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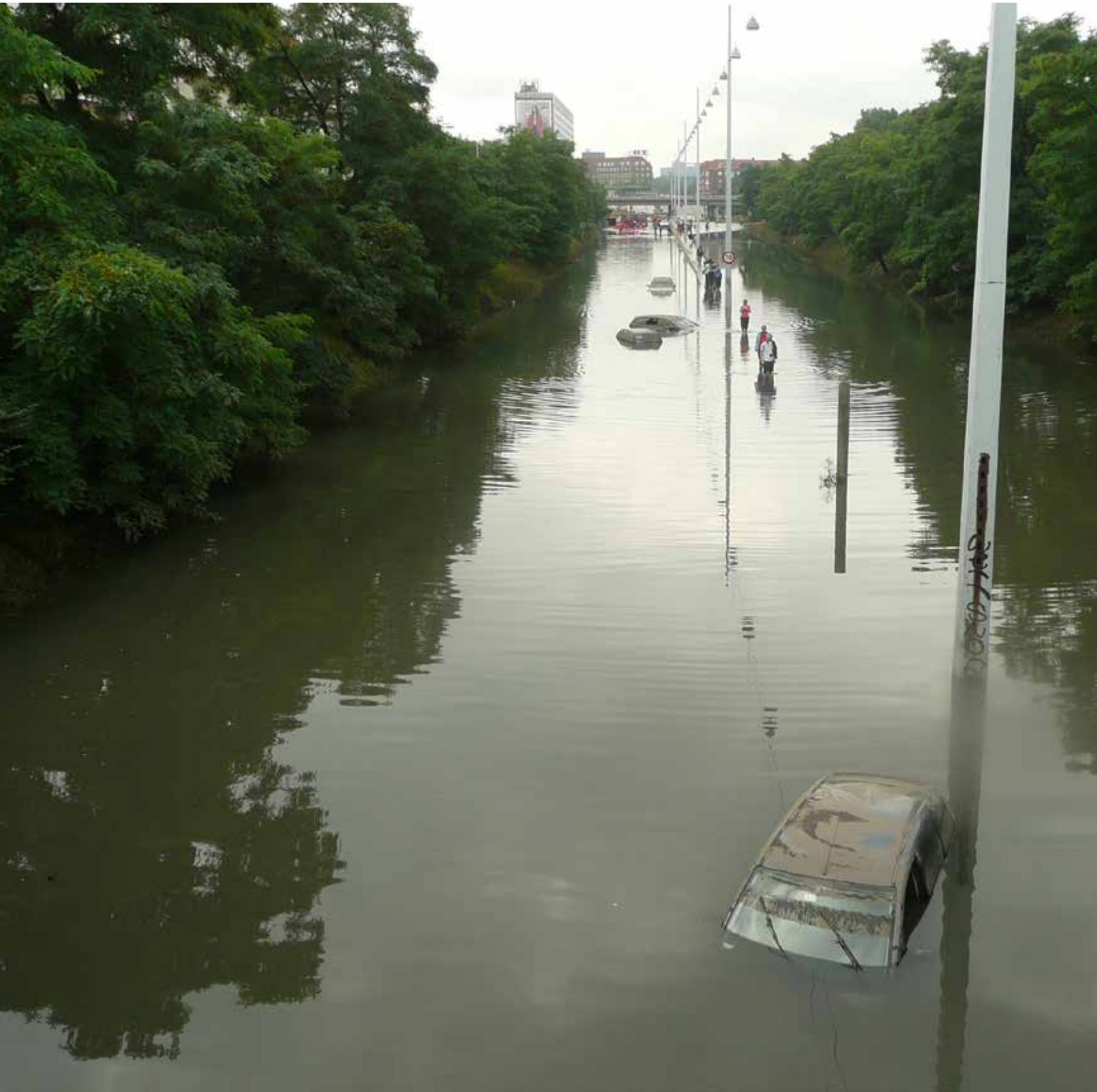
MILJØ METROPOLEN

THE CITY OF COPENHAGEN
CLOUDBURST MANAGEMENT PLAN 2012



CLOUDBURST MANAGEMENT PLAN 2012
PREFACE

Our climate is undergoing change. In future, extreme rainfall events will increase in frequency and intensity.

Copenhageners must be able to feel safe in the city where they live, also at times with massive downpours. For this reason, we need to take adaptive action against future extreme rainfall events. We can never protect the city fully, but we can prepare the city far better for the floods than is the case today. With this Plan, we are considerably raising the safety level benchmark required for Copenhagen to cope with extreme rainfall events.

The initiatives set out in this Plan cost DKK 3.8 bn and will protect the city against extreme rainfall events of an intensity seen only once in a hundred years. This sounds expensive, but last year's intense downpour caused damage to the tune of DKK 5 - 6 bn in Copenhagen. Hence recommendations point to using the money on preventing floods rather than on regeneration once the damage has been done.

Stormwater from extreme rainfall events can be drained away at or below ground level. Adaptive measures at ground level are both easier and cheaper to effectuate. New blue and green oases and recreational areas can be made by combining ground level measures with plants and trees. Hence these solutions will be preferred in those parts of the city with enough space to accommodate them. The green and blue solutions are not suitable in densely built-up areas. In certain areas, therefore, we will be implementing adaptive measures by means of subterranean tunnels.

Implementing adaptive measures to counteract intensive rainfall in Copenhagen will be a long haul lasting an estimated 20 years. That is why we give priority to flood risk hotspots and to areas where quick-response mitigating action can be effectuated.

Water knows of no municipal boundaries or title numbers. We have, therefore, collaborated closely with the City of Frederiksberg on this Cloudburst Management Plan. Future work with adaptive action in the city will be a pooled effort with neighbouring local authorities and utility companies. Copenhageners must contribute by continuing to make their properties safe. Coordinated action will make Copenhagen a safe place to live and to invest in – for us and for future generations.

