environment, etc.

6.1 Infiltration

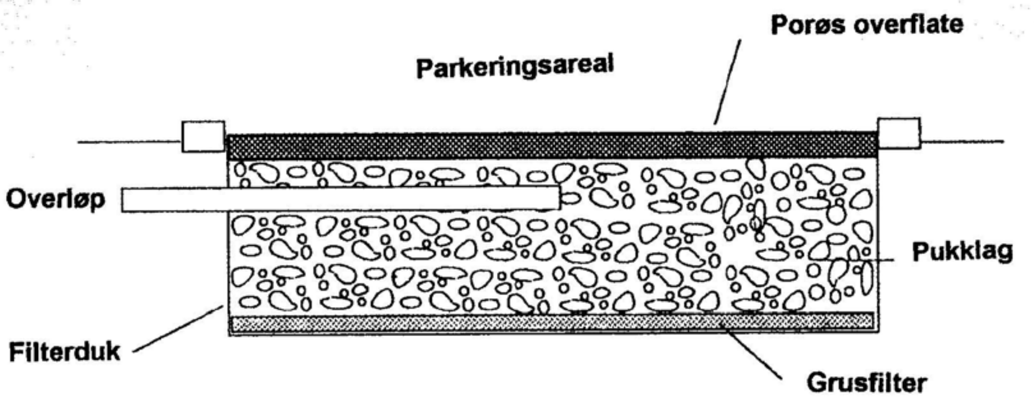
In populated areas access to infiltration areas is limited. In addition to exploiting areas of vegetation / grass-covered surfaces for infiltration, should one also consider whether more or less permeable cover types can be used (see list below) on the traditional "impervious" surfaces such as parking areas and walkways.
Where impervious surfaces are elected (asphalt and concrete cover, etc.) the surface run-off must be transported to the nearest surface infiltration /storage. With the recharge to the infiltration areas such as vegetation surfaces, lawns, etc. the water should be spread out so that one achieves a diffuse distribution of infiltration surface. Point supply gives less distribution and infiltration and can lead to erosion in the area.

Infiltration covers can be roughly divided into the following categories:

-Vegetation surfaces (ground surfaces, grass, marshes, wetlands,…)
-Covers of fine crushed rock / gravel and grass (eventually with "reinforcement")
-Combination of grass and coating stone
-Permeable asphalt
-Cobblestone cover
-Concrete stone covers (w / gravel filled spaces)

Experience shows that the compact gravel can almost be regarded as a dense cover. It is therefore important to use masses that maintain a certain porosity and permeability. When using permeable covers it must be ensured that the underlying ground has sufficient infiltration capacity. It may be appropriate to improve the subsurface infiltration capacity by means of mass replacement.

The infiltration capacity is affected by vegetation, soil type, structure, slope conditions etc. and can vary significantly within a small area. For the assessment of an area's infiltration capacity and the design of infiltration facilities necessary investigations must be carried out. This will usually require knowledge of the fields of hydrology and hydrogeology. For simple, small fields simplified methods can be used. For major and complex areas or in areas where existing water channels / networks are overloaded or are close to being overloaded, more thorough reviews and investigations need to be carried out.
In the construction -/ building phase the existing infiltration surfaces must be protected from construction activity. Unnecessary traffic and compaction of the infiltration surfaces should be avoided.



