# A PLANNING TOOL & A WORKING METHOD WHEN CREATING A STORM WATER MANAGEMENT PLAN

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## ABSTRACT
A planning tool and a working method has been developed and used for storm water management in e.g. whole municipalities or for specific surface waters. The storm water and recipient model tool StormTac has been used. It is as a simple-to-use forecast tool (requiring little input data) for water quality to use when making action plans for storm water and surface water, e.g. to address issues linked to the EU water framework directive.
Sweco Environment has together with several municipalities implemented and further developed a useful planning-level tool for storm water and watershed management calculating the runoff water flows, pollutant loads, acceptable load to the receiving waters and required pollutant load and flow reduction.
Measures for flow detention, preventing floods and for storm water treatment have been proposed. Here the results and experiences from the two Swedish municipalities are presented.

## KEYWORDS
Storm water; material transport; planning; watershed management; StormTac

## INTRODUCTION
Storm water originates when precipitation and snowmelt runoff does not infiltrate into the ground but instead becomes surface runoff. The storm water may transport large loads of nutrients and pollutants to the receiving waters resulting in eutrophication and impaired water quality. As a result of increasing urbanization the amounts of impermeable surfaces and therefore the surface runoff are increasing, affecting the water quality in the receiving waters.

In 2000 the Water Framework directive was adopted within the European Union with the aim to improve the water quality in Europe. As a part of the directive the water quality in Sweden were analysed and mapped. The analysis showed that one of the biggest issues in southern and central Sweden was and still is eutrophication, partly due to the load of nutrients in the storm water. Numerous municipalities in Sweden have recognized the problem and are starting to address how to reach the goals of the directive. To be able to optimize measures needed to be taken to decrease the effect of storm water on the receiving waters some municipalities have developed watershed management plans.

Sweco Environment has together with several municipalities implemented and further developed a useful planning-level tool for storm water and watershed management. Calculating the runoff water flows, pollutant loads, acceptable load to the receiving waters and required pollutant load and flow reduction. After studying the overall pollutant and flood situation, actions needed to be taken to improve the water quality and to decrease the number of floods have been proposed.

The objective with this paper is to share the methodology, approach and process when creating a storm water management plan. But also to share our experience in order to help other municipalities to cope with the measures that will be needed to be taken to reach the goals and the requirement within the Water framework directive. The aim is also to provide better understanding of urban water management.

**METHODS**

There is generally a need for simple-to-use forecasting tools when creating a management plan in order to be able to make a priority of measures resulting in the best result for the receiving waters. A requirement is that the model should be able to work using a reasonable amount of input data. The tool and working method chosen in both Tyresö and Upplands Väsby is the existing tool and model StormTac.

StormTac is a watershed management model for the quantification of concentrations and material transport in discharge points and from different land uses. The model can also be used for designing storm water treatment facilities and to study effects on receiving waters. It is a simple model that requires few input data, the only obligatory input data is watershed area per land use, and the area and volume of the receiving water if acceptable load shall be calculated. More input data can be added, if desired. The model is best suited for long-term, i.e. not dynamic, predictions and employs a watershed system approach, i.e. the system boundary is natural not administrative. The material transport calculations employ standard values of runoff coefficients and pollutant concentrations together with precipitation data and estimated areas of different land uses within the subwatershed. A very fine selection of both urban and rural land uses is possible to define, e.g. detached houses, terraced houses, apartments, industrial, commercial, forests, meadows and agriculture. A large amount of pollutants can be chosen for calculation (nutrients, metals, suspended solids, oil, PAHs etc, both in total or dissolved fractions). The land-uses and pollutants are continuously being updated to reflect time trends and new available measured data of more and more pollutants. During 2011 the plan is to update the model with land-use specific standard concentrations for all 33 substances of priority within the water framework directive, and also with the concentration criteria in surface water of these substances. Included system components, all integrated in one model are surface water, storm water, groundwater, agriculture (farmland), atmospheric deposition, other point sources (e.g. from waste water treatment plants), treatment, transport and detention facilities.