Ayfer Baykal
Mayor of Technical and Environmental Administration

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1 INTRODUCTION

Future weather projections point to an increase in extreme rainfall events during summer, an increase in precipitation during winter, more days of high wind, and rising sea levels. While experts generally agree on the extent to which sea levels are expected to rise within the next 100 years, it is, on the other hand, difficult to project where and when the intensive precipitation known as extreme rainfall events* is likely to occur.

* EXTREME RAINFALL EVENT IS A TERM USED FOR BRIEF BUT VERY INTENSE RAIN. THE DANISH METEOROLOGICAL INSTITUTE (DMI) DEFINES IT AS "MORE THAN 15 MM OF PRECIPITATION IN THE COURSE OF 30 MINUTES". DURING THE EXTREME RAINFALL EVENT ON 2 JULY 2011, PRECIPITATION MEASURED CLOSE TO 100 MM IN ONE HOUR.

The City of Copenhagen is working towards achieving carbon neutrality for the city while also preparing for the extreme weather expected in the future. Copenhagen must be a safe and pleasant place to live in and to visit – now and for future generations. At present, however, there are no mitigation measures in place to deal with extreme rainfall events like the ones we saw in the summer of 2010 and again in 2011. Flooding causes numerous problems, not least economic ones, for society and citizens alike. Extreme rainfall events present enormous challenges which vary from area to area and cannot, therefore, be solved by a single initiative such as upgrading the sewerage system. For this reason, there is a need for coordinated and consolidated action combining the solutions appropriate to each area.

The City of Copenhagen initiated its climate adaptive measures in earnest after the climate summit, COP15, in Copenhagen in December 2009; on 25 August 2011, the City Council adopted the Copenhagen Climate Adaptation Plan. This plan sets the framework for the implementation of climate adaptive measures in the City Administration area.

This Cloudburst Management Plan is an offshoot of the Copenhagen Climate Adaptation Plan. The Cloudburst Management Plan outlines the methods, priorities, and measures recommended for the area of climate adaptation including extreme rainfall. With this Plan, we have taken decisive steps forward to protect Copenhagen against high-intensity rain like the ones witnessed in August 2010 and again in July and August 2011.

Concurrently with the initiatives to protect Copenhagen against flooding resulting from extreme rainfall events, work is going on to protect the city against storm surges where sea water is forced inland. Work is also going on to find new ways for the city to exploit rainwater – water is a resource we need to take great care of.

In future, rainfall events will generally increase in volume and it essential to make sure that this water does not end up in the sewerage system as it can be put to good use in green areas, canals, and basins. Another solution might be to upgrade the sewerage system, in which case there would be no water for recreational green and blue areas in the city.

The Cloudburst Management Plan has been coordinated with Københavns Energi (Copenhagen Energy), the City of Frederiksberg, and Frederiksberg Forsyning (Frederiksberg utility company), since all rainwater falling in Frederiksberg during an extreme rainfall event has to be led to either a sewage treatment plant or into the sea via the City of Copenhagen.

Furthermore, collaboration has been initiated with neighbouring local authorities who lead surface water and waste water through the city to the common sewage treatment plants or to common water courses and lakes.

2 RECOMMENDATIONS

Copenhagen needs to effect adaptive measures against extreme rainfall events and the Plan must ensure that the political decisions on how to implement these can be made on a scientifically sound basis.

The Plan is based on the Copenhagen Climate Adaptation Plan and on detailed flood mapping and risk analyses. The Cloudburst Management Plan will form the basis for the implementation of mitigation efforts in the city and will also form part of general City Administration planning.

Putting the Cloudburst Management Plan into action will take a long time. To make Copenhagen more resilient to flooding, initiatives need to be launched in the City Administration area as a whole as well as in several neighbouring local authorities. Also, a partnership approach including the City Administration, the utility companies, and the people of Copenhagen will be necessary to solve this task. An estimated minimum of 20 years are likely to elapse before the Plan has been put into action in its entirety.

SPECIFIC RECOMMENDATIONS:

Copenhagen must attain a level of resilience which limits potentially damaging floods from extreme rainfall events to the type which, statistically, occurs only once every 100 years. We talk of potentially damaging floods when water levels in streets, for example, reach 10 cm. It would be disproportionately expensive to implement adoptive measures in the city against events with return periods of more than 100 years when compared to the costs of the ensuing damage.

- At present, sewerage systems are only required to handle 10-year rainfall events and there are no systems able to handle the extensive flooding caused by an extreme rainfall event. Therefore, requirements regarding the level of flood risk mitigation in Copenhagen must be tightened significantly in future:

FROM: sewer discharge reaching ground level once every ten years
TO: sewer discharge reaching ground level once every ten years, and average water levels exceeding ground level by 10 cm once every 100 years, excepting areas specifically designated for flood control storage.

- There is a need for planning and investment in adaptive action which both protects the city against pluvial flooding and relieves the pressure on surface drains on all other days with precipitation. From a socio-economic perspective, it pays to opt for solutions which are also capable of handling ordinary rainfall which will become more frequent due to climate changes.

- Ideally, pluvial flooding adaptive measures in Copenhagen must combine solutions which make the city more green and blue by draining off rainwater at ground level. Tunnel solutions will be used in those parts of the city where no opportunities exist for drainage solely at ground level.

- Adaptive measures need to be put in order of priority taking into account both the risk of flooding and the scope for synergies with other projects such as road renovation, urban development etc.

- Estimated construction costs up to 2033 amount to a total of DKK 3.8 bn in present-day prices.

Calculations in the Cloudburst Management Plan contain both technical and economic uncertainties which will be dealt with later in this Plan in the further efforts to make Copenhagen more resilient to flooding.

3

UPGRADING CITY RESILIENCE TO EXTREME RAINFALL EVENTS

In the past, when gutters were replaced by actual surface drains in Copenhagen, a combined system was established to cope with both rainwater and waste water. In Copenhagen, the majority of the sewerage system is still a combined system where waste water and rainwater flow in the same sewer pipes. This enormous sewerage network below the city is, in fact, Copenhagen's only drainage system for surface runoff from roads and buildings.

The sewerage system lacks sufficient capacity to handle extreme rainfall events. This is why the surface drains are unable to cope when there is a massive downpour. Nor is the city adapted to handle large quantities of surface water and the result is flooding and damage.

