A green improvement of Käglinge Road area

Josefin Larsson
Anders Fransson
Cecilia Waldehorn
Hamse Kjerstadius

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Abstract

This report is a proposal of a possible way to recover Käglinge Road area into a healthier environment. The solutions have been considered with respect to the prerequisites that preside over the area today such as water conditions, area use and biodiversity. These are the factors in focus of improvement. These goals are also part of local and international regulations, interests and goals.

Within the area meandering of water will take place, water will cover greater areas forming ponds and wetlands and the strolling possibilities will be enhanced. Trees and bushes will be planted creating a more beautiful and inviting area. A great number of smaller measures will make sure that the goals are fulfilled in an effective way.

Careful calculations have been considered to make sure that the changes are safe for the surrounding areas and this has also been weighed into the cost analysis.

Hopefully this will create a pleasant corner for recreation where both people and nature can prosper together.
DeCo - Daphnia Environmental Consulting

Since the foundation in 2006 DeCo has skyrocketed in the world of environmental engineering. This position has been granted by a modern 21st century approach on pollutant and ecological problems created during the old century. State-of-the-art sustainable solutions from the very front line of technology in combination with a profound understanding of the inevitable intervening between humanity and its environment has granted an overall success. Today DeCo represents the largest environmental consulting agency in northern Europe, its services demanded by government and private contractors all over the globe.

Fundamental for DeCo’s achievements is our company motto, reflected in every project undertaken by our agency. Making precise improvement of the local environment by point targeting measures DeCo can minimize the single project budget still having the effects gradually recovering the larger surrounding region. For the common greatness of our world DeCo takes pride in accomplish local actions ending in global change, hence DeCo’s motto “Small money, big change!”

From the company headquarters in southern Sweden DeCo presently plans and lead multiple tasks simultaneously taking place all over the globe. Our technical staff is highly skilled cross-disciplined engineers with expertises reaching all over the spectra that modern environmental problems demand. The variety of experienced and qualified personnel lets DeCo complete every task with satisfactory solutions.

Behind our staff at DeCo stands a proud executive board which below are proud to present DeCo’s plan for restoration of the Käglinge road project area to the board of Malmö municipality. It is our greatest concern that its members will find our plan satisfactory and let DeCo start the restoralional work as soon as possible, presenting a better environment for the citizens of Malmö as well as the world.

Yours sincerely,

Cecilia Waldehorn
Executive President

Anders Fransson
Chief Economist

Josefin Larsson
Fauna & Floristic Specialist

Hamse Kjerstadius
Marketing & PR
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Introduction

Background

Once upon a time, the landscape of Scania consisted of much more wetlands than today. These wetlands surrounded meandering water like rivers and streams. However, during the 19th and 20th centuries, the human needs of agricultural areas increased due to population growth. To make more land available for agriculture, drainage of the landscape took place. As meandering rivers were straitened out, the hydrological and ecological systems were affected in many ways. The common-growing use of fertilizers increased the agricultural profit but in turn gave eutrophication of surrounding rivers, lakes and eventually the sea.1

When former wetlands became fields, the ecosystem services diminished severely. This is due to the fact that wetlands are valued as one of the most important resources per unit area regarding this factor.2

A typical example is the region of and around Malmö. Riseberga River is located in the outskirts of the eastern parts of the city. Starting up in the agricultural area southwest of Ovie the river later connects to Sege River and discharges to the Öresund. The area of Riseberga River contained by far more wetland regions than today. During the nineteenth’s century when agriculture became dominant and Malmö city developed the area was exposed to grave changes in form of drainage. Also, pollutants and nutrients from the catchment area increased in abundance due to changes in the surrounding populated areas. The need of agricultural products increased when the population augmented whereas the industrialisation brought new technical solutions with great side-effects such as different chemical substances from industry. Since the wetlands were dried out these plentiful substances was not reduced in wetlands but were transported with the newly dug ditches straight into the river instead of being absorbed in the earlier wetlands. The river then carried the substances to lakes and eventually the sea. The eutrophication continued and today e.g. algal blooms are a problem caused by eutrophication in the sea.

In this project, focus is set on the upstream area called Käglinge Road. The size of this catchment is 1000 ha, which is one sixth of the total catchment area for Riseberga River. At Käglinge Road, 50 ha are impermeable areas such as parking lots, roofs etc. As much as 60% of this impermeable part consists of industry. Remaining areas (950 ha) consist of agriculture areas.3 Citizens use the area close to the river for riding and strolling.

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1. Tonderski, Karin et al; Våtmarksboken - Skapande och nyttjande av värdefulla våtmarker; Västra 2002
2. Hansson, Lars-Anders et al.; Conflicting demands on wetland Ecosystem services: nutrient retention, biodiversity or both?: Freshwater Biology 2005
3. Berndtsson, Ronny and Hansson, Lars-Anders; Project work Riseberga river - Hydrology and aquatic ecology VVR 111, Period 1 och 2; 2006
Project description

Due to the severe changes that have affected the Riseberga River during the last century, both abiotic and biotic factors have changed rapidly. The results are understandable. An example is that 25% of all stormwater in Malmö eventually ends up in the Riseberga River together with all the pollutants the water contains. It is apparent that the conditions alter in the river given the chemical reactions the pollutants induce. In the upstream areas the increased level of nutrients, mainly phosphorus and nitrogen, are not only influencing the river itself but are also transported through the system ending up in Öresund and the Baltic Sea where the impact continues. Downstream where the river passes the outskirts of Malmö, pollutants such as heavy metals are taken up into the water mass contributing to the contamination.¹

Due to the focus on problems like eutrophication during the last decade the Swedish Government and Malmö Community has set up an environmental restoration plan.² The aim with this project is, with respect for these water restoration plans, to analyze and find out how the ecological system of Käglinge Road area looks like today and make conclusions of how it would be possible to improve these conditions in several ways. These proposals must be considered with respect to factors such as recreation, biodiversity, pollution and function for the surrounding habited areas.

Figure 2. The project area, marked in red. For details, see the specific areas in the Course of action part.³

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¹ Berndtsson, Ronny and Hansson, Lars-Anders; Project work Riseberga river - Hydrology and aquatic ecology VVR III, Period 1 och 2; 2006
² Miljöprogram för Malmö Stad - 2003-2008 - En presentation
³ Berndtsson, Ronny and Hansson, Lars-Anders; Project work Riseberga river; KFS i Lund AB 2006 (map)
Aims of “A green improvement of Käglinge Road area”

The goal of this project is to improve the environmental conditions of the area Käglinge Road. DeCo has divided this objective into three partial goals.

1. Decreased nutrient, and heavy metal, concentration in Riseberga River.
2. Increased citizen acknowledgement of the area by strengthening the recreational values.
3. Increased biodiversity in the area.

A budget of 1.46M SEK will not be exceeded.

The aims in detail

This project is topical even on international level. The European framework for water consists of a time plan of measures that will ensure the protection of fresh-, coastal-, marine- and ground waters. These goals are to have been achieved 2015 and already this December 2006, environmental monitoring programs should have started. The aim is that 2009 have a plan for management, including goals and measures for all lakes in the country. This project could therefore be a part of these grandiose goals and a step on the way to achieve these important objectives.¹

To fulfil the aims of this project, the relevant goals in Malmö municipaly’s environmetal plan (Miljöprogram för Malmö stad 2003-2008), based on the Swedish national environmental plan (Sveriges 16 nationella miljömål och miljökvalitetsmål) have been used as a templet. These goals are integrated in each other and the goals of the project are therefore part of both national and regional objectives. Several of the national goals are about water. Their main concern is to preserve and create ecologically sustainable varied habitats in a way to maintain or create biodiversity. Biological production, cultural values and outdoor life should also be protected.²

1. Eutrophication

Due to the eutrophication problems in both freshwater sources and in the Baltic Sea, it is important to reduce the concentration of nutrients in streams, rivers and lakes. In salt water, nitrogen is the limiting nutrient whereas in freshwater, it is phosphorous that sets the perimeter for algal growth. Water is eutrophicated when the amount of these nutrients is very high. Therefore, it is important to focus on both nitrogen and phosphorous concentrations.³ The eutrophication problem is significant in Riseberga River. Therefore, in this project focus is set upon reduction of the nutrient transport from Riseberga River that will end up in the Baltic Sea. A lower amount of these nutrients will result in positive effects such as cleaner and more inviting water and a higher biodiversity. Water

1. Hansson, Lars-Anders; lecture, University of Lund 2006-11-13
2. Sveriges 15 nationella miljömål och miljökvalitetsmål
3. Hansson, Lars-Anders et al.; Conflicting demands on wetland Ecosystem services: nutrient retention, biodiversity or both?; Freshwater Biology 2005
in eutrophicated lakes and streams is not proper to use as drinking water or for swimming. Therefore it is also in the nearby regions’ interest to decrease the eutrophication. The sedimentation process that reduces nutrients will also reduce heavy metal concentrations which have a poisonous effect when the amounts are too high.1

2. Recreational values

The recreational value of an area is hard to measure, but still very important. Pleasant surroundings can for example contribute to making the area more attractive for outdoor activities. This is part of both international and national objectives. An improvement of such an area is also a good possibility for the Malmö Community to show the citizens its environmental policy. To improve the recreational values of the surroundings of Riseberga River, DeCo consider several factors such as availability and security for e.g. playing children. The atmosphere of the area, e.g. beautiful and inviting nature is also important.