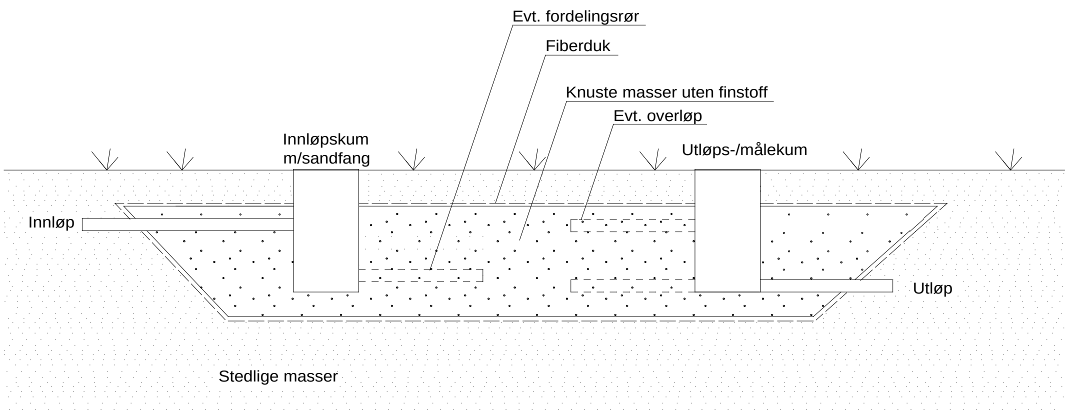
6.2 Retention

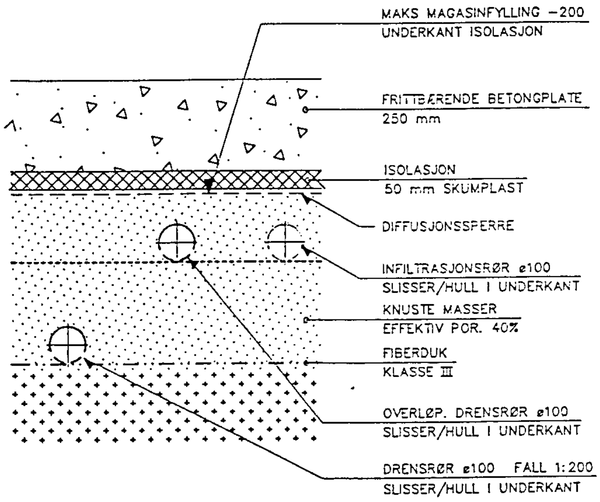
If a site does not have sufficient capacity to infiltrate all surface water measures must be considered to retain run-off, i.e., "to retard" water. Retention is also used to smoothen out the run-off from a site and thus prevent flooding peaks. For retention natural retention basins in the area can be used and / or artificial pools / storage must be established. There are two main types of retention basins:

- Open pools such as natural depressions in the terrain, trenches with, ponds, marsh-/ wetlands and various types of artificial pools.
- Closed pools (stone panels, pipe trenches, buried prefabricated structures, concrete storages, bio filters, etc.)

With the use of stone fillings one can achieve a porosity of ca. 30%, i.e. the effective water volume. Prefabricated elements have a porosity of approx. 95%.

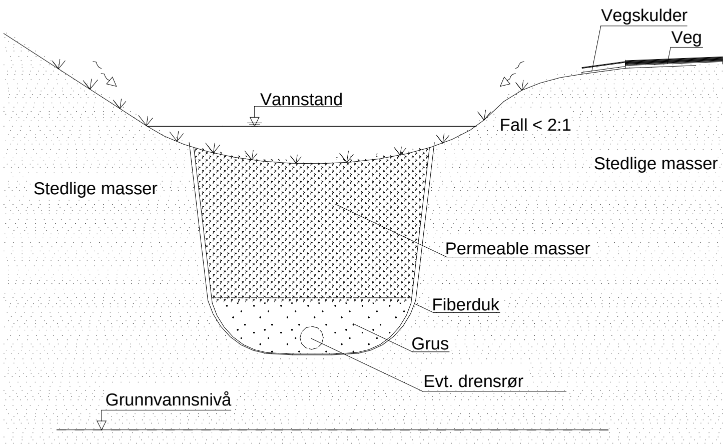
The required retention volume is determined by the largest difference between the recharged flow and discharged flow and / or the infiltrated water volume for the area. The rain envelope method or an equivalent is used to calculate the retention volume.
The possible designs for stony storages and (building) foundation storages are shown below.





6.3 Drains, canals, dikes and streams

In order to lead the run-off to local or central infiltration areas, a retention basin or recipient shall be considered that contributes to the infiltration, retention and purification of water. E.g. through the use of ditches, drainages, canals, dikes and / or streams that are shaped so that they can retard and infiltrate water. Good infiltration and / or retention can partly be achieved by the use of grass-/vegetation covered ditches with a little slope. Artificial watercourses should be established so that the water drainage time is not reduced.