3.1 RECOMMENDATIONS OF THE CLIMATE ADAPTATION PLAN

THE CLIMATE ADAPTATION PLAN POINTS TO TWO MEASURES WHICH ARE NECESSARY TO AVOID PLUVIAL FLOODING:

- Future-proofing sewerage function by separating rainwater from waste water
- Implementing adaptive measures to counteract extreme rainfall events in the city (Plan B)

Originally, the Climate Adaptation Plan recommended that rainwater from extreme rainfall should be evacuated by draining it to places where the flooding would cause a minimum of disruption: parks, sports grounds, open spaces, and similar. The idea was to store the rainwater in these buffer areas until the drainage system had recovered its capacity. The extreme rainfall event of 2 July 2011 and subsequent calculations have now proved beyond question that this method is inadequate in preventing pluvial flooding in large parts of the city. In fact, estimates show that the storage method – the method known as 'Plan B' in the Climate Adaptation Plan – would only be able to cover a minor part of the need for draining off rainwater. New studies show that storage should be supplemented by measures where the water is led out to sea via roads, canals/urban waterways, and subterranean tunnels. Hence the preferred solution will be drainage out to the sea via new flow routes.

The difference in choice of method between the Climate Adaptation Plan and the Cloudburst Management Plan does not mean that the goalposts have been moved, but rather that we are now better informed about this subject. A fact that was tested to the full during the heavy rains of 2 July, 2011.

3.2 METHODS OF IMPLEMENTING ADAPTIVE MEASURES IN COPENHAGEN

When protecting Copenhagen against extreme rainfall, the optimal way forward, from an economic perspective, would be to invest in a combination of measures able to handle extreme rainfall events and reduce the impact on the drainage system on all other precipitation days. This will provide the biggest socio-economic savings on damage costs resulting from intensive rainfall compared to the cost of implementing the measures.

3.2.1 DRAINING STORMWATER OUT TO SEA

The major part of the precipitation resulting from intense downpours must be drained out to sea/harbours while a minor part must be channelled to freshwater basins such as Utterslev Mose and the Lakes of central Copenhagen.

At this point, it should be stressed that the potential environmental impacts caused by the proposed drainage have not yet been studied. This is because the Cloudburst Management Plan, until now, has had the primary goal of clarifying overall conceptual measures and priorities. The environmental conditions of draining stormwater will be clarified in a subsequent project prior to drainage permissions being granted. This applies in particular to drainage to freshwater basins.

3.2.2 STORAGE OF STORMWATER

The scope for slowing down the passage from 'rain to drain' and for storing surface runoff in buffer areas during intensive downpours are decisive factors when estimating the actual need for initiating specific resilience measures. Such measures could be actual emergency flood channels, constructed canals or tunnels reserved for stormwater which would generally increase the drainage capacity. This type of measure would, in addition, help reduce damage in the city and reduce the costs of otherwise handling stormwater.

The scope for draining stormwater to areas where it can be stored temporarily causing the least possible damage has, therefore, been studied. However, calculations show water volumes from intensive downpours to be so massive that no storage capacity in Copenhagen such as green spaces, car parks, or similar would be large enough to contain the water.

The suitability of open urban spaces to store stormwater differs considerably. Paved spaces* are generally best suited while the consideration of historical and aesthetic interests tend to hamper the use of green spaces such as parks.

The selection of suitable areas must take place in conjunction with the detailed urban planning taking place in the various parts of the city.

* PAVED SPACES ARE TARMACKED OR FLAGGED AREAS WHERE THE WATER IS UNABLE TO INFILTRATE TO THE GROUND.

3.3 THE CONTRIBUTION OF FLOOD RISK MANAGEMENT INITIATIVES TO A BLUE AND GREEN CITY INFRASTRUCTURE

The City of Copenhagen has an ambition to increase the blue and green infrastructure in future. The drainage of precipitation from intensive downpours is an important element in the physical planning process in Copenhagen. Pluvial flooding adaptive measures must, therefore, be incorporated into the wider local master plans and urban development projects thereby promoting the blue and green infrastructure of the city. A blue-green infrastructure in a city expresses the correlation between water in streams, canals, green spaces, parks, and urban areas.

Mitigating pluvial flood risk in Copenhagen will contribute most to the blue and green infrastructure if the adaptive measures applied store or drain excess water at ground level. Initiatives might include reopening streams, constructing new canals or establishing lakes and more green spaces, and using roads with high kerbstones to lead the pluvial flood water into these.

However, the quantities of water that need handling are so enormous that it would be impossible to transport all pluvial flood water at ground level in the most densely built-up area of central Copenhagen. In these areas, the water can be diverted to the harbour through large pipes. They will, like the Metro, be laid deep down so as not to disrupt anything situated directly above.

Therefore, the Cloudburst Management Plan points to a solution that will protect Copenhagen by combining measures that will make the city greener and bluer by draining stormwater at ground level with tunnels in those areas of the city where ground level drainage is not possible.

4

THE LEVEL OF FLOOD-PROOFING REQUIRED FOR COPENHAGEN

It is not feasible to protect Copenhagen against extreme rainfall events covering the entire scale of severity. Regardless of how comprehensive the systems implemented, there will always be the uncertainty that an intense rainfall event will produce even bigger quantities of water. Besides, it would be disproportionately expensive to protect the city against events which, statistically, only occur extremely rarely. There is a need, however, to define an acceptable water level during floods resulting from an extreme rainfall event.

Today, it is a common and widespread practice that sewer discharge at ground level is acceptable once every 10 years as a maximum. Sewer companies are not required to protect basements against flooding. Cloudburst Management Plan recommends that these levels are raised significantly for Copenhagen.

To adjust investments to the benefits they provide, new risk dimensioning criteria must be determined. This is to be understood as the costs incurred by flood damage in a certain area multiplied by the probability of a recurrence in the same area. The result is expressed as 'DKK per year'.

RISK DIMENSIONING FOR EXTREME RAINFALL EVENTS MAY BE EXPRESSED USING TWO PARAMETERS:

- How frequently is flooding acceptable?
- What would be an acceptable water level during a flood?