Figure 3. A member of Deco staff is test walking the path.

3. Biodiversity

High biodiversity is significant for a healthy ecosystem. It makes the system less sensitive to environmental changes and invasive species, a problem getting more and more common in the globalisation of the world. The drainage of wetlands is a serious threat against species that only live and reproduce in this biotope, e.g. amphibians like frogs and lizards. Therefore, an important national issue is to maintain the biodiversity in wetlands. When creating new wetlands around the Riseberga River, we make it possible for typical species to colonise. Environmental restoration means to establish more natural conditions. When reducing the nutrient concentration, which is our primary goal, the biodiversity is often naturally increased. However, when designing a wetland, decreased nutrient concentration and higher biodiversity is not always the result of the same measures. Therefore one must decide the highest priority or compromise when determining the course of action.2

1 Brönmark, Christer and Hansson, Lars-Anders; The Biology of Lakes and Ponds Second Edition; Oxford University Press; 2005

2 Hansson, Lars-Anders et al.; Conflicting demands on wetland Ecosystem services: nutrient retention, biodiversity or both?; Freshwater Biology 2005
Methods

The planning of this project started with hydrological calculations (for details, see *Further Information*). Maps of Käglinge Road were studied before DeCo went out to the area to make the field study. This field study consisted of an inventory walk through the area where the topography and surroundings were noted, shown in figure 3. Facts were collected from books, articles, essays, internet and lectures. As focus also is set upon the recreational values, DeCo has interviewed people using the area. These different information sources contained enough facts for DeCo to go through the suggested project.

*Figure 4. A member of the DeCo staff is test riding the path together with Zens.*
The following part contains the suggested course of action from DeCo. The text contains our solutions and the expected results. The results are based on facts which are also, partly, presented in the text. The reason behind mixing facts and subjective conclusions is pedagogical. It is easier to understand a measure’s relative importance if the reason behind is presented. More specific facts behind the mechanisms are presented in the section “Further information”.
**Course of action for improving the Käglinge Road area**

This is the plan of improvement of Käglinge Road area. Here all solutions and their effects are presented. For the reader who wishes to know even more about the mechanisms behind the effects there are more specified information in the Further information part as well as in the appendix where all calculations are presented.

**Area A**

Figure 5. Map of Area A which is marked by red.

Today

This area is situated next to Stenåldersgatan and is surrounded by industrial areas. Green areas are relatively small and leaves little room for major changes as seen in figure 5. The river inflow is directly followed by a long, straight deep ditch covered with dense vegetation. As described before this water originating from cultivated areas are rich in nutrients such as phosphorus and nitrogen. Next to the stream line there is a newly built horse lane and partly also a walking lane. The usage of this area today is therefore mostly associated with riding. Since the direct surrounding contains industries with a lot of impermeable areas the runoff collects accumulated heavy metals from earlier rains on the asphalt as well as other pollutants from the air. Large parts of impermeable areas also mean that rain results in much runoff fast which could be a risk of flooding. However, concerning this area which holds just the deep ditch and not much more these amounts of runoff is probably not a problem. The area has a relatively rich birdlife and common vegetation. In our Course of Action for area A DeCo will mainly focus on the second main goal of “increased citizen acknowledgement of the area by strengthening the recreational values.”

**COURSE OF ACTION**

**Crossing**

To ease entry to the area from Stenåldersgatan a pedestrian crossing will be built. Today the entry is not safe for children, trolleys etc. A safe entry to the area is important to strengthen its recreational values.
Inflow of Riseberga River into the area
To make sure that migration of fish up along the water body is not hindered the culverts of the inflow should be designed so that the fish swim through.

“Käglingestigen” as a recreational strolling path
Where visitors enter from Stenåldersgatan there is already an existing stone fundament. This will be completed with a concrete top wearing the name “Käglingestigen”, see figure 9. This will inform visitors that they are entering a strolling path, and will also gather new visitors to the area. It will be easier for people who already have visited the area to tell friends and relatives about their experience if they have a name of the area they have visited.

Gravelled walking path
Visitors of area A today have to walk on a very poor and muddy path. To ease visiting of the area the walking path will be broadened and gravelled for higher comfort. A proper walking lane along “Käglingestigen” is important, see figure 6.

Figure 6. Map of measures
Improved horse lane

Today horse riders from the nearby “Örestads Ryttareförening” are main visitors of the area and in area A they travel a rather poor horse lane. In the other areas the walking path and the horse lane are intertwined. Since DeCo expect an increased number of horse riders from the nearby “Örestads Ryttareförening” when a safe crossing over Kantyxegatan is created the horse lane in area A will be improved and run parallel with the walking path through the areas. In an interview, Anette Liljegren, instructor at the “Örestads Ryttareförening” expressed concern about the importance of keeping the riding path clear from plants. DeCo will fill the lane with more material such as gravel, wood flakes or bark to hinder the growing of plants. This will enhance the conditions for the horses, something that will aid recreation.

Cutting of wild roses

Another concern that was raised by Anette Liljegren was about the wild roses growing next to the horse path. They are covered with thorns and can hurt or frighten the horses resulting in an accident. The area should be safe for everybody to visit and thus wild roses spreading too near the riding path will be cut away.

Keeping the trees

The riverside today holds a relatively mature population of trees. These are important to keep for two reasons. Firstly, the trees provide covering of the water course which will lower the temperature and thereby increase the amount of oxygen solved in the water. More oxygen means better conditions for animal and plant life in the river and thus increased nutrient uptake by living organisms.\(^1\) Secondly, the trees are good for the bird population of the area, see more in Nestling boxes. Both of these reasons strengthen DeCo’s third main goal of increased biodiversity and in addition more oxygen support DeCo’s first main goal of decreased nutrient concentration in Riseberga river.

Riffles and pools

The river in area A follows a straight ditch. This minimizes surface area where nutrient reducing plants and algae can grow. In order to increase bottom area groups of stones will be put in the river to create riffles and pools. Since the bottom becomes more complex more microhabitats will be created for animal life. Hence, biodiversity will be boosted.\(^2\) Also, group of stones in the river course will raise the water surface facilitating the entrance to area B. The water will also be oxygenated encouraging plant growth and therefore nutrient retention.\(^3\)

\(^1\) Brönmark, Christer; lecture, University of Lund 2006-11-01
\(^2\) Stenberg, Marika; lecture, University of Lund 2006-09-11
\(^3\) Brönmark, Christer; lecture, University of Lund 2006-11-01
Nestling boxes
Among the mature trees saved along the river nestling boxes will be built. This will mainly have two good effects. Firstly, this will help increase the bird population of the area. Since the wetland will habituate more insects, birds will gather and live in the nestling boxes. Secondly, an increased population of birds will increase recreational value for the people visiting the area, especially for bird watchers. All in all, nestling boxes will strengthen both the second and the third main goals for the project area.

Getting a Tawny owl to Käglinge road
An extra treat for bird watchers visiting the area is the challenge of getting a tawny owl to nest there. After an interview with the president of the Scanian branch of the Swedish ornithological society (Svenska Ornitologiska Föreningen, SOF), Kenneth Bengtsson, DeCo was informed that although tawny owl exists in Scania, none is known to nest within Malmö community. Hopefully put up nestling boxes for owls will result in owls nestling in the project area. This is for several good reasons. Firstly the habitation conditions of the area improve greatly with the overall changes DeCo applies. Secondly the construction of a wetland will increase the food sources of an owl by creating an enhanced biodiversity. These two prerequisites will hopefully eventually lead the tawny owl to the area. A great joy for both the enthusiastic members of SOF and other bird watchers. This measure strengthens both the biodiversity and the recreational goal.