6.4 Vegetation

Sometimes surface water problems are caused because the vegetation is removed. Vegetation helps to reduce run-off and improves the purification of surface water. Preservation of vegetation and / or re-establishment of vegetation are therefore an important part of surface water management. Natural landscapes (ground, vegetation) should be preserved or re-established as much as possible. Sufficiently large and suitable areas shall be preserved for this purpose. This is necessary to fulfil requirements for water infiltration, erosion control by waterways, retention storage etc. With the re-establishment of vegetation one shall use plants that are particularly suitable for this goal. This could particularly be salt-tolerant plants, plants that tolerate frost, drought, prolonged flooding etc.

6.5 Solutions in the downtown area

Surface water drainage in the city can normally be characterized as a run-off with rapid response, high peak run-off and large volumes. This is because the downtown area has a high percentage of impervious surfaces in the form of roofs, roads and areas that provide a fast and powerful run-off. A very small portion of the water is retarded or infiltrates on its way to gullies and networks. In addition, surface water has a varying content of contaminants depending on land use.

With the choice of surface water management solutions in the downtown area shall, if possible, measures be used that reduce and retain the run-off and that reduce the surface water pollution content. This can partly be achieved through more frequent utilization of permeable and semi-permeable surfaces, by the use of semi-permeable street- and square covers etc., separate clean / contaminated surface water, by more use of retention storage, by more use of open drains in the city environment, by leading roof water to the street / off-road and not directly to the sewerage network. Dam wall separations, lanes and other green- and infiltration areas along roads and squares can be adjusted for infiltration of surface water. The above solutions need to be considered for all measures within city development, there are: entries of individual buildings, revitalization of blocks /areas, street works, rearmament/refurbishment of urban spaces etc.

Surface water normally is not to be drained to the sewerage network. Dispensation from this can be given if other solutions are not possible or bring unreasonable costs. Heavily polluted surface water can be considered transferred to the sewerage system.

For all measures that bring changes in run-off conditions such changes should be documented. Measures should not worsen conditions of surface water management. Flood routes shall be safeguarded.

6.6 Recent initiatives for local run-off management

A future directed and sustainable surface water management is based on retardation and infiltration of run-off by local run-off management. As a starting point when developing new areas / facilities and the measures within existing areas / facilities local run-off management shall be investigated. Aberration from this shall be justified by the developer / enterprise and must be approved by the municipality. In following sections a number of opportunities are listed concerning local run-off management.

6.6.1 General principles

- Surface water should in principle be kept separated from other urban waste water. Contaminated surface water should be kept separated from non-contaminated surface water (e.g. roof water separated from traffic polluted water)

- Contaminated surface water should be collected and led to the discharge point where environmental damage does not occur, treated before emission whenever possible.

- Non-contaminated surface water should, if possible, be managed at the source by the use of local surface water plants or with local field control in the area.

- An increase in surface water run-off from the environment during area development is in principle not allowed. The municipality may set maximum requirements on discharge to the public pipe system.

- Surface water should be managed within the area where it is produced. Special permission is required to lead the water out of the natural watershed using artificial measures (lines, tunnels, canals,…).

- Surface water should not have a negative effect on neither groundwater quality nor -quantity, or cause other negative effects in the ground.

- Brook damping is not allowed. Re-opening of former damped brooks needs to be evaluated.

- Brook slopes / waterways must be protected against erosion and slumping.

- The potential for surface water management in green areas should be investigated. Natural vegetation is retained / replaced. Areas of vegetation, soil zone and fractured bedrock etc.

shall be used for infiltration. Infiltration possibilities should be considered with the choice of soil- and seeding type.