4.1 WATER LEVELS DURING FLOODING

Cloudburst Management Plan analyses show that the risk of water entering basement windows in Copenhagen is negligible when water levels are kept at approximately 10 cm on roadways. Furthermore, it is quite a manageable task to adapt roads and kerbstones and also to prevent water from entering basement entrances.

Although approximately 10 cm of water on roadways is likely to reduce passability during and after an extreme rainfall event, it will still be practicable to get through by car, by bicycle, and on foot. This is why acceptable flood water levels will be set at approximately 10 cm on roadways.

This level will facilitate keeping the water on the roads thereby using these as drainage routes in the case of high-intensity rain. Also, from an economic perspective, this will be a sustainable flood water level which is illustrated in the following section.

4.2 BACKGROUND TO RISK DIMENSIONING

The probability of floods is dependent on the intensity and frequency of the downpour, a criteria known as the return period*.

* A RETURN PERIOD EXPRESSES THE MEAN TIME ELAPSING BETWEEN THE OCCURRENCES OF SAME-INTENSITY RAINFALL EVENTS. COMPARE THIS WITH THE 'RETURN PERIOD' OF LOTTERY PRIZES. SMALL PRIZES ARE MORE FREQUENT THAN BIG PRIZES, JUST AS SHOWERY RAIN IS MORE FREQUENT THAN HIGH-INTENSITY DOWNPOURS. IN BOTH CASES, HOWEVER, THE 'BIG PRIZE' MAY BE DRAWN AT SHORT INTERVALS.

To protect the city from damage caused by extreme rainfall events, a series of initiatives must be implemented including the construction of canals. The larger and more comprehensive the canals, the less damage is likely to be done and hence society will benefit from the measures. Very large canals will prevent any kind of damage from occurring, but, on the other hand, society will have to pay large sums to have them constructed and to operate them.

When comparing the costs of establishing flood defence with the costs of flood damage, you will get a cost-benefit analysis showing the economic gains or losses connected with implementing each individual mitigating measure.

Figure 1 shows these calculations with values from the various risk dimensionings based on the frequency of flooding considered to be acceptable and hence how much water the selected initiatives must be capable of handling.

All calculations are based on an acceptable water level of 10 cm. No socio-economic gains/losses scenario has been worked out regarding the level of blue-green elements in the solutions. The calculations include the fact that the mitigating measures will also serve to drain water from ordinary rainfall events. The calculations are based on the assumption that property owners are responsible for implementing heir own flood-defence measures.

GAINS FROM ADAPTIVE ACTION

Figure 1 shows that a risk dimensioning with a return period of between 20 and 400 years will result in socio-economic gains. Gains are greatest when implementing adaptive measures against the 1 in 100 year events, but there are also socio-economic gains to be had in both larger and smaller risk dimensionings. A lower risk dimensioning will mean more damage and reduced construction and operational costs. A higher risk dimensioning reduces damage insignificantly but construction and operational costs will be considerably higher.

4.3 RECOMMENDATIONS FOR RISK DIMENSIONING

WHEN DETERMINING THE CRITERIA FOR RISK DIMENSIONING, THE FOLLOWING SHOULD BE CONSIDERED:

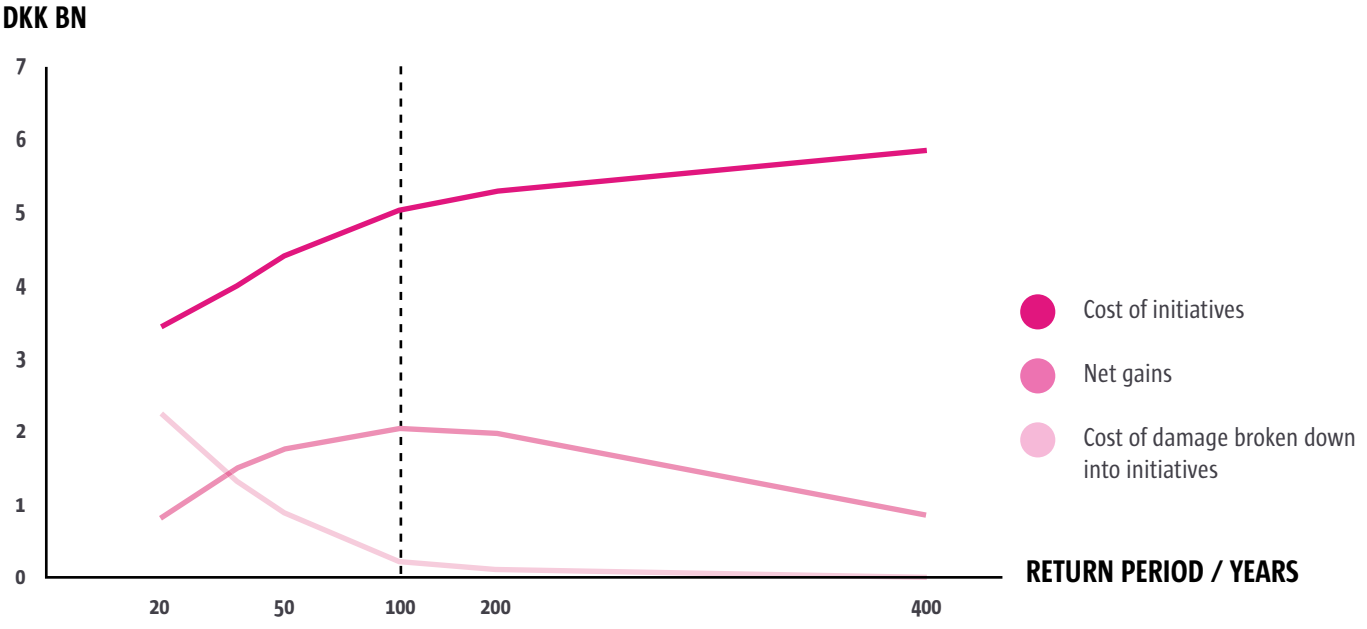
- A high risk dimensioning will result in a resilient city where damage incidents will be a rare occurrence.
- A very high risk dimensioning will increase costs without achieving significant reductions in damage incidents.
- A low risk dimensioning will keep investments down, but there will be more to pay when the damage occurs.
- A very low risk dimensioning will not reduce investments significantly, but damage incidents will rise sharply.