Raised sides of ditch
Since the water level will be raised in the ditch caused by measures further up in the stream line, earth from the dug out areas in area B will be put where it is needed along area A. This is to make sure that the water will not flood over the edges.
Area B

Today

![Figure 10. Map of Area B, marked in red.](image)

The water keeps floating straight forward in the deep ditch but a big meadow appears east of the stream line. This meadow, called “Skogholms ängar” is simply a flat field approximately 4.5 ha (45 000 m²) situated between two industrial areas. When entering area B, the riding path and the strolling lane join each other. Due to the downgoing slopes on both sides there is only room for one path. More stormwater are of course entering the area and the vegetation changes into consisting more of bushes than trees.

![Figure 11. Skogholms meadows seen from the walking path.](image)

Course of action

*Leading the water onto the meadow*

Since the deep narrow ditch leaves little or no room for wetland constructions the open space is used for such solutions. The old ditch is filled up and a new one is dug. On the meadow there are many possibilities for designing different solutions intended to realise the set goals. The effect will be a nice area effective in improving water conditions, see figure 12.

*Filling up of the old path of the ditch*

When leading the water to the meadow one can either chose to take all water or just some of it. A reason to keep the old ditch open with some water running is that if there is a weir in the wetland the fish might have trouble passing. Also if the wetland dries out now and then it would also be a problem for the fish. On the other hand,
dividing the water would in this case make it necessary to have a concrete wall with a tunnel at the bottom allowing just some of the base flow but not more into the old ditch. This is because the water level in the wetland is so regulated. These sorts of openings have a tendency to get filled with dead organic material such as branches and grass. It would need to be cleaned up every now and then. As simple solution as possible is preferred and since the wetland is designed with a minimum depth of 0.25 metres, fish will always be able to pass through. A fish step will be put next to the weir or any other point hard to pass for fish. Therefore the old ditch will be filled up creating a solution needing less care.

**Deeper smaller pond**

After a few metres of slight meandering the water is gathered in a smaller deep pond. “Deep” meaning at least one meter of depth. Smaller deeper ponds have documented effect in reducing phosphorus concentrations.⁴ The reason why the phosphorus retention is put first is to avoid having the rest of the wetland being eutrophicated.² This results in less algae and therefore clearer water which in turn increases the biodiversity in the rest of the wetland when more organisms such as macrophytes and piscivorous fish will be able to establish.³ However, a deep small pond is not the ultimate solution concerning the biodiversity in the pond itself.⁴ Here reduction of phosphorus is prioritised since other part of the wetland will be efficient in increasing biodiversity.

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1. Hansson, Lars-Anders et al.; Conflicting demands on wetland Ecosystem services: nutrient retention, biodiversity or both?; Freshwater Biology 2005
2. Hansson, Lars-Anders; lecture, Lund University 2006-11-08
4. Hansson, Lars-Anders et al.; Conflicting demands on wetland Ecosystem services: nutrient retention, biodiversity or both?; Freshwater Biology 2005

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**Figure 12. Map of measures in area B.**
Sedimentation of heavy metals is another vital function. This is possible when water velocity is slowed down making it possible for larger particles to sink to the bottom. These substances are still poisonous but they do much less damage in the sediment than moving around in the ecosystem.\textsuperscript{1} If possible or estimated effective, the community could dredge the pond with e.g. 10-15 years interval getting rid of the polluted sediment. A downside of this is of course that organisms are removed as well. Also heavy metals might leak into the water. One must take these consequences into account when deciding this.

**Shallow large pond with island**

After a few metres of slight meandering the water is gathered in a shallow (2-4 dm) quite large pond. This design has documented high nitrogen retention which is the primary function of this pond. It is constructed so that the shoreline is long and complex giving more space for organisms, especially plants, to grown on. The shallowness also promotes plant establishment. This in turn will hopefully increase the macrophyte species richness and therefore the nitrogen retention. Also bird species richness is known to be positively related to an intricate shoreline.\textsuperscript{2} This will contain many microhabitats which will increase the biodiversity. In the inlet an island will be placed. Material could be dirt from the out dug areas. The island will force the water to go in two directions making the pond more effective since the water will circulate better. Since this also makes the pond more complex, biodiversity can increase further.\textsuperscript{3}

**Meandering of river**

Leaving the ponds the water follows an out dug shallow meandering waterway. The curves should be strengthen with rocks to prevent erosion from changing the water path too far. The meandering creates riffles where the water velocity increases passing more shallow parts and pools in the turns where the depth is higher and the water moving slowly. Many microhabitats are created and the water is oxygenated. Another advantage is that the meandering prolongs the resident time of the water in the wetland which makes is possible for plants to use more nitrogen and phosphour.\textsuperscript{3}

**Planting of trees and bushes**

In the inside curves of the meandering, trees will be planted to shadow the water. Some species are dependent on shadow but it also has other effects. The decrease in light will result in less macrophytes. Fish like to hide in the darker water. Less water will evaporate when hot weather and a lower temperature in water means that more oxygen can dissolve giving a more oxygen rich habitat. Trees and bushes will also create a beautiful environment as well as a more diverse habitat for birds and animals. Trees and bushes will naturally immigrate to the area and one should

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\textsuperscript{1} Brönmark, Christer and Hansson, Lars-Anders; The Biology of Lakes and Ponds Second Edition; Oxford University Press; 2005

\textsuperscript{2} Hansson, Lars-Anders et al.; Conflicting demands on wetland Ecosystem services: nutrient retention, biodiversity or both?; Freshwater Biology 2005

\textsuperscript{3} Brönmark, Christer; lecture, University of Lund 2006-11-01
perhaps consider clearing the area every now and then from too much upcoming
trees and bushes making sure the region stays open. If planting vegetation, one
should have in mind that the wetland will be flooded over and over again and make
sure that the species planted survives such oscillations of change in their habitat.¹

Root zone ending the meadow
Reaching the "endstation" of the meadow the water enters a root zone with a lot of
vegetation growing. A root zone is designed as a shallow pond where the water is
more or less still. A small waterfall can be designed before the root zone securing an
almost completely plain bottom. Planted trees and bushes will be able to consume
remaining nutrients from the water. The water contains some oxygen gained
passing both meanderings and waterfall. This is very important since it hinders the
phosphate bindings in the sediment from leaving the sediment dissolved into the
water which would work against the goal of decreasing nutrient levels. To maintain
oxygen the last part of the wetland should be shallow making sure it is oxygenated
all the way to the bottom.

General information of wetland size and expansion
When base flow running through our area 1 ha will be water covered. Then our area
will consist of meanders, ponds, root zones etc. When heavy rain falls, our area will
behave as a flooding area and water flows all over the inner part of the meadow. If
the rain is very huge (once in a 100 years occurrence), a maximum total area of 2.5
will be covered.²

Käglingestigen raised
The walking path Käglingestigen will not be part of the flooded area but pass around
it in the outskirts of the meadow. This is to avoid having it destroyed and also to
make it possible to visit the area even after heavy rainfall. It will be about a meter
higher then the surrounding ground which also gives the walker a better view over
the rest of the area.

Information signs following Käglingestigen
A good thing would be to inform people using or passing the area of the importance
of wetland constructions. Therefore information signs should be placed regularly
along the path with short and easy understandable texts and illustrations of how
wetlands function and why. More knowledge usually results in growing interest
and hopefully people will become more aware of their water related environmental
problems.

Figure 14. Example of information sign, here about one of the commonly found
species in the area.

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¹ Stenberg, Marika; lecture, University of Lund 2006-09-11
² www.hassloholmsvatten.se/pdf/mikaelanderssimonviktor.pdf
Bridges crossing meandering

The path Käglingestigen, that enters the meadow are circulating at the outer part of the meadow. Two bridges will lead the path into and out from the meadow. In this way recreation and environmental care is combined. Though, the horses are not allowed to enter the wetland area since their hooves might destroy the ground and vegetation. The horse lane will go on straight forward and pass the meadow without entering it.

Benches for visitors

When visitors enter the meadow, it is important that the area is inviting for outdoor activities. Therefore benches will be placed along the path. This will hopefully result in an increased usage of the wetland area.

Safety

To minimize any risks of accidents on the wetland area, the path will take a route quite far from the wetland, especially the deeper parts. The benches are also placed so that flooding will not change their position or destroy them. The bridges will be stable and massive with railings to increase security. It is also important to consider shape of the basins concerning the gradient of the sides. This is important since small children might play in the area. Steep sides of the wetland could be a risk whereas slightly sloping sides will decrease the risk of a child falling into the basins.