- Unnecessary compression of natural souls should be avoided. Construction traffic must not be allowed at infiltration surfaces.
- The environments biology / ecology should be respected (e.g. maintain / improve fish spawning- and migration opportunities).
- Emergency flood routes should always be planned / established. Traffic areas, squares, parks etc. can be considered as flood areas.
- The run-off coefficient should be reduced whenever possible. This can partly be achieved by facilitating adequate infiltration, linkage/connection of permeable surfaces and decoupling of impervious surfaces.
- The recharge time should be increased whenever possible. This can partly be achieved with the construction of a rough surface structure on the terrain / ditches, small terrain slopes, the use of ponds / thresholds, extension of recharge areas, linkage/connection of permeable surfaces and decoupling of impervious surfaces.

6.6.2 Developing areas, road construction

- Hydrological oriented land use planning and landscape design. Make advantage of natural opportunities for infiltration, retention and purification of surface water. Opportunities depend on factors as permeability, groundwater level and terrain slope.
- Establish buffers between the impervious surfaces / urban environment and waterways (filter strips, vegetation areas)
- Use of vegetation overgrown ditches along road surfaces (infiltration, purification, retention). Do not allow run-off from roads directly to vulnerable watersheds.
- Establish a minimum proportion of impervious surfaces.
- Conduct run-off from impervious surfaces to the ground, infiltration areas or retention basins.
- Facilitate diffuse run-off to infiltration areas. Point run-off should be avoided.
- Use non-impervious surface covers instead of impervious asphalt on pedestrian and bicycle roads, parking lots and traffic areas (porous asphalt, cobblestone, concrete cassettes, gravel surfaces, etc.)
- Border stones along traffic areas, parking areas and squares should be avoided where possible. Existing border stones should be removed where there is no need for them. Ditches can replace gutters. If border stones are used, they should not have openings so that water can escape from permeable surfaces. Avoid point flow to the infiltration surfaces.
- Impervious surfaces are separated by permeable borders and should as much as possible be surrounded by permeable surfaces. Such permeable surfaces / borders are designed as concave surfaces so that water from the impervious surfaces flows into these, and could have a good purification-/ infiltration- / retention effect.
- Drains are not directly connected to the drainage network. Existing pits are disconnected if local possibilities exist.
- Private retention basins or infiltration facilities can be established in the area. Blast rock fillings /-ditches in the roads and squares can be used for infiltration and retention.
- Sand-/stone traps in all supply to pipeline-/ retention systems (avoid sealing).

6.6.3 Plots

- Roof water / drainage water will normally not be connected to the pipeline network. In

existing areas roof water / drainage water should be disconnected from the combined system and transported to the ground or infiltration areas whenever possible. The gradient should fall from a building towards a terrain slope.
- The use of non-impervious surfaces instead of dense asphalt parking lots/ ramps is to be evaluated.
- Preserve the original infiltration capacity by means of land and vegetation plots whenever possible.
- With the use of green roofs, vegetation roofs can easily be used (total thickness of 8-10cm) as an alternative to heavy, traditional turf.
- Sustainable materials (building materials, etc.) should be used.

6.7 Operation and maintenance of local surface water management constructions

Plants must be designed in a way that no operational problem will occur, even under winter conditions. This can be achieved by establishing emergency overflows/drains in storages / ditches. On all supply to the storages, infiltration surfaces, etc. sand traps must be established or the equivalent to reduce or prevent supply of sand, waste etc. Easy access is needed to these points for inspection and sludge removal. Procedures for inspection and maintenance must be established.

7 REQUIREMENTS FOR MAXIMUM RELEASABLE QUANTITIES

Where the existing pipe network or recipient is overloaded or has low spare/ reserve capacity, it can be important to sett requirements on the maximum quantity to release to the pipe network / recipient. This will depend on the environment and must be assessed in each case. The developer / enterprise is responsible for the costs for the necessary measures to remain within the given requirements.

8 TRADITIONAL SURFACE WATER SOLUTIONS

Where traditional facilities for surface water drainage are built, the standards of the Water and sewerage department and other relevant regulations / standards are required with regard to design, technical solutions, material use etc.

With the dimensioning and design of networks any future connection of the facility upstream in the catchment shall be considered and preferably the system is dimensioned for such a connection.
The intake and outflow from pipeline constructions, culverts, canals etc. shall be constructed in a way that sealing, undesirable water velocity, erosion and sedimentation are avoided.