ON THE BACKGROUND OF THIS, THE CLOUDBURST MANAGEMENT PLAN RECOMMENDS THE FOLLOWING RISK DIMENSIONING TO BE APPLIED IN THE FUTURE:

- Formerly: sewer discharge will be allowed to reach ground level once every 10 years.
- In the future: sewer discharge will be allowed to reach ground level once every 10 years, and average water levels will be allowed to exceed ground level by 10 cm once every 100 years, excepting areas specifically designated for flood control storage.

GAINS FROM FLOOD DEFENCE MEASURES

FIGURE 1 // Net gains from flood defence measures in Frederiksberg and the City of Copenhagen. The amounts are present-day values over a period of 100 years.



5 ORDER OF PRIORITY

The City of Copenhagen has neither the capacity nor the economy to implement all measures at once. The Cloudburst Management Plan operates with a minimum time frame of 20 years. Hence there is a need for ranking the initiatives in order of priority which was also the case, earlier, with the Climate Adaptation Plan.

ESSENTIAL ELEMENTS TO BE CONSIDERED WHEN RANKING THE INITIATIVES DEFINED IN THE CLOUDBURST MANAGEMENT PLAN ARE AS FOLLOWS:

1. High risk areas
In connection with the Climate Adaptation Plan, a risk analysis was prepared. The results were presented as a risk map pinpointing the city areas with the highest risk of flooding (expressed in DKK) and, consequently, where adaptive measures would have the biggest effect. (See map at the back of this Plan)

2. Areas where measures are easy to implement
Areas where, by applying relatively simple measures, pluvial flood water can be drained to localities where it will not impact. These would be areas close to the harbour such as Ny Kongensgade and Ved Stranden where pluvial flood projects were carried out in 2012 to protect the areas against flooding by making openings in the quay thereby allowing the rainwater to drain into the harbour.

3. Areas with ongoing urban development projects
The costs of pluvial flood projects can often be reduced considerably if they are implemented in conjunction with renovation projects and new urban development projects. A good example is road renovation.

4. Areas where synergistic effects can be gained
Synergistic effects may be gained by combining flood risk initiatives with those of other urban schemes such as local authority water directives.

5.1 DIVIDING AND PRIORITISING THE CITY INTO WATER CATCHMENT AREAS

A water catchment area is an area where all precipitation will flow along the same route at extreme rainfall events. Basically, it is the ground level variation in an area which will determine which way the water will flow, but in a city, built-up areas will, at times, dictate a redirection of the flow. The routes taken by the water are known as flow routes. Figure 2 shows the major flow routes in the Cities of Copenhagen and Frederiksberg.

FIGURE 2 // Copenhagen flow routes
The flow routes start at the point where the lines are thin and become thicker proportional to the quantities of water flowing into them. You will notice that all flow routes end in the sea despite the long distance travelled in some cases. (See larger map at the back of this Plan)

To make the work of prioritising solutions and measures more manageable, Copenhagen has, for the purpose of this Cloudburst Management Plan, been divided into 26 local water catchment areas as shown in Figure 3.

Each water catchment area is assessed according to the following four elements: risk, implementation, coherence with urban development projects and synergistic effect. This means that action will be given a higher priority in areas with a high flood risk where measures are easy to implement and will achieve good synergistic effects with urban development projects or other kinds of urban planning. The result of a weighted ranking is shown in Figure 3.

With a time frame of around 20 years before the Cloudburst Management Plan is fully implemented, it will be necessary to set a number of measures in motion in different water catchment areas simultaneously. This is not to say, however, that the adaptive action must be completed in one area before initiating activities elsewhere. The coordination of the pluvial flooding projects with ongoing urban development projects all over the city will mean that activities will be underway at several sites simultaneously, in any case. Finally, it might be necessary to deviate totally from the ranking order as work must be continuously coordinated with road renovation work, for example.

In some water catchment areas, natural water courses are used as main flood ways such as the water catchment area of Harrestrup Å (stream) located at the western Administration boundary. In most other districts, however, new main flood ways must be established to drain pluvial flood water away. These flood ways should be positioned in places where the water would course naturally and, as set out in the Climate Adaptation Plan, green recreational solutions should be preferred where possible to gain most from the investment. When selecting a solution model, it is important to see it in the context of the blue-green infrastructure of the city.

The final decision on methodology and the positioning of flow routes will be made as part of the ongoing work with the Cloudburst Management Plan when the individual climate adaptive measures will be planned in detail.

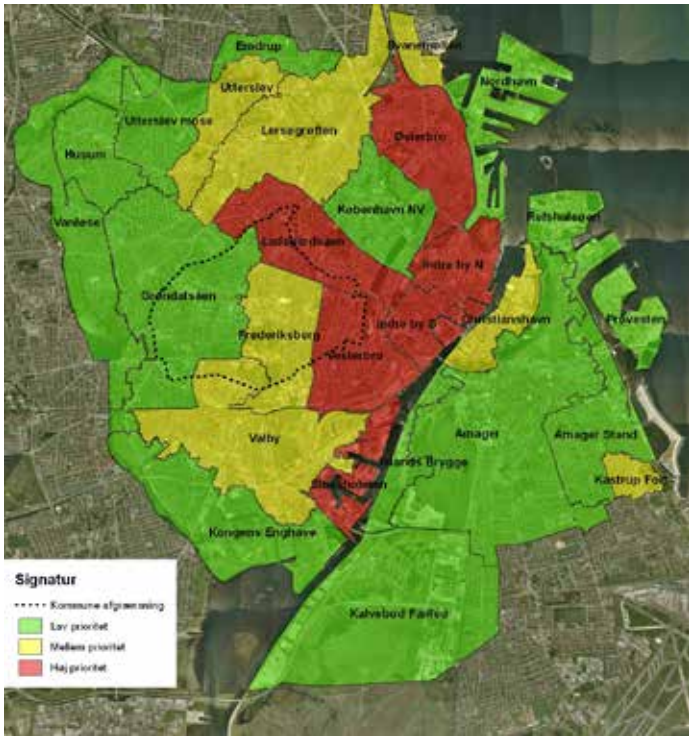


FIGURE 3 // PRIORITISING ADAPTIVE MEASURES
The map shows the priority of measures in the water catchment areas of Copenhagen – at three levels according to risk, implementation, and synergistic effect with urban planning and development projects.