Mosquito control

A sustainable method will be used to control the population of mosquito in the wetland constructed at Käglinge road area by granting the area with beneficial conditions for natural predators on mosquito. Controling mosquito by the use of natural predators (e.g. birds) is an economic measure which also will increase the biodiversity of the area.
Entering Area C the river makes an L-like bend turning west for just about 40 metres before continuing north following the original direction in the persistently deep ditch. East of the river industry is already using all space and the plan for the west side are of similar kind which leave the area available for changes around the stream narrow, approximately 20 metres on each side of the river. The bend of the stream contain one bridge.

The use of this bridge does not seem to fulfil any purpose at present. In fact a big excavator scoop is positioned upon the bridge probably in order to hinder people from entering the industrial area under construction next to the stream line, as seen in figure 17. Another bridge is found just before the outflow from the project area, see figure 18.
The last hundred metres the available area is broaden up a little bit at the same
time as the river turns faintly northeast. On the west side of the stream some wells
are found. These collects stormwater from the surrounding industrial areas before
letting the water into the stream. The vegetation consists of bushes while the L-bend
have some higher trees. All high vegetation follows the stream line consequently.
More pollution from stormwater enters before it is let out from the project area.
This vegetation are, just like before rich in animal life, especially birds. In the
beginning of area C there used to be a dump. Therefore it is important to consider
any pollution that might come with the stormwater from this region. According to
Ronny Berndtsson, LTH, the dump is probably mostly consisted of material used in
the building of the industry such as concrete, earth etc and will probably not add any
dangerous chemical substances.

Course of action

*Slight meandering of Riseberga River*

Leaving the wetland area the area available for changes during the last 400 metres
are about 40 metres wide. This means that a solution needs to be found that does
not need too much space. On the other hand some effect concerning the goals of the
wetland are wanted. The solution is to dig out a slight meandering of the river. A
meandering works naturally with erosion meaning that the bows will expand more
and more over time. Since the area are so limited with industry facilities at the east
side and planned industry locality on the west side it is important to make sure that
the meandering does not expand due to erosion. This could erode the ground close
to or even directly where these facilities are located. This take quite some time but
to be sure of avoiding this stones will be placed in the bows to strengthen these.
Water will then not be able to erode further then the size and design that has been
decided when digging the ditch. The effects of this long-curved meandering will
help increased biodiversity as well as further nitrogen retention to some extent.

*Planting of trees next to paths*

Having passed the nice wetland area the walkers of Käglingestigen and riders on the
horse lane will find themselves heading straight forward with the meandering river
on the east side. This holds pleasant vegetation. To make the path more inviting
trees and bushes will also be planted on the west side. Insect should like these
changes giving birds more food. Animal life in general will be favoured from more
vegetation such as trees and bushes. This would therefore boost both biodiversity
and recreational values. Another aspect of these paths is that riding school students
often have parents spending time in the area waiting for their children’s lesson to
end, according to Anette Liljegren. This would mean that they would have a nice
walk to make passing their time of waiting, see figure 19.

*Outflow from the area of Käglingestigen*

After the meandering the river will leave the area under the road Kantyxegatan. To
help fish from establishing in the area and moving up and down along the water
body, culverts should be made so that they do not hinder fish from migrating.
Figure 19. Map of measures for area C.
Retention of nitrogen and phosphorous

When creating a new wetland, it is undoubtedly interesting to look at its efficiency in nutrient reduction. These results depend on many factors, e.g. wetland area, amount of precipitation and water passing through the system, nutrient concentration, wind exposure, bedrock conditions, vegetation coverage etc.

In Hässleholm municipality, the Magle wetland was created in February 1995. About this wetland, a study of nutrient reduction during the first five years has been made. The total nitrogen reduction of incoming nitrogen in Magle wetland was mean 35% per year. During the best year 37% was reduced. The minimum reduction of a year was 23%. Of phosphorous, the mean reduction was 27% per year, the highest 38% and the lowest 1%. The levels of heavy metals were low, both in the inflowing and out flowing water. For example, during 2005 Cupper decreased by 50% and lead increase a little.

Although the local conditions are different, e.g. the total area (Magle wetland is about 30 ha), DeCo has used the results from this study to estimate the nutrient retention of the wetland on Skogholms meadows. It is estimated that 100% of the catchment runoff passes through the wetland. In reality, this is probably not true, as it is almost impossible to calculate the exact amount of water passing through a wetland. However, as DeCo has calculated both minimal and maximal reduction values, the expected results will be of good quality.1

In the wetland on Skogholms meadows, the reduction of nitrogen will be about 4870 kg/year and of phosphorous 120 kg/year. This is mean values; due to the study about Magle wetland it can be a huge difference in reduction from year to year.

Estimated nutrient reduction in one year:
Nitrogen: between 2 139 and 6 845 kg/year
Phosphorous: between 1.8 and 209 kg/year

Estimated nutrient reduction per year during a five years period:
Nitrogen: between 3 255 and 6 475 kg/year
Phosphorous: between 49 and 149 kg/year

(For calculations, see Appendix.)

1. www.hassloholmsvatten.se/pdf/mikaelanderssimonviktor.pdf
Costs and further details

When creating a wetland it is important to control the amount of water staying and leaving the wetland. This can be done by using a weir. A weir is a construction that is placed in the end of the wetland to risen the water level to wanted height. Dimensions at the weir such as length and height decide the amount of water passing.\(^1\) When the dimensions was decided following was considered: Deco wanted the mean depth and total area to be 0.4 m respectively 1 ha at base flow. When a rain with once in a 100 year occurrence appears the maximum area was set to 2.5 ha and the maximum depth to 1.4 metres. These are the maximum dimensions of the wetland area when it is flooded. The mean value of water amounts passing through the area has also been considered, both during base flow and when the rain of 100 years occurrence take place (for data use, see appendix).

The dimensions at the weir are:
- Length: 1.5 m
- Height from bottom: 0.3 m
- Security height: 1.4 m

The weir will be formed as a rectangle.

When deciding dimensions of the area, data given above have to be considered. Roughly, an area of 1 ha and a mean depth of 0.4 meter (at base flow) will be filled with water from Riseberga River. The sedimentation pond will in the beginning have a mean depth of 0.9 m. The rest of the area will have a mean depth of 0.25 m. (For calculations and more details, see appendix.)

Since the difference in level between the bottom of the ditch and the meadow is approximately 2 metres, the water surface level needs to be risen. This can be done in several ways and the plan is to combine them. Gravel and stones will be placed at the bottom of the ditch in area A. This can raise the surface level with a maximum of 0.5 metres. Filling in the ditch where the water was originally led and where it is instead lead to the meadow will raise the level with roughly another meter. The weir at the end of area B will raise the water to the wanted level. Another way to raise the water surface level is to wait or large rains. Of course it is also necessary to dig out the wetland so the bottom level of the wetland is lowered and formed into wanted shape. The topography in the area is used and the ponds is therefore placed so that the amount of digging required is minimized. The present topography is also used during heavy rainfall. This in combination with som digging make sure that not more than 2.5 ha is flooded. A total volume of 25 000 m\(^3\) will be removed to a maximum cost of 1.46 M SEK (see appendix for calculations).

Some of this mass will be used to fill in the former ditch and some to change the topography so that the water will be forced to run to the flooding areas during heavy rainfalls. It will also be used to secure the borders of the wetlands. Some of the ponds will have deeper surrounding areas than other as a way to control where the flooding goes. An example is that a slightly sloping border of a pond can be flooded even during smaller rainfalls which make it possible to augment the nutrient retention in the flooded area. The waterfall will have a height of around 0.25 metres. Käglingestigen will be placed on the higher areas of the meadow. Fish steps will be placed both next to the weir and waterfall to enable fish to migrate along the water.

\(^1\) Representative from ”Ekologgruppen, during study visit to restored areas, Lund University 2006-09-08
Further reading
for the interested reader
Futher information

The Käglinge road catchment today is far from the status it could have. In general it provides a rather poor environmental frame leaving plenty of room for hydrological, ecological and recreational improvement. The present conditions are here presented in four separate parts, which will help to guide the reader through the text.

1. Area Usage
   Impact from the companies located within the area. Frequency, purpose and surrounding factors for citizens spending time there.