Roof run-off and leaching should preferably be led to the street / off-road and not directly to the sewage network. Street pits should be planned so that in number, design and placement the desired function will be achieved.

9 FLOOD ROUTES

Surface water management is assessed with regard to both the normal rainfall situation and flooding. If the sewage system is overloaded, clogged or destroyed, there shall be a surface water accommodation for water to run-off over the surface without creating damage.

Flood routes should be planned both on Master plan level and detailed level. Flood routes must appear in current plans (e.g. regulation plans and construction plans). Flooding routes shall be designed to drain all run-offs from the entire watershed, and should at least have the capacity equal to a 100-years flooding. The capacity of the flood route should be defined. It must be checked that the downstream area can manage the supplied volumes from flooding routes.
Road -/street surfaces, parking areas etc. can eventually be included/accounted for as part of the flood route. This requires special justification and approval by the competent authority. Flood routes on private property / land should be avoided.

10 EROSION AND SEDIMENTATION

At the planning and design stage of surface water systems, erosion control shall always be considered. This applies both to new plants (ditches, channels, ponds, etc.) and for existing facilities / waterways if measures cause increased run-off to these plants. For canals and culverts the design of the inlet and outlet should be considered in particular.

Recent measures for erosion control can be reduction of water velocity using energy dampers, plastering of slopes and in-/outlet areas, use of vegetation etc.

At construction sites and facility areas special measures should be considered to prevent undesired influence from watercourses and / or groundwater as a result of erosion, leaching and sedimentation.

11 EVALUATION OF COLD CLIMATE

Frost, frozen ground, snow/snow melt, etc. can cause problems both to conventional surface water plants and facilities for local surface water management. Challenges associated with the design and operation of surface water plants in cold climates can be of the following:

- Frost/icing in pipes
- Icing, clogging of pits/ inlets, brash of ice that obstructs the water way
- Icing on ponds (reduced cleaning and retention effect)
- Reduced oxygen level in ice-covered ponds
- Low biological activity
- Reduced sedimentation rate
- Frost heaving (geology) or frost heave (roads)
- Reduced infiltration in the ground
- Short growing season for vegetation

- Various negative effects of road salting
- Higher run-off coefficients for frozen / ice covered fields
- Large run-off of simultaneously rain and snow melt
- High pollution load at snow melting times
- Snow deposits

In the design and construction of facilities issues related to the cold climate must be considered and satisfactory conditions with regard to operation and maintenance of facilities must be safeguarded.

12 RECIPIENT CLASSIFICATION

Where the water is transported to its recipient, the receiving capacity should be considered with respect to quantity and quality. The recipient's capacity to treat pollution without pollution accumulation depends, among other things, on the recipient's volume, morphology and emptying frequency.

Essentially the recipients are divided into vulnerable and less vulnerable areas. The vulnerable areas include all freshwater deposits. In addition, sea areas with poor water quality emissions are classified as vulnerable.

If surface water is led to vulnerable areas the pollutant content should be considered with respect to treatment. Recent cleaning measures are listed in Section 13.2. In case of emission to less vulnerable areas there will in general be no need for treatment. However, at times of special high traffic load or if other conditions require it, treatment must be considered here as well.

13 SURFACE WATER QUALITY

13.1 Pollutants in surface water

Surface water contains various concentrations of suspended material, organic material, nutrients, heavy metals, PAHs, and oil / gasoline products. The contamination level varies considerably depending on land use, traffic volumes, atmospheric pollution, snowmelt quantities, precipitation volumes etc. A significant part of polluting substances is related to fine particles which occur in suspension (suspended in the water phase).

Contaminated surface water influences the environment and the possibility of a rich outdoor life in many ways. In addition to a direct effect of emissions also pollutant accumulation in bottom sediments occurs. Such pollution can be toxic to flora and fauna, cause eutrophication of watercourses and lakes and can reduce bathing water quality, etc.