6

LEGISLATION, RESPONSIBILITY, AND FINANCING

Present legislation on the environment and waste water does not provide sufficiently for the optimal handling of increasing quantities of pluvial flood water seen from an environmental and financial perspective. The City of Copenhagen has, therefore, tabled a number of proposals for amendments to be considered by the Danish Ministry of the Environment.

6.1 PROPOSAL FOR AMENDMENTS

City of Copenhagen proposals for amendments primarily concern amendments regarding payment rules relating to waste water and the Planning Act in Denmark.

Existing legislation obstructs the implementation of measures where existing roads will be used as flood ways for pluvial flood water. This is because the utility companies are only allowed to finance projects relating directly to waste water handling. A flood risk solution where roads, for example, were to be used to drain pluvial flood water cannot, with the present legislation, be financed by revenues from charges. If Københavns Energi (Copenhagen Energy) and Frederiksberg Forsyning (utility company) are to implement these measures, it will be necessary to designate the roads, in part, as waste water plants. This, however, is not feasible with the present Payments Act, Roads Act, and Environmental Protection Act.

6.2 METHODS OF FINANCING

The climate adaptive initiatives in Copenhagen will be financed by a combination of public and private investments. Private homeowners, on one hand, and the City Administration and the utility company (Københavns Energi) via taxes and revenues from charges*, on the other.

* REVENUES FROM CHARGES COMPRISE THE DRAINAGE CHARGES PAID AS PART OF THE PRICE FOR EACH M3 OF WATER PURCHASED FROM THE WATER COMPANY.

At present, there are clear definitions regarding the kind of investments sewer companies are allowed to make and to charge for. Likewise, there are clear rules regarding the City Administration's collection of taxes to finance climate adaptation measures. But rules allowing the utility company to finance climate adaptation measures that are over and above ordinary sewer services remain unclear.

The City of Copenhagen expects that the Danish Ministry of the Environment will clarify the legal barriers that are obstructing the effective implementation of climate adaptation measures during 2012-13 (see section 6.1).

If the Danish Ministry of the Environment were to make the amendments which the City of Copenhagen has recommended, the financing of the adaptive measures could be distributed as shown below.

In the case of private properties where there is a big risk of flooding from ground level, it will, additionally, be necessary to implement measures to protect against flooding through light wells, basement entrances, etc. The level of flood defence required must be assessed for each individual property via flood mapping. It is not possible, therefore, to put an exact price on this measure at the present time.

METHOD OF FINANCING	DESCRIPTION	CAPITAL COSTS
PRIVATE FINANCING	Initiatives for private properties consist of flood-proofing them in areas with common sewerage systems* during extreme rainfall events. This could be done by installing an anti-flood backflow valve* on the private service pipe* or by discontinuing floor drains in basements. For those private properties where there is a risk of flooding from ground level, it will also be necessary to implement measures protecting basements from flooding via light wells, basement entrances, etc. The need to protect against flooding must be assessed for each individual property via flood mapping. It is not possible, therefore, to put an exact price on this measure at the present time.	Calculated capital expenditure for implementing these measures is estimated at approximately DKK 1.2 bn in present-day prices.
FINANCING BY CHARGE REVENUES	By far the majority of the adaptive measures must be financed by the revenues from charges collected by the utility company.	If this Plan's recommendations of risk dimensioning to protect the city against a 100-year event together with the combined measures are adopted, the estimated capital expenditure via revenues from charges is estimated at DKK 2.2 bn in present-day prices.
FINANCING BY TAXES	Those adaptive measures carried out at ground level and combined with green and recreational solutions must be financed by municipal tax revenues if they exceed the limit imposed by financing via revenues from charges..	These measures will amount to DKK 400 m in present-day prices.

* A COMMON SEWERAGE SYSTEM MEANS THAT WASTE WATER AND SURFACE RUNOFF FLOW IN THE SAME PIPES.

* AN ANTI-FLOOD BACKFLOW VALVE IS A DEVICE MOUNTED TO ONE OR MORE SERVICE PIPES IN A PRIVATE PROPERTY. THE ANTI-FLOOD BACKFLOW VALVE BLOCKS THE DRAIN IF THE WATER IS PRESSED BACK THROUGH THE SERVICE PIPE.

* A SERVICE PIPE IS THE PIPE CONNECTING THE INDIVIDUAL PROPERTY WITH THE MAIN SEWERS.

6.3 TOTAL INVESTMENTS 19

The speed with which the Cloudburst Management Plan will be implemented is a political decision but, technically speaking, it could be done over a period of approximately 20 years.