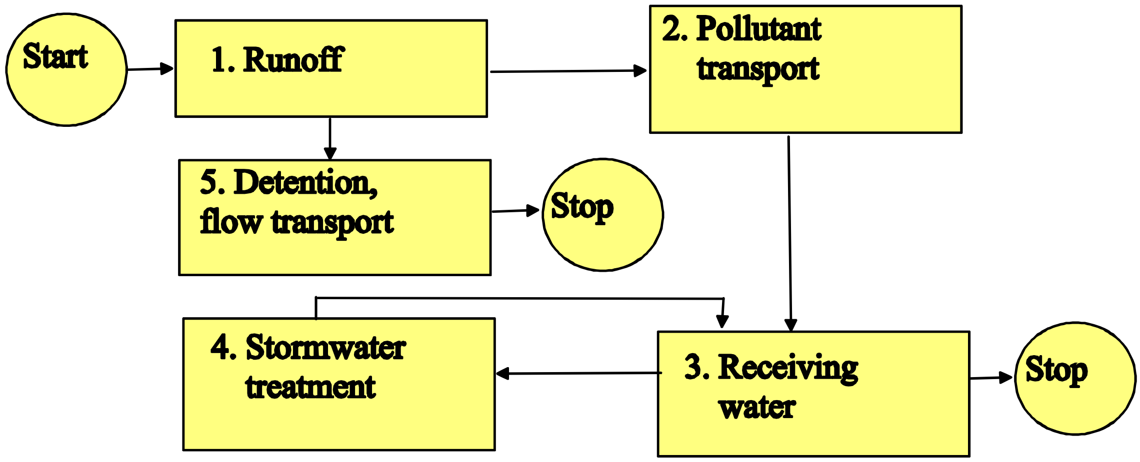


**Figure 1** Simplified flowchart of the watershed management model StormTac.

In the process of developing a storm water management plan the sub watershed areas are first identified and quantified. These areas are specific for each discharge point and separated into different land uses. Topographical maps and the technical storm water sewer systems within the areas are studied. The next step is to calculate the runoff water flows and pollutant loads using StormTac. When the largest pollutant sources have been identified, possible treatment measures are considered before discharge to the receiving waters. However, other factors must also be considered. These include comparisons of calculated concentrations and loads to estimated limit concentrations and acceptable loads to avoid ecotoxicological effects in the receiving water. Therefore measured data in surface water are compared to environmental quality standards (EQS), i.e. water quality concentration criteria within the Water Framework directive. If the measured concentrations exceed the criteria, measures to reduce the pollutant external and/or internal loads are to be taken and different types of storm water treatment facilities are proposed. The model is able to quantify needed load reduction and the effects of different measures on the concentration in the surface water. Furthermore the net yearly internal load within the receiving water is calculated.

Examples of measures which can be simulated in StormTac are changed land use and pollutant source control, storm water treatment and detention facilities (e.g. wet and dry ponds, wetlands, filter strips, swales and detention basins). The types of facilities to be used also depend on the site-specific conditions such as soil, groundwater level and topography.

When the types of measures have been identified cost-benefit analyses is performed in the model by calculating facility costs and reduced loads. The results of the calculations are used to make a priority between different measures.

## RESULTS

The calculations are carried out in the watershed management model StormTac (www.stormtac.com) and the results are presented in a GIS format.

The aim with the watershed management studies is to answer the following questions with help from the model and working tool:

- How are different land uses (roads, residential areas, forests etc.) distributed and which areas contribute with fluxes to a specific discharge point or receiving waters?
- How large are the water flows generated in the sub watershed areas?
- How large are the pollutant concentrations (mg/l) in the storm water runoff from different land uses and in the discharge points to the receiving waters?
- What pollutant loads (kg/year) can be expected to the receiving waters from each discharge point and where are the largest points of discharge located?
- What are the conditions of the receiving waters (nutrient and pollutant concentrations)?
- What are the acceptable loads (kg/year) and the required load reduction?
- Where have floods been reported as a problem (capacity problems of the transport system)?
- What are the required detention volumes and places for flow reduction measures?
- Where are storm water measures to be considered and what kind of measures are relevant due to site-specific conditions?
- What are the receiving water quality criteria, e.g. the environmental quality standards (EQS) according to the EU Water directive or other criteria?