The biggest source of pollution of surface water in urban areas is traffic, i.e., run-off from roads, streets, squares, sidewalks, terminal areas etc. In addition, also various types of industrial areas and buildings add to a not negligible pollution of surface water. Diffuse run-off from different surfaces and erosion off ditches, watersheds, agricultural land, facility areas etc. can also contribute tremendously to pollution of surface water (particles, suspended

matter and nutrients). Run-off from a car wash tunnel, facade cleaning, pipeline flushing etc. should also be considered especially with regard to surface water quality.
In the first phase of a rainfall shower we get the so called "first flush" effect, where the first surface run-off includes the pollutants that have accumulated since former showers. If a long time has passed since the last rainfall to run-off, such first-flush can contain large amounts of contaminants.

As the snow melts also heavily polluted surface run-off occurs by the release of accumulated pollutants in the snow (particles, heavy metals, nutrients, road salt, oil, PAHs, PCBs). Melt water from snow may contain significant higher amounts of pollutants than rain because the accumulation of pollutants in the snow happens over a long period. This should be taken into account when planning the landfill / dump sites for contaminated snow.

Surface water quality measurements must be attended in the planning of measures.
For traffic rich environments separate surface water planning shall take place, where water volumes and assumed pollution is documented and a need for treatment is considered.

The largest part of annual run-off is caused by rainfall showers with relatively low intensity. Treatment measures therefore need not necessarily be dimensioned for the largest showers. Design basics must be based on the requirements set by the recipients and the precipitation run-off distribution over the year. A curve showing the run-off distribution for the environment will thus be useful for the assessment of run-off.

If no more locally appropriate data or more precise data are available, the concentrations specified in the following table are used for estimation calculations (suggested template for concentrations (µg / l) for surface water from impervious surfaces. O. Lindholm, Vann no.4 2003)

Area type	**Cd**	**Cr**	**Cu**	**Hg**	**Ni**	**Pb**	**Zn**	**PAH**	**BaP**	**PCB**
Downtown area	0,5	5	30	0,1	10	20	140	0,6	0,1	0,01
Villa areas	0,15	4	10	0,05	6	4	30	0,2	0,1	0,01
Townhouse areas	0,20	5	15	0,05	7	5	40	0,25	0,1	0,01
Block areas	0,25	6	20	0,05	9	7	45	0,6	0,1	0,01
Business areas	0,5	5	30	0,1	10	20	140	0,6	0,1	0,01
Roads 5000 vehicles per day	0,25	3	30	0,1	4	10	60	0,3	0,1	0,01
Roads 30000 vehicles per day	0,5	5	60	0,1	10	20	140	1,5	0,1	0,01
Classification of state V (very highly polluted) for fresh water (97:04)	> 0,4	> 50	> 6	> 0,02	> 10	> 5	> 100			

As one sees the pollution content in surface water run-off from impervious surfaces is in many cases within the boundaries of class V, i.e., very strongly polluted water. Template values for nutrients (phosphorus, nitrogen) and suspended material are not shown in the table, but also for these parameters the value will normally be within the action class V. In

particular, the content of suspended substances could far exceed the limit for action class V (> 10 mgSS / l).
In the table below are various area types divided into three main categories with regard to the expected pollution content in surface water (*Stockholm VAV, 2002*). The division can be used as a general area-classification of pollution level in surface water, and together with the table in Section 13.2 it is used for an initial assessment whether the water should be treated or not.

Small house areas Local streets with NTU < 8.000 Parks, natural areas	Low pollution content
Outer city area (dense villa areas) Roads with NTU 8.000-15.000	Low to middle pollution content
City centre (living-/working areas)	Middle pollution content
Large parking- and terminal areas Roads with NTU 15.000 - 30.000	Middle to high pollution content
Traffic areas with NTU > 30.000	High pollution content

13.2 The need for treatment

The need for surface water treatment should be considered based on the recipient's state of order and the surface water quality. For existing developed areas and plants treatment may be required if measurements show high level of pollution content in surface water from the environment, or if the environment is used as aim which leads to high risk of contamination. With the design of new developing area / measures the need for surface water treatment needs to be evaluated based on pollution potential and recipient conditions.