2. Hydrological conditions
   Rainfalls and runoff over the area.

3. Ecology
   Evaluation of plant and animal life.

4. Pollutant concentrations
   Load of nutrients and heavy metals from both the area and upstream.

AREA USAGE

The usage of the area is reflected by its position in the outskirts of the city of Malmö. A large network of roads dominates the surroundings of the area, leading from and to the city as well as the famous horse racing ground Jägersro. In the direct surrounding of the river there is a dominance of industrial companies and even more of the area is planned to become future industrial sites. The river itself is surrounded by a thin, dense streak of trees and bushes making the river more or less unreachable. Therefore large parts of the area are unavailable for recreational use for nearby living citizens. Also since the ditch where the stream floats is very deep, it is not proper for smaller children to play around. The water level is normally not high and the undergrowth makes it cunning to reach but it is important to notice these factors when trying to make the area more available.

Figure 20. Strolling is a nice way to use the area.
The exception from the unavailability is a newly built riding lane following the creak. This is often used by the members of the nearby Örestads Ryttarförening and less frequently by pedestrians visiting the area for recreational purpose. Safety is affected by the fact that footers partly use the same path as horse riders which might result in both accidents and a walking lane damaged by hooves. Another safety problem today is when horse riders are about to cross Kantyxegatan which makes the area more difficult to reach for recreational activities.

HYDROLOGICAL CONDITIONS

Planning restoration for an area like Käglinge road where the environmental problems are found in the circulation of water the solutions will be found in water movement as well. DeCo therefore concentrated its collection of empirical data for the project area from the water balance. The water balance simply means that all the water entering the catchment from precipitation must leave the catchment, either in form of evaporation, runoff or infiltrate the ground and become groundwater. Having estimated these central parts, a model of how large quantities of water will circulate through the project area during different time intervals is made. This is the basis for calculating dimensions of the different technical solutions for the project area.

The data presented below tells the reader how different amount of precipitation will result in changing volume of water in the project area and its impacts on the different problems the area is facing.

Water balance at the project area

All water within the area comes from direct precipitation over the catchment of Käglinge road with an annual average of 700 mm. In technological context of DeCo’s work there are definitions made of the water flow from the precipitation, water staying on the soil surface forms runoff in ponds, wetlands, rivers etc. This is the main ingredient of focus in the “Course of action” part. The rest of the water either evaporates or infiltrate through the soil surface and form soil water that may later percolate down to the groundwater.

Ground water

When constructing a wetland it is important to understand the dynamic relationship between surface water and ground water. The levels of these two water systems are depending on each other; low water levels in ground water means an infiltration of surface water. To make sure that the water intended as surface water in the wetland stays as surface water (and do good things) the level of ground water needs to be raised.

1. Precipitation = rain, hail and snow.
2. Evaporation = transpiration through leaves on plant and trees.
3. Groundwater = water deep down in the soil, can not be reached by the roots of plants and trees.

1.Fig2.21 Hydrology textbook
1.Berndtsson, Ronny and Hansson, Lars-Anders; Project work Riseberga river - Hydrology and aquatic ecology VVR III - Period 1 and 2; KFS i Lund AB 2006
Knowledge about how fast a pollutant particle is transported through the groundwater system is also important. The greatest risk of pollutant leakage (e.g. oil) to the project area seems to be a road accident at the nearby highway E6 situated one kilometre south. For calculations see Appendix.¹

Runoff (Average and Maximum)

The most basic sort of calculations is a mean runoff from the area over a year. This gives a rough estimate of how much water that runs through the area and also decides how much water the area must be able to normally hold without risking flooding. Measurements from Kåglinge Road area implies an annual mean runoff of 0.058m³/s from the river where it exits the catchment.²

This unit is good for calculating normal storage within the area but one must also consider the rapid increase of water volume that follows sudden intensive rainfalls. These rainfalls do not reoccur very often but when they do they can have a devastating effect. Hence, one must consider gathered statistic data from earlier rainfalls to avoid flooding. An overflow could be both dangerous and costly for the surrounding areas. Excess water could be led either to a detention basin or an overflow area created within the project area. The importance of such measures for infrastructure will only grow over a longer time perspective and it is an effective way to minimize future costs for reparation of storm water damages.³

In the table in figure 21 the reader is able to find calculated runoff from rains of different magnitude. These are of such magnitude that they on average occur only once every one, ten and one hundred years. Calculations are to be found in Appendix. It is important to note that an average probability of occurrence does not rule out the possibility of such rains to occur more frequently within the time spawn.⁴

![Unit Hydrograph & Estimated total Runoff](image)

Fig. 21. Estimated total runoff from the maximum rainfalls occurring every once, tenth and hundred years.

The information given above is the basis for the volume of the planned wetland in area B in the “Course of action” part.

1,2,3,4. Berndtsson, Ronny and Hansson, Lars-Anders; Project work Riseberga river - Hydrology and aquatic ecology VVR 111 - Period 1 and 2; KFS i Lund AB 2006
ECOLOGY

Surroundings and vegetation

The river’s location in the south of Sweden states a temperate climate and since Scania is surrounded by the sea in three directions (Kattegatt, Öresund and the Baltic Sea) the climate is mostly maritime. The animal life is predominantly consisted of e.g. Raw deer, Deer and Hares. The bird life is famous for its species richness and bird watchers from around the world travels to Scania to watch the birds.

Before the river enters the area of Käglinge road, it passes through an agricultural area consisting mainly of fields. As many other rivers, the Riseberga River was once straightened out and are now more or less a straight line cutting the fields of the surrounding industrial areas. 1

The bottom consists of sand and gravel, which makes it quite hard. 2 An important factor of the life in the water is the shallowness, the depth of the river during base flow reaching just a few decimetres. As it is more of a stream than a river, with a width of just one-two metres. This amount of water implies a flora and fauna that is able to live in such conditions of low water. One example is that sunlight reaches the bottom which enables certain species to survive and reproduce. A result of this is more sternly oscillating temperature which also contributes to the selection of fauna.

Walking next to the Riseberga River it is hard to see any water at all. This is due to the dense vegetation covering the stream line composed by trees, bushes and high growing herbs like Nettle and Great Willow-herb. The nettle is a typical indicator of a nitrogen rich environment. A common found tree is the Black alder, which often grows close to a rivers and streams, as seen in figure 22. 3

Figure 22. Black alder (Alnus glutinosa). This tree, which can be found in almost the whole country, is often growing very close to rivers and creaks. 4

Figure 23. The Blach alder is one of the trees foundin the area.

1. Berndtsson, Ronny and Hansson, Lars-Anders; Project work Riseberga river - Hydrology and aquatic ecology VVR 111 - Period 1 and 2; KFS i Lund AB 2006
2. Nilsson, Anders and Svensson, Mikael; Fiskfaunan i några årar och bäckar i Malmö Kommun - resultatet av en inventering november 1998; Zoekologiska avdelningen, Ekologihuset, Lunds Universitet
3. www.lovtrainstitutet.se/traslagsinfo/fakta/al.html
Not to be forgotten when talking about vegetation surrounding a water source is the 
plants that grow in the river or lake itself. These species can be divided into three 
different groups; emergent macrophytes which are growing closest to the shore, 
floating leaved macrophytes which have their roots in the bottom sediment but the 
leaves on the water surface, and finally the free-floating macrophytes which are, as 
the name indicates, floating on the water surface taking up nutrients directly from 
the water instead of from the bottom sediment.¹

Plants growing under the water surface are called submerged macrophytes. A high 
emergent macrophyte coverage, which is the case in Käglinge Road area, induce 
a high nutrient concentration since they out conquer their lower competitors from 
light resources.²

Algae are another factor. High amounts are shown by turbid water and a low amount 
of vegetation in the sediment zone. Since a clear water state is preferred it is important 
to maintain low nutrient concentrations which hinder algae communities from taking 
over the water column. This will have affects on the rest of the fauna of the lake 
as well. An example is the piscivorous fish feeding on benthivorous fish feeding 
on zooplankton. Since the turbid, algae filled water makes it difficult for the bigger 
fish to find and eat the smaller ones, the smaller species will increase in number, 
eating more zooplankton which will not be able to limit the algal growth inducing 
even more turbid water. This will result in low biodiversity and a high number of 
individuals of the same species such as emergent macrophytes and algae.³

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1.2. Brönnmark, Christer and Hansson, Lars-Anders; The Biology of Lakes and Ponds Second Edition; Oxford 
University Press; 2005
3. Hansson, Lars-Anders; lecture, University of Lund 2006-10-02
4.5. Ursing, Björn; Fältflora - en handbok; Prisma 1986
Benthic invertebrates