Here we describe and present the process with pictures showing the steps from pollutant mapping, presenting examples of existing and proposed measures and finally presenting built measures as results. We begin with Tyresö municipality and continue with Upplands Väsby municipality.

The first watershed management plan was performed in 1998 in Tyresö municipality and then in 2001 in Upplands Väsby. These plans are now being updated with new areas and with updated concentrations of pollutants in the runoff from different land-use. The plans are also adapted to comply with the criteria for the receiving waters within the Water framework directive and to new requirements and regulations within the municipality.

Figure 2 presents a map of phosphorus load from subwatershed areas in Tyresö municipality. There are similar maps of other pollutants which gives an overview of the pollutant situation and a basis for pollutant treatment measures.

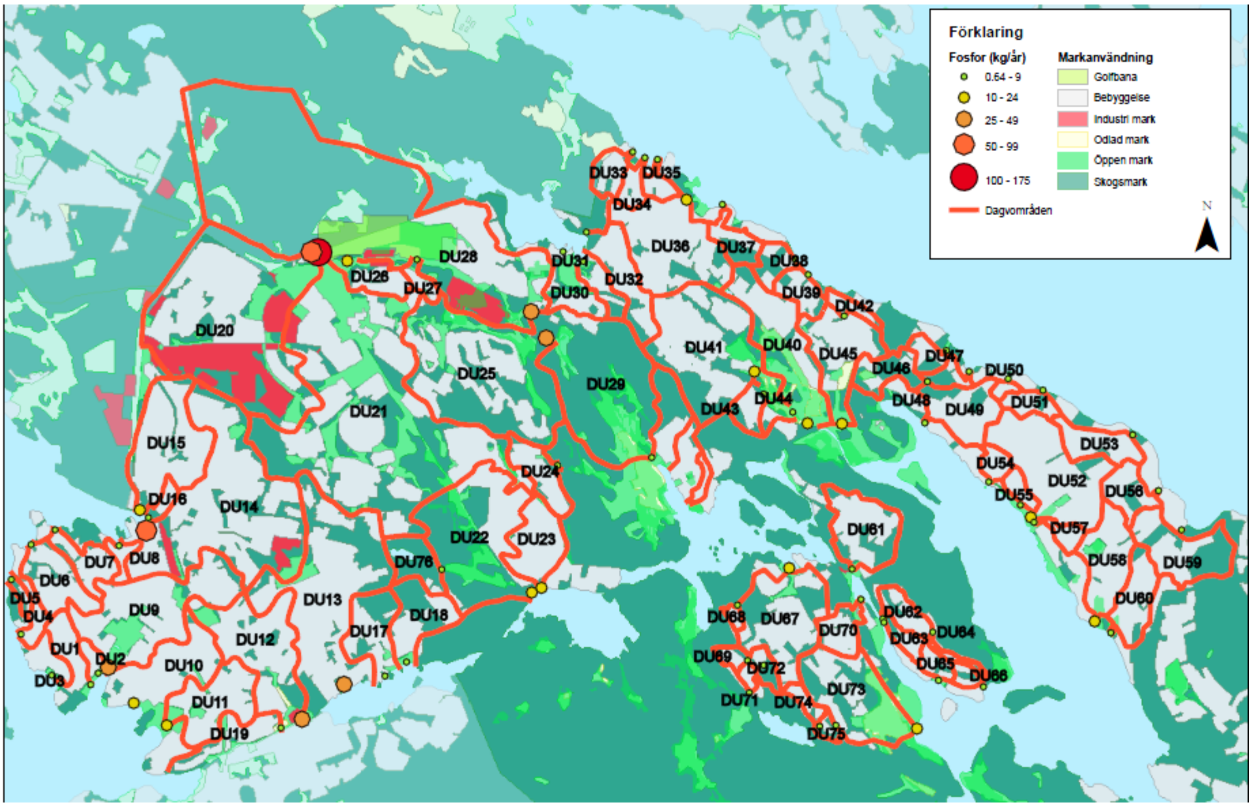


**Figure 2** GIS map of the municipality of Tyresö with an overview of the phosphorus load from different areas in the municipality 2010.