Requirements for surface water treatment or the need for assessment of treatment can be compiled with the following matrix (*Stockholm VAV, 2002*):

	Recipient				
	Mark		**Catchment/sea**		
Pollution content	Infiltration	Soil not suitable for infiltration			
Low	Infiltration and retention	Drainage to streams or sewerage network	No treatment	No treatment	No treatment
Middle	Infiltration and retention	Drainage to streams or sewerage network	Treatment considered (eventually drainage to drain network/other recipient)	Treatment considered (eventually drainage to drain network/other recipient)	No treatment
High	Pre treatment for infiltration (eventually drainage to drain network/other recipient	Drainage to sewerage network Treatment	treatment	treatment	Treatment considered

13.3 Recent treatment measures

In Chapter 6, about local surface water management, a series of solutions is outlined that contribute to cleaner surface water. Rational/wise land use planning and resource focus, where one tries to prevent / reduce pollution where it occurs is the starting point. Adequate land use planning will largely be able to reduce urbanization applying negative effects on the hydrological conditions. This requires that a number of surface water management solutions are integrated in land use and building plans, including solutions that lead to water treatment. Then often additional cleaning measures can be avoided.

Polluting land use should be located so that run-off directly into waterways can not occur. Special treatment- or security measures for risky land use should be assessed (catch basin for effluent / leaks, oil shields etc.). Direct drainage of surface water from the impervious surfaces in gas stations, etc. to waterways or terrain must not occur.

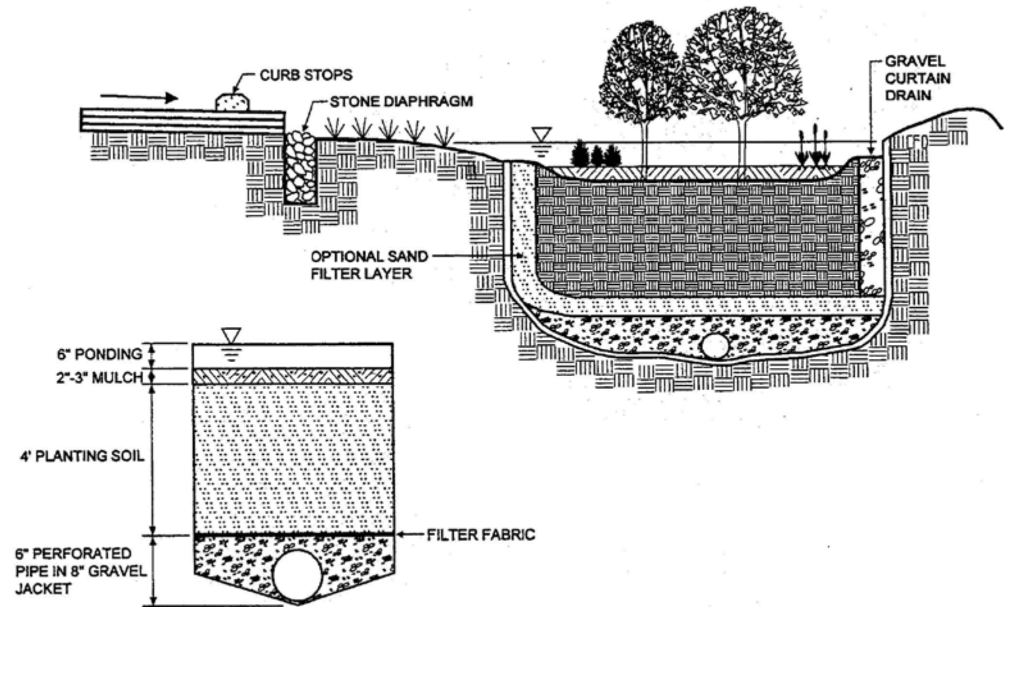
Most of the pollution components in surface water are particle bounded, so that particle removal also will remove most of the pollution, except from phosphorus and nitrogen.

Below examples of cleaning measures are listed that are representative for normal contaminated surface water. Most of these are also mentioned in the chapter on local surface water management and are usually integrated into the overall goals for surface water management.