Benthic invertebrates are small animals living and feeding on the bottom. A considerable number of different species of this sediment living creatures usually show of a low phosphorus concentration.\(^1\) It is interesting to investigate the state of this group of organisms since many other animals such as fishes feed on them; an example is the rare Stone loach (figure 26).

\[\text{Figure 26. Stone loach (Barbatula barbatula). A rare fish living in Riseberga River is the Stone loach, which is a bentivorous fish. This means that it lives and feeds on the bottom. The ”hair” under its mouth is used as antennas when searching for food.}\] \(^2\)

Fish

The fish community seems to be rich in species variety. A study made in 1998 by Anders Nilsson and Mikael Svensson, Ecology Department, Lund University, showed a high occurrence of e.g. Brown trout and Stone loach. An interesting fact since especially the Stone loach is quite rare and classified as critically endangered on the red list. The Brown trout (figure 30) most probably mates in some areas of the river. A situation worth taking measures to maintain. The study by Nilsson and Svensson also showed that species such as Pike (figure 29) and big as well as small Stickleback are living in Riseberga River. Since there are large roads close to the river, there are risks of negative affects from human activities. Roads cutting the stream might be a hinder for migration along the river depending on how culverts and tunnels are designed. Wetlands offer food and habitat for fish which means that they usually have a positive effect on fish populations.\(^3\)

\[\text{Figure 27 and 28. Big and small Stickleback (Gasterosteus aculeatus and Pungitius pungitius). The Stickleback is quite a small fish, just about 5-8 cm. It is easily recognized on the thorns on its back, used as protection against predators. During the spawning in springtime, males get a nice red colour. The big Stickleback has only three thorns on its back whereas the small one has plenty.}\] \(^4\)

\(^1\) Hansson, Lars-Anders et al.; Conflicting demands on wetland Ecosystem services: nutrient retention, biodiversity or both?; Freshwater Biology 2005
\(^2\) 4. www.vattenriket.kristianstad.se/fisk/fiskart/index.htm
\(^3\) Nilsson, Anders and Svensson, Mikael; Fiskfaunan i några år och bäckar i Malmö Kommun - resultatet av en inventering november 1998; Zoekologiska avdelningen, Ekologihuset, Lunds Universitet
Amphibians

Another functional group depending on wetland habitats is the amphibians. The two major groups living in Swedish freshwater are frogs and salamanders. As they during their lifetime live both on land and in water, the amphibians are a food source for both birds and fish. They are also good indicators of the environmental state an freshwater area is in, since they are very sensitive to environmental changes.

Mosquitoes

Among the insects habituating the Käglinge road area, mosquitoes are the most concerning when planning environmental recreation and the impact it will have on people living and working in the area. Although they are a natural part of wetland fauna some measures can be taken to balance the abundance of mosquito versus local recreational since mosquito are generally considered as a nuisance for nearby populace. Read more under Course of Action, Area C.

The southern part of Sweden is home to roughly 20-30 different species of mosquitoes and in a wetland area these thrive. This affects the numbers of natural enemies of both the mosquito larvae and full grown insect.
Birds

In a recent interview with the president of the Swedish ornitologian society (Svenska Ornitologiska Föreningen), Kenneth Bengtsson, DeCo briefed itself upon the local prerequisites for birds. The most common species for Scania (Blue tit, Great tit, Tree sparrow, Redstart, Starling; se figure 32-37) already habitats in the area, but more rare birds such as the Pied Flycatcher also appears from time to time.

Figure 32. Redstart (Phoenicurus Phoenicurus). These birds usually sings in the mornings and are, as the name indicate, easily recognized on the blue tail.
Aims to increase bird population would have two main benefits. Firstly, birds are natural predators on mosquito and will help to regulate mosquito abundance. Also, the birds themselves are a potential recreational value for bird watchers and people walking through the area. However, Mr. Bengtsson, who is well situated with the situation of the area, expressed concern about the area's population of young trees since birds need older trees for nesting. A possibility to relieve the nesting problem, he suggested, is the use of nesting boxes. A special bird that probably would like this habitat is the Tawny owl, a bird which according to Mr. Bengtsson does not exist in the municipality today (see figure 36).

Figure 33. Blue tit (Parus caeruleus). This tiny bird, about 12 cm from beak to tail, is easily recognized because of its blue colour. ¹

Figure 34. Pied Flycatcher (Ficedula hypoleuca). During August and September, the Pied Flycatcher emigrates to Africa. In April or May it is back in Sweden again and often seen in parks and gardens.²

Figure 35. Great tit (Parus major). To recognize the Great tit, look for the black line on its breast.³

Figure 36. Tawny owl (Strix aluco). A nice habitat for the Tawny owl is where it can find big trees, specially oaks, which it often does in parks. The colour vary between brown and grey for different individuals.⁴

Figure 37. Tree sparrow (Passer montanus). The Tree sparrow is a common guest in gardens, especially during the winter. Look for its brown head and black spot on the checks.⁵

¹, ², ³, ⁴, ⁵. Imby, Lars; Svenska fåglar - en fälthandbok; Prisma 1986
When treating a polluted area such as Käglinge Road the main thing to focus on is the key solvent for involved substances: water. When water precipitates as rain it contains a lot of pollutants collected in the air. However, when rain reaches the ground, the water solves even more substances, above all nutrients and heavy metals. The importance of water is emphasized by the fact that it transports all substances from air and ground to creeks, rivers, lakes and eventually the ocean.

**Nutrients**

Phosphor and Nitrogen are the primary problem in the eutrophication process, both in salt- and fresh waters (nitrogen in marine waters and phosphorus in fresh waters). Since they are the growth limiting factors of primary producers (plants, algae etc) they decide the extent of biological production. An obvious example of this is the greenish and bad smelling lakes in the end of summer. The main source of nutrients being agricultural areas, they are a huge part of Käglinge Roads pollutant transport. The eutrophication process results in turbid waters with a high occurrence of algal blooms, undrinkable water, low biodiversity and in the end contributes to the unnatural algal growth of the Baltic sea together with thousands of other eutrophicated streams.¹

**Heavy metals**

Heavy metals are natural substances entering the water by human activities and natural processes such as mining, industry, traffic and weathering rocks. Mainly Lead, Zink and Cupper are the contaminants in the Käglinge Road. In small amounts they are important in natural systems but as they often accumulate in the nowadays water systems, they reach poisonous concentrations. These elements collects higher up in the food chain where they effect many organisms negatively. Effects on organisms are e.g. dysfunction of gills. Since heavy metals accumulate in animal fat they are especially common in e.g. fish which is eaten by humans. Therefore it is vital to reduce this influence by minimizing these concentrations.²

**Deciding concentrations**

By using the mean runoff it is possible to calculate the pollutant transport in a year. This is easily performed and based on simple measurements out in the field. Considering the area use in the catchment area is of great importance when estimating the movement of substance concentrations. Since Käglinge Road is surrounded by a lot of impermeable area, pollutants will be accumulated on the ground when water evaporates. These pollutants will be washed away in the next rainfall. This runoff from Käglinge Road catchment will eventually end up in planned restoration areas. Storm water concentrations vary greatly depending on this impermeable areas such as parking lots, roof, roads etc. In the appendix these constants are presented with following calculations.

¹ Berndtsson, Ronny and Hansson, Lars-Anders; Project work Riseberga river - Hydrology and aquatic ecology VVR 111 - Period 1 and 2; KFS i Lund AB 2006
² Brönnmark, Christer and Hansson, Lars-Anders; The Biology of Lakes and Ponds Seccnd Edition; Oxford University Press; 2005
The mean pollutant transport from Käglinge Road area is:

Nitrogen: 13900 kg/year
Phosphorus: 445 kg/year
Zink: 58 kg/year
Lead: 16 kg/year
Cupper: 16 kg/year

Wetland construction

A wetland is an area covered with surface water for a substantial part of the year. This includes lakes, rivers, creeks, puddles, mires etc. The purposes of artificially creating such an area can be many. For starters, wetlands reduce nutrients and increase biodiversity. It often slows down runoff from the area, which benefits biological processes as well as reduces the risk of floodings. In populated areas a wetland can easily be combined with recreational values. ¹

Firstly when constructing an artificial wetland it is important to understand the dynamic relationship between surface water and ground water. The water level of these two waters depend on each other; low water levels in ground water means an infiltration of surface water and vice versa. To make sure that the wetland won’t be drained the level of ground water generally need to be raised with a downstream weir. ²

Nutrient reduction in a wetland area is an inexpensive and environmental method with good results. The primary nutrients, nitrogen and phosphorus both descend mainly from rural areas where they are used in fertilizers. The transport of these nutrients in nature is called the nitrogen cycle, respectively the phosphorus cycle and is the tool for understanding the eutrophication problem. From a human point of view some of the molecular forms that nitrogen and phosphorous have, are wanted in certain areas whereas they can be directly bad in others. For example, in Scania the large percentage of rural areas has led to a dramatic abundance of nitrate since the substance is wanted when fertilizing crops. The use of it has led to outspread eutrophication of downstream fresh water systems. ³

A main benefit from constructing a wetland is the opportunity to increase local biodiversity. Since a wetland has such a mixture of different form and shapes all within the same area it creates a blend of habitats all with their own unique prerequisites. These constitute chances for a lot of different animal and plant species that does not thrive in the surrounding region to habitat within the wetland. There they are given food, habitual and breeding prerequisites that the surrounding region does not represent. In such a heavily agricultural area as Scania a wetland would literally create an island in the sea of similar, drained landscape the agricultural areas represent.