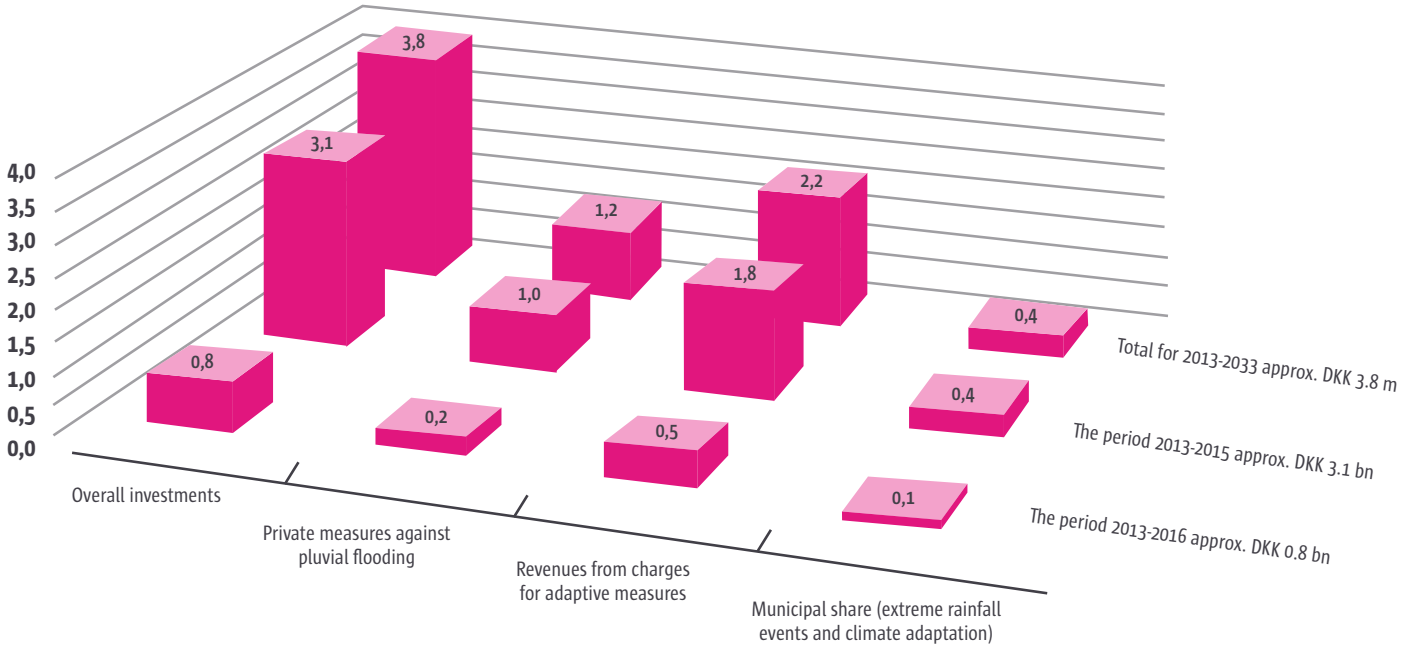
Figure 5 shows the estimated total costs during the period broken down into private, revenue-financed, and municipal investments. The period is furthermore broken down into three intervals: 2013-2016, 2016-2025, and 2026- 2033. Those measures which are easy to implement and those able to drain the largest quantities of water hence limiting most incidents of pluvial flooding are expected to be implemented during the first two investment periods.

6.4 ALLOCATING RESPONSIBILITY

To make the city more resilient to pluvial flooding will require action by at least three players: property owners, the utility company, and the City Administration.

- Property owners are, basically, responsible for flood-proofing their properties on private soil. This might involve protecting basements by means of anti-flood backflow valves, ground level adjustments, raising the sides of light wells, basement entrances, etc.
- The utility company is responsible for ensuring that drainage systems meet the service levels, i.e. that an average of one occurrence of sewer discharge to ground level is permitted per 10 years. The utility company is not responsible for protecting privately owned basements.
- This Plan will also allocate responsibility to the utility company for implementing adaptive measures in accordance with the new risk dimensioning (see section 4).
- The City Administration is, in its capacity of urban planning authority and owner of the utility company, responsible for ensuring that the adaptive measures will be incorporated into the municipal master plans and implemented. The City Administration will also be responsible for climate adaptation/redirection of water courses.

Figure 5 // Overview of the economic consequences of the Cluodburst Management plan during three periods: up to 2016, up to 2025 and overall up to 2033. All prices are present-day prices (2012) – without discounting – exclusive of financing charges, and exclusive of VAT.



7

EMERGENCY RESPONSE PLAN

The high-intensity rain of 2 July 2011 showed that there is a need to prepare the city for similar incidents in the future. When the projects contained in the Cloudburst Management Plan are implemented, the city will be much better prepared to handle extreme rainfall events.

A number of years will elapse, however, before the initiatives and projects stipulated by the Cloudburst Management Plan will be implemented throughout the city. There is a need, therefore, to have an emergency response plan in place to mitigate the worst damage from an extreme event until the city's resilience to extreme weather events has been secured.

Therefore, a plan of action has been made to mitigate pluvial flooding. The plan details those areas especially at risk from pluvial flooding together with buildings and facilities which are particularly important to protect. These include, for example, critical institutions such as hospitals.

To reduce the risk of pluvial flood damage to critical institutions, municipal emergency response units have been significantly consolidated in 2011 and 2012. Pumping capacity has been increased and collaboration with neighbouring emergency response units has been intensified.

As the initiatives of the Cloudburst Management Plan are being implemented in various parts of the city, the need for emergency response will also be reduced. It will, however, still be necessary to retain an element of emergency response, even after the Cloudburst Management Plan has been fully implemented, as the city cannot be protected from all imaginable incidents (see section 4 about determining the level of protection against flooding).

Retaining an emergency response plan after the Cloudburst Management Plan has been fully implemented means that the city will be adequately prepared when striving to mitigate the consequences of future extreme rainfall events.

8

POSITION IN RELATION TO OTHER PLANNING ACTIVITIES

The Cloudburst Management Plan is not per se legally binding – neither for property owners, the utility company, nor the City Administration. To have an effect, the contents of the Cloudburst Management Plan needs incorporating into the Administration's general planning process: primarily the Municipal Master Plan, sectoral plans (Waste water Plan) and local master plans. Furthermore, urban renewal plans and local neighbourhood facelift schemes should incorporate the Cloudburst Management Plan into their drafting.

Finally, and depending on the wording of the notified amendments, it might be necessary for the Plan with its specifications to e.g. risk dimensioning to be adopted by the Board of Directors of Københavns Energi.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THE NEXT PHASE

The work involved in the next phase of the Cloudburst Management Plan gives rise to a number of new issues and projects which are essential with regard to implementing the Plan.