-Infiltration areas (infiltration surfaces / storages / ponds /-ditches) where surface water is infiltrated in / to the ground either directly from the surface or via storage / ditches.
-Natural or artificial wetlands
-Ponds
-Grass-/vegetation covered ditches
-Bio filter (combined biological filter and physical filter)
-Sedimentation basin/ sludge shields
-Sand Filter
-Different types of screens or filter system
-Oil shields
- Whirl shields /hydrosyklon

For the need of cleaning a further assessment of current treatment methods is preferred. It must be emphasized that solutions are achieved that are reliable and stable regarding treatment and capacity. Surface water with much particles / sedimentary materials puts special demands on the preparation, when collided material may lead to fast clogging of different types of filters and infiltration facilities.
The illustration below is taken from the United States and shows the design of a so called? Bio retention facility including the following features:
-Purification in both the bio filter and mechanical filtering
-Retention
-Infiltration

(MDE 2000)



CURB STOPS
STONE DIAPHRAGM
GRAVEL
CURTAIN
DRAIN
OPTIONAL SAND
FILTER LAYER
6" PONDING
2"-3" MULCH
4' PLANTING SOIL
FILTER FABRIC
6" PERFORATED
PIPE IN 8" GRAVEL
JACKET

14 WORD EXPLANATIONS

Urban waste water	Common term for domestic waste water or the mixture of domestic waste water with industrial waste water and/or run-off rain water;
Run-off factor	Ratio of run-off of an area and the precipitation of that area.
Collecting systems	Drainage system where effluent and surface water are drained by a combined drainage network.
First flush	Storm run-off during the first significant rainfall of the wet season. Often is highly polluted.
Flood	Abnormal high run-off due to extreme rainfall, clogged drainage systems etc.
Flood ways	Low points- or routes in the terrain or developed areas where the water can be led through in case of flooding.
Retention	Recharged water can be retained / stored in case of high run-off, to reduce peak run-off to the downstream drainage system, watershed, area.
Xenogenic water	Infiltration- and leakage water into the drain system through leaky joints, tanks etc.
Recurrence interval	Expected return period for a certain catchment, i.e. for a rainfall with a certain intensity and durance. Ex: rainfall with 1-year recurrence interval occurs on average one time per year.
Infiltration	Water penetration to underlying layers. The more permeable the land surface, and the more porous the ground, the higher the infiltration capacity for the area.
Concentration time	The time a water drop needs to migrate from the most outer part of the watershed to a certain point in the drainage system. The concentration time is the sum of run-off time and flow time through the pipe system.
LOH/LOD	Local surface water management/Local surface water disposal
LID	Low Impact Development, i.e. gentle development with use of solution that do not or in a low means influence the natural surface water-/ ground water system
Contamination	Heavy metals, PAH's, PCB's, dioxins etc
Catchment	A limited area where al rainfall runs-off to a certain point downstream of the area, also called the watershed.
Overflow procedure	In case of overloading of the drainage system the drained water flows to recipients
Flooding frequency	Frequency of flooding/ overloading of pipe systems or other waterways. For facilities flooding occurs when the water level increases to the terrain surface or when backflow in cellars etc. occurs.
Surface water	Rainfall, effluent, melt water that flows over the surface.
PAH's	Polycyclic aromatic hydrocarbons. Some of those are toxic, mutagenic and carcinogenic.
PCB's	Polychlorinated biphenyls. A class of synthetic chlorine compounds that are toxic, very degradable and bio accumulative.
Recipient	Sea, water system or other receiver of surface water or drainage water
Separate system	Drainage system with separate pipes for resp. effluent and

Effluent/domestic waste water	Contaminated drainage water from buildings and industry.
Suspended materials	Small particles of organic and inorganic materials that float in the water.
Run-off time	The time necessary for precipitation to run-off from the far most point in the catchment to the outlet /surface water drainage.
Heavy metals	Metals that can have severe negative impact on the environment - and health (including: cadmium, chrome, mercury, lead, zinc, copper, nickel)

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