For studying pollutant emissions as basis for estimating required treatment measures, consideration should preferably be taken to pollutant load (kg/year) from the study area and from adjacent areas to the receiving waters for comparison, and (if possible/relevant) the total load on the recipient. Pollutant load in storm water are generally more relevant than pollutant concentrations when studying the effects on receiving waters. Criteria concentrations in the water mass of the recipient may be estimated, the changed concentrations in the receiving waters may be calculated and the load reduction on the recipient after treatment, if required. Furthermore, the acceptable load on the recipient, to comply with the recipient criteria, and the required reduction load are to be calculated, e.g. by StormTac. Such calculations are in general more relevant to use than the storm water concentration criteria alone. This described "Integrated acceptable/allowable load method" is a major feature of StormTac and is generally recommended instead of using only storm water concentration criteria. In some cases, it may however be difficult to only estimate required measures based on load, for instance if the studied load is very small compared to much larger total load to very large recipients. In such cases, it may be difficult to know how much load is required to be reduced within a facility. A design for selected concentration criteria may then be an option.

Figure 3 presents existing and proposed measures for both flow detention and pollutant treatment. The suggested measures and sites are a result of model simulations of required areas and volumes that have been compared to available areas and volumes. They are also a result of performed site visits.

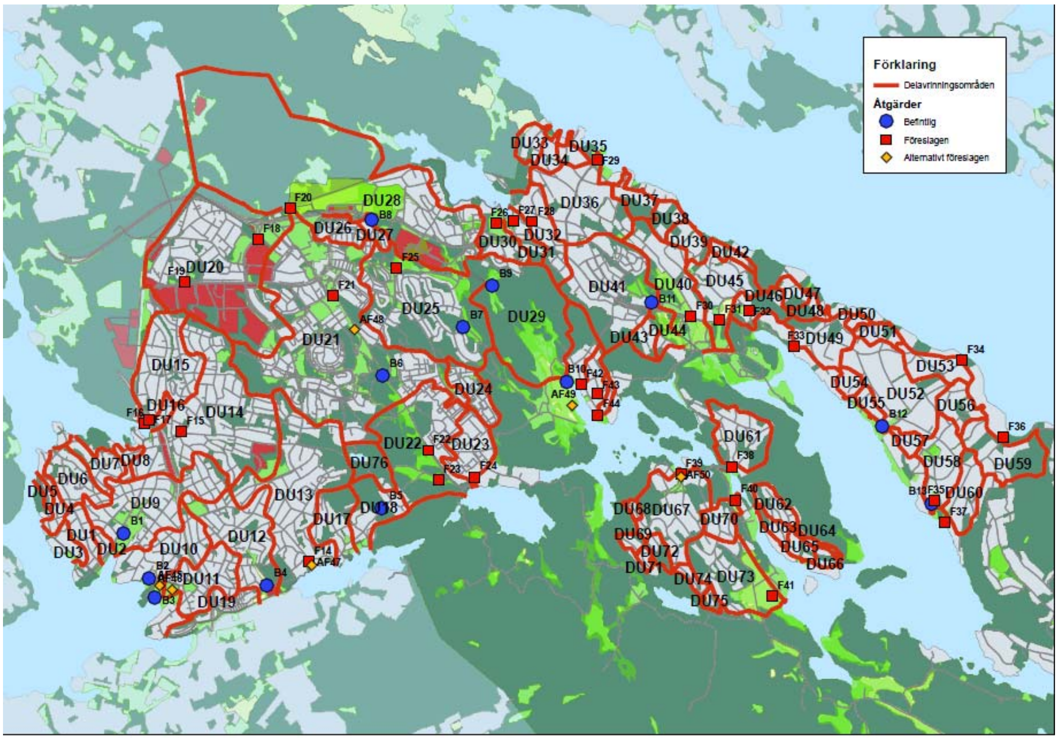


**Figure 3** Map of existing and proposed detention and treatment measures in Tyresö municipality.

Figure 4 presents proposed detention measures for reducing floods in one of the subwatershed areas in Lindalen, Tyresö and shows a proposed place for one of the suggested detention dry ponds.