Species who can not survive within the ecosystem created by human rural activities

1. Tonderski, Karin et al.; Vätmarksboken - Skapande och nyttjande av värdefulla våtmarker; Västra 2002
2. Berndtsson, Ronny and Hansson, Lars-Anders; Project work Riseberga river - Hydrology and aquatic ecology VVR 111 - Period 1 and 2; KFS i Lund AB 2006
3. Hansson, Lars-Anders; lecture, University of Lund 2006-09-04
will have a chance to at least partly recover. A wetland could thus create small areas where rare or endangered species could live despite being surrounded by human areas. However, even though wetlands usually increase the available habitat area for many rare species, it is not always biodiversity increasing. This is because the measures taken to maximise nutrient retention might not be the ultimate solution for increased biodiversity. Increased biodiversity usually needs a complex surrounding creating many microhabitats while nutrient retention many times might consist of a quite simple solution. Therefore this should be evaluated and the main focus and function of the wetland decided before determining the design of the wetland.

Nitrogen

A rough profile of the part of the nutrient cycles that will occur in our wetland will be presented below:

The main part of nitrogen entering the catchment is in nitrate form ($\text{NO}_3^-$) from agricultural areas further upstream. This form can be reduced from the water course mainly by two things, denitrification and assimilation. Living organisms form amino acids and proteins from nitrate and gathering of this from the surroundings by mainly primary producers such as algae, bacteria and plants is called assimilation. This is a major reducer of nitrate and occurs in all the “green areas” in the wetland. The nitrate is simply stored within the plants. In areas where there is low oxygen, denitrification can occur, this is reduction of nitrate by bacteria in oxygen depleted zones. Roughly it’s bacteria breathing nitrate instead of oxygen and reducing the nitrate in to gas form which will raise from the water and be solved into the atmosphere, thus decreasing the nutrient in the water course.\(^1\)

Phosphorous

Phosphorous is generally the limiting nutrient in fresh water eco systems, i.e. the nutrient that controls the abundance of growth in the area. Phosphorous levels are strongly related to the oxygen amounts dissolved in the water. During high oxygen concentration, phosphorous easily forms larger molecules with metal ions which sink down to the sediment. These large molecules have to be broken down to phosphate ($\text{PO}_4^{3-}$) in order to be available for organisms. Where phosphorous has sedimented it is important that the oxygen level is relatively high in order to maintain the low phosphate concentration. Otherwise the binding with e.g. iron ions will brake and phosphorous will be released from the sediment into the water. This is called internal loading.

The exchange of phosphates between the sediment and the surface water is mainly regulated by bacterial break down of larger molecules and dead organic material. Disturbances in the sediment can suddenly release large amounts of phosphorous to the water which will lead to highly increased growth. A way to reduce the amount of phosphorous in the system is to slow down the water and thereby increasing sedimentation which later on will be dredged from the bottom and deposit in an area

\(^1\) Hansson, Lars-Anders; lecture, University of Lund 2006-09-04
\(^2\),\(^3\),\(^4\) Tonderski, Karin et al.; Våtmarksboken - Skapande och nyttjande av värdefulla våtmarker; Vastra 2002
where it will not easily infiltrate into the water course again. Of course, vegetation using the nutrient is another way of reducing the amount.

Generally the effect of all processes above increases with the amount of surface and time the nutrients are exposed to the processes.\textsuperscript{3} The sedimentation process also reduces the heavy metal concentration.

Mosquitoes

A commonly expressed concern by people living nearby a planned wetland is about mosquitoes. These are, although a natural part of the wetland ecosystem, considered as a nuisance and often measures to control mosquito population will be executed when planning the wetland area. Firstly, mosquitoes do thrive in wetland areas since they lay their eggs under water. Thus an increased area of water surface will increase the number of mosquitoes. When the area is flooded, greater quantities of mosquitoes will hatch, especially during summer and, to a lesser degree, spring floodings. These hatchings can be the especially aggressive “flooding mosquito”. Hatching during early seasons may also increase the length of the mosquito season in to September or even longer.\textsuperscript{4}
Discussion

The area Käglinge Road are one of many places where the natural conditions have been altered and changed due to human activities. The technical development in the world has led to various pollutions spreading and a decrease of biodiversity all over the world. A situation that seems to continue far into the future, especially in the developing countries. Eutrophication and abnormally high heavy metal concentrations are just one of numerous problems mankind are facing. It is important that everyone takes their responsibility in order to make a fundamental change. This is a problem for all organisms on earth, including humans.

Goals implying a return into natural sound conditions have been put up both internationally and within most nations. The UNEP (United Nations Environment Programme) has freshwater as one of their main issues. Goals set up there affects countries’ legislation and in the end communities.1 Sweden has a history of interest in environmental questions, a growing awareness and the country produce a lot of research in the field. To be able to make a big change laws and regulations has to be changed, which they to a great extent in Sweden have been. This can be seen in the national environmental goals. But words need to be put out in the reality where they make a difference. An enormous number of small changes in areas such as Käglinge Road will together switch back the negative effects of our welfare into the natural state they once had. Therefore, the plan for the project DeCo has presented is linked all the way to international agreements and goals as well as to the goals of Malmö municipality. A way of seeing this is that if the project is successful, the decreased amount of nutrients will in the end reduce the amounts reaching the Baltic sea and in the end the Atlantic and all oceans on earth. The difference this project makes in the grand oceans is of course diminishingly small, the point is that everything is connected. There are no borders of impact when it comes to the environment.

A project made to improve an area such as Käglinge Road environmentally can of course have infinite different solutions. They all depend on the main project goals set up in the beginning. Given the conditions that rule the area and the surroundings, improving Käglinge Road can be done so that different areas are more prioritized than others. The main areas to be considered are nutrient retention, heavy metals sedimentation, biodiversity and recreational values. These can also be divided into subareas. If an increased biodiversity is the main goal, then one must define biodiversity and decide if it is e.g. insects, birds or fish that will be most prioritized. It is not always the same solution that favors different species. Many times compromises needs to be made. Also measures taken to achieve high nutrient retention might not raise the biodiversity significantly or give the best conditions for heavy metals sedimentation. If and how recreational values are raised is often a question of taste and habits.

When it comes to pollution the surrounding areas’ qualities needs to be investigated. What sort of pollutions passes the region? Where do they come from? Can the sources be diminished or at least reduced? What are the effects? Which are most important to

1. www.unep.org/themes/freshwater
focus on given the decided main goal? There might not be one correct answer. It is all about definition. Käglinge road has a surrounding dominated by agriculture. It is also exposed to heavy metals from storm water entering the area. The meadow and straight ditch are not favoring increased biodiversity and much can be done to make the area more inviting for e.g. strolling.

Deciding which area that gets the main priority can be done thinking in several ways. The solutions for decreasing heavy metals are not the most prominent when it comes to wetland. However, they still have an effect not to be neglected and heavy metals are poisonous in current amounts found in nature. Nutrient retention can be quite effective in wetlands and since the water are so eutrophicated entering Käglinge Road it is a goal that can be reached relatively efficiently. Biodiversity defined as a sound distributed number of individuals over a great species richness range should be considered. Today Käglinge Road has a respectable bird population. The wetland can be constructed so that more fish species can establish. However, fish- and bird species richness are not necessarily following each other. According to some wetland experts, the opposite are often reality. This should be evaluated and could mean that an already existing bird species richness could be maintained or even increased with the cost of a not so great fish biodiversity. Others might say the opposite. Recreational values are another tricky question since it deals with what kind of recreation that is valued by the nearby living or working population. Käglinge Road has a newly built riding path often used by riders and parents to riding lessons taking children of stroll in the area. Industry are close by and a grasp of air in a nice green area during break for the people working there could be another thought.