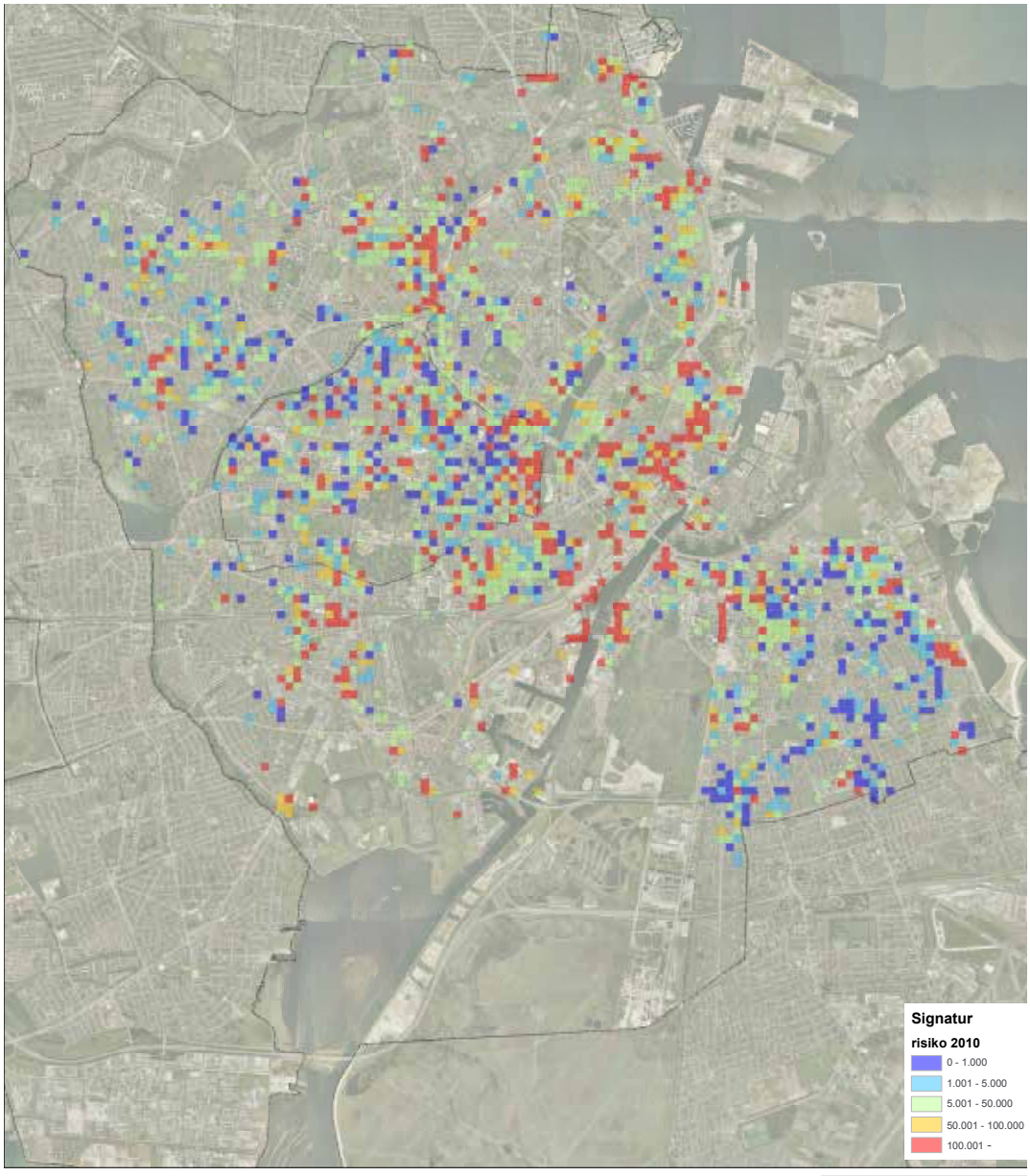
First and foremost, there is a need for clarification of the legal framework for climate adaptation such as the proposals for amendments described earlier. These issues must be clarified before the projects can be realised:

- A detailed project must be worked out for each of the water catchment areas in the Cloudburst Management Plan in order of priority.
- Any effects on the environment as a consequence of draining pluvialflood water to the harbour and, in particular, to freshwater basins, must be clarified prior to giving drainage permission. It is important that this project is initiated quickly as the detailed project work regarding the water catchment areas is dependent on the result.
- There is a need for future-proofing the hydraulic impact and capacity of the water courses*.
- Two intermunicipal projects must be studied closely: one for Harrestrup Å's water catchment area including Herlev, Ballerup, Frederiksberg, Gladsaxe, Rødovre, and Hvidovre local authorities and one for Søborghus Rende-systemet (drainage ditch-system) with Gentofte and Gladsaxe local authorities. The objective of these projects is to climate-adapt the impact on and possibly also the capacity of these water courses so that they can form part of the general flood-proofing measures of the city.
- Detailed planning of flood ways must be coordinated with the neighbouring local authorities including, in particular, the City of Frederiksberg.

* HYDRAULIC CAPACITY EXPRESSES THE QUANTITY OF WATER A GIVEN WATERCOURSE CAN HANDLE MEASURED IN LITRE PER SECOND.

APPENDICES

Copenhagen Flow Routes
The flow routes start at the point where the lines are thin and become thicker proportional to the quantities of water flowing into them. You will notice that all flow routes end in the sea despite the long distance travelled in some cases.



This map shows the areas of Copenhagen with the highest risk of significant damage as a result of high-intensity rainfall *

* THE MAP ILLUSTRATES THE AREAS IN THE CITY WHERE ADAPTIVE ACTION IS REQUIRED AND THIS WILL BE USED AS A BASIS FOR RANKING THE ACTIONS INTO A FIXED ORDER OF PRIORITY TOGETHER WITH THE REST OF THE CRITERIA IN SECTION 5 ABOUT ASSIGNING PRIORITY.

RISK IS EXPRESSED AS THE LIKELIHOOD OF DAMAGE MULTIPLIED WITH THE DAMAGE COSTS. THE FIGURES IN THE KEY TO SYMBOLS EXPRESS AMOUNTS IN DKK ADDED UP OVER A PERIOD OF 100 YEARS.

Svanemærket tryksag

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