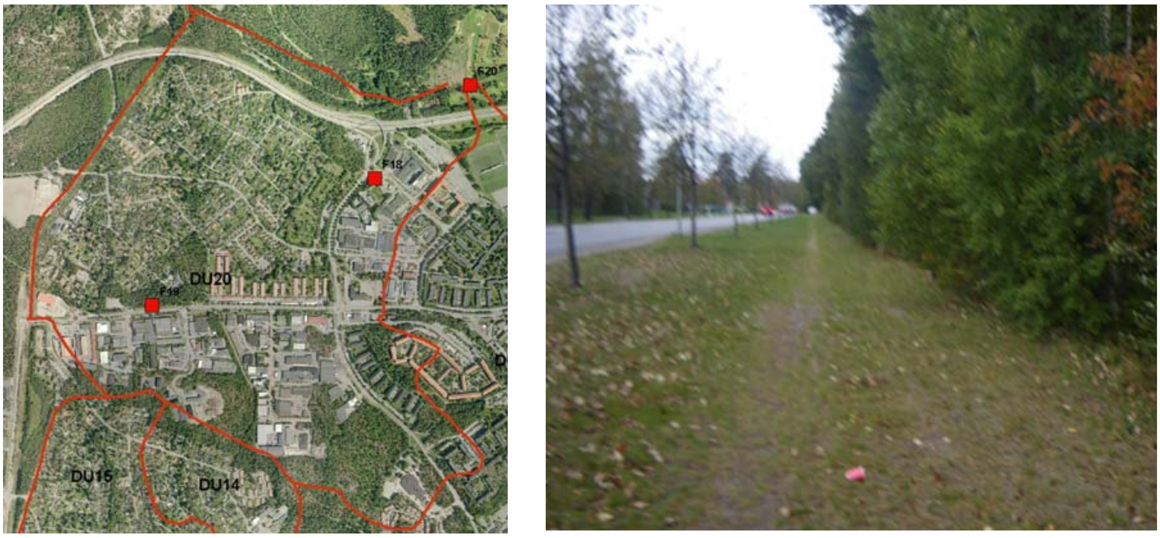


**Figure 4** To the left proposed detention measures for reducing floods in one of the subwatershed areas in Lindalen, Tyresö. To the right the proposed place for a dry detention pond, adjacent to the road Bollmoravägen in Tyresö.

Figure 5 presents a built wet pond for treating storm water from a subwatershed in Fornudden, Tyresö. It is a result of the first watershed management plan.

**Figure 5** A wet pond facility in Fornudden, Tyresö. A result of the first watershed management plan.

Below we present the watershed management for Upplands Väsby, beginning with an overview map from their first plan that is now being updated, showing the watersheds of the lakes and proposed places for storm water treatment facilities, see Figure 6. The map also presents where the pollutant acceptable load of different pollutants in the lake is exceeding the lake water quality criteria. Different pollutants in the runoff are important to reduce in different lakes depending on the conditions in the lake. This is a basis for deciding the type of facilities that are to be proposed.

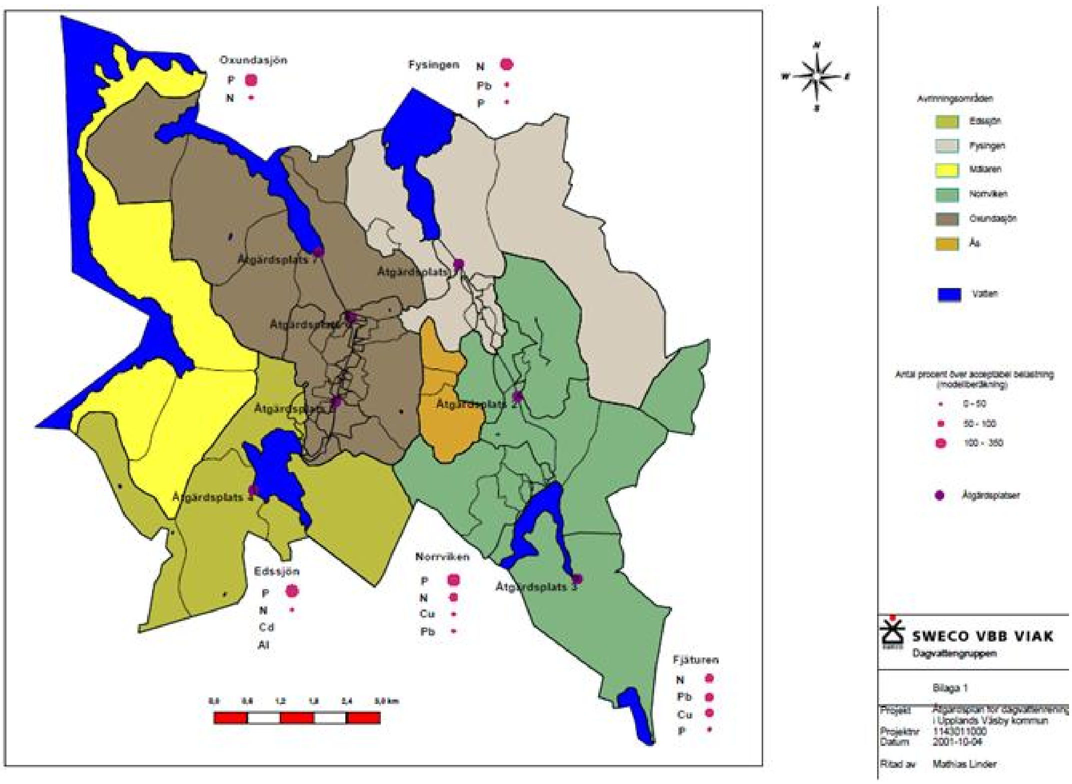


**Figure 6** An overview map of lake watersheds in Upplands Väsby, places of proposed storm water treatment facilities and which pollutant acceptable loads are exceeded.

Figure 7 presents a map of the part of Lake Oxundasjön that is situated in Upplands Väsby municipality and the subwatershed areas. It also presents the proposed location of a storm water treatment facility both in the map and at sight before and after a treatment facility including a wet pond with a filter strip or wetland area that was built during 2001. The pond treats the storm water from the central areas of Upplands Väsby. This was a direct result of the management plan.


**Figure 7** To the left a map of the part of Lake Oxundasjöm that is situated in Upplands Väsby municipality and the subwatershed areas. A proposed location for a storm water treatment facility is marked in the map. In the middle the proposed area for a treatment facility, Ladbron, Upplands Väsby, before the pond was constructed. To the right the constructed storm water treatment facility Ladbrodammen, a result of the first watershed management plan.

With the use of the planning tool, the largest pollutant discharges in the municipalities are identified. This information, together with data on the conditions in the receiving waters, gathered experience from the municipalities and in-situ studies, serves as a basis for suggesting possible measures to be taken for reducing the flow and pollutant pressure on the receiving waters. This provides the user with an overview of the storm water management and a plan to study where and what kind of measures needed to be taken to get the best result and to comply with e.g. the Water framework directive.

The proposed measures are then prioritized using different criteria:
- The location, size and type of the recipient in the lake system.
- Reduced pollutant load.
- Cost-benefit, e.g. facility cost per reduced load.
- Floods and their resulted problems and frequency.

The list of priority is a help for the municipality for implementing the measures.

## DISCUSSION

The tool and the method of working have successfully been implemented in the municipalities of Tyresö, Botkyrka and Upplands Väsby in Sweden. Since the first plans both Upplands Väsby and Tyresö municipality have built most of the facilities proposed in the early storm water management plan. The plans have served a basis to make a priority between different actions and different kinds of treatments. The plans have also been a good basis in order to gain the support from politicians and a way to increase the awareness and understanding of urban water management within the municipality

New urban areas have been developed in both Tyresö and Upplands-Väsby since the first plans and as the urbanization increases the runoff to the receiving waters change and therefore the demand for new facilities increase. With time new rules and regulations are also formed to which the plan most be adapted. Therefore the plans need to be living documents and continually be updated. Both Tyresö and Upplands Väsby are now updating their plans.

## CONCLUSIONS

After ten years of experience we believe that the success factors when implementing storm water management plans is communications and an open discussion between experts and people with good local knowledge. It is also important to use the plan as a basis when planning and to continuously update the plan. A good plan is also a valuable tool when motivating measures needed to be taken. The working method and used model have shown to match the available amount of input data, give the needed results and are continuously being improved and complemented with new experience and data.


## ACKNOWLEDGEMENTS

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