In this project the main focus is set on firstly nutrient retention and secondly recreational values. The intention is that the recreational values are maximized given the possibilities that the design for nutrient retention and biodiversity give. No specific measures are taken to increase heavy metal sedimentation but a fact is that it will be an ecosystem service that the wetland will induce. This means that heavy metal reduction in the streaming water will be a consequence of the nutrient decreasing procedures. Not to be forgotten is the attention put to safety all through the project. It has a high priority in the Käglinge Road wetland design.

Other alternatives of focus could of course have been to give recreational values highest priority. Design the area to make it look more like a park with perhaps less efficient solutions for decreased pollution concentrations of the water. Or to have a lot of plants and flowers planted around the wetland. These would need care and the costs would increase. This should then be weighed to the use of the area. If increased biodiversity had the highest priority ponds could have been designed differently, no need to consider the constructions favoring nutrient retention. Perhaps then recreation would not be so desired in the area. Animals and plants could be thought of as protected from human intrusion.

The costs could have been reduced by giving up the safety of the wetland being able to hold a heavy rainfall of once in 100 year occurrence. This term raises the cost
quite notably when it comes to the work of digging. If the intention was to only hold a rain of, say, once in 10 year occurrence, the costs could have been reduced. However the costs for the surrounding areas could of course increase greatly in case of flooding. It could also have been cheaper if the focus was not set at both nitrogen and phosphorus. If just e.g. phosphorus retention was prioritized, just one deep pond could have been dug. Then of course a bigger biodiversity would have been another loss. This also means that focusing only on biodiversity could have saved resources put on nutrient retention. All these factors could have decreased the costs but DeCo’s solution gives better improvements of the area.

Conclusion

The measures given by DeCo will to a great extent solve the environmental problems connected to the project area. These actions will according to the project goals improve the present conditions. In these goals, focus is mainly on the environmental goals set up by Malmö municipality and in the end international thinking.

The creating of a new wetland on Skogholms meadows means that both phosphorous- and nitrogen concentrations are reduced, nutrients that contributes to eutrophication in the river and in the end in the Baltic Sea. When choosing Skogholms meadows for the wetland, the future industrial area is not affected. DeCo is content with a solution that favors both ecological and economical interests.

The wetland also increases the recreational values of the area and DeCo has focused on making the place welcoming to visitors. Since the area is frequently used for both strolling and riding, the different needs of these activities has been taken into account and solved in best possible way given the prerequisites.

Even though the surroundings of the river in area A and C are quite narrow, DeCo has presented a possible improvement of the water conditions using relatively simply methods. The design of the wetland and together with the changes of the river create good possibilities for an augmented biodiversity in the area which is presented as the third project goal.

To the interest of Malmo municipality, the entire project of restoring the Käglinge road area has a budget well under 1.46 MSEK.

Hopefully this will create a pleasant corner for recreation where both people and nature can prosper together.
APPENDIX

Water balance
Käglinge road catchment area is 1000 ha, and for extra certainty to different measurements of annual water balances will be used, firstly Fig.2.21 of the hydrology textbook:

Precipitation (P): Runoff (Q): Evaporation (E):
700 mm 200 mm 500 mm

Precipitation
From a diagram in the hydrology textbook made by “Malmös vatten- och avloppsverk” DeCo finds the largest rains. We assume it rains for 30 min. and call the statistic largest rain for 30 min in 1 year the 1-year rain, in 10 years the 10-year rain and in 100 years the 100-year rain.

The diagram shows up to 10 years, but when the time period is doubled it ads the same amount of water. This tells us the scale is logarithmic, and we can easily calculate the 100-year rain too. Using diagram 3.15 in hydrology textbook maximum rainfall during the time periods is calculated:

<table>
<thead>
<tr>
<th>Time Period</th>
<th>1 year</th>
<th>10 years</th>
<th>100 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>litre/(s*ha)</td>
<td>50</td>
<td>80</td>
<td>110</td>
</tr>
<tr>
<td>mm/30 min</td>
<td>9</td>
<td>14.4</td>
<td>19.8</td>
</tr>
</tbody>
</table>

If a volume is divides by an area it is equal to a distance so we can easily calculate how many mm rain per second, or even per 30 min the 1-, 10- and 100-year rain are. This is unit is better for calculating effective rainfall.

\[
\text{liter/(s*ha)} = \frac{(m^3*10^{-3})}{((s/1800)*10^4m)} = \frac{m}{30\text{min}}
\]

<table>
<thead>
<tr>
<th>Time Period</th>
<th>1 year</th>
<th>10 years</th>
<th>100 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm/30 min</td>
<td>9</td>
<td>14.4</td>
<td>19.8</td>
</tr>
</tbody>
</table>

The effective rainfall is the amount of water that runs down into the river from the rain this equals to the runoff. Some factors that affect this are landscape, soil and vegetation. Looking at some old rains at the catchment we calculate a coefficient that gives us the runoff. Precipitation was measured at four points in the catchment. Their locations make them represent a percentage of the catchment. When calculating effective runoff from Riseberga River catchment area we're using Fig.10 from the Hydrology textbook.

Runoff coefficient(K)= Runoff(Q)/Precipitation(P)

<table>
<thead>
<tr>
<th>Unit</th>
<th>Rain1</th>
<th>Rain2</th>
<th>Rain3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Runoff (Q)</td>
<td>mm/3h</td>
<td>2.5</td>
<td>7.5</td>
</tr>
<tr>
<td>Precipitation</td>
<td>mm/3h</td>
<td>P1</td>
<td>10% *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P2</td>
<td>30% *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P3</td>
<td>40% *</td>
</tr>
<tr>
<td></td>
<td></td>
<td>P4</td>
<td>20% *</td>
</tr>
<tr>
<td>Precipitation total (P)</td>
<td>mm/3h</td>
<td>55</td>
<td>105</td>
</tr>
</tbody>
</table>
Runoff coefficient (K)  0.17  0.3  0.2

* Percentage of Catchment Area.

Calculating effective rainfall (Runoff) from Rain1-3 during timeperiods: mm/30min

The runoff coefficient is effective rainfall divided by precipitation. We use the mean value of the coefficients. Calculating effective rainfall from maximum rains:

<table>
<thead>
<tr>
<th>Coefficient</th>
<th>1 year</th>
<th>10 years</th>
<th>100 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rain mean</td>
<td>0.223</td>
<td>2.01 mm/30 min</td>
<td>3.21 mm/30 min</td>
</tr>
</tbody>
</table>

### Runoff

The runoff presented in the table below was observed at Käglinge road after a total rainfall of 10 mm during 30 minutes given the catchment area of 1000 ha. Base flow from the catchment (i.e. the standard runoff not depending on the rainfall) is also presented to give a view of the differences. With this a unit hydrograph for an effective rainfall of 1 mm is calculated and presented in the right side of the page.

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Unit Hydrograph (l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0,0</td>
</tr>
<tr>
<td>30</td>
<td>38,3</td>
</tr>
<tr>
<td>60</td>
<td>153,0</td>
</tr>
<tr>
<td>90</td>
<td>459,8</td>
</tr>
<tr>
<td>120</td>
<td>689,7</td>
</tr>
<tr>
<td>150</td>
<td>1149,6</td>
</tr>
<tr>
<td>180</td>
<td>996,3</td>
</tr>
<tr>
<td>210</td>
<td>842,6</td>
</tr>
<tr>
<td>240</td>
<td>689,7</td>
</tr>
<tr>
<td>270</td>
<td>306,5</td>
</tr>
</tbody>
</table>
From the unit hydrograph it’s plain that a small rain gives a lot of runoff distributed over a long period of time compared to the duration of the rainfall itself. This will only increase when calculating runoff from the 1-10 and 100 year rains using above unit hydrograph. In the table below all the runoff from these rains are presented along with the information given above, again this make the magnitude of rarely occurring rains such as the 10 or 100 year rains stand out much clearer.

As seen, the unit hydrograph provides us with the fact that runoff up to 5000 litres per second will eventually occur from käglinge road during a hundred year perspective. This is alarming but the solution is an ample storm water treatment plan as we’ll present later on.

### Calculations for runoff

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Q total: Runoff (l/s)</th>
<th>Base Flow</th>
<th>Q direct (runoff-base flow)</th>
<th>Q mean: Average (runoff-base flow)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>38,3</td>
</tr>
<tr>
<td>30</td>
<td>86,6</td>
<td>10</td>
<td>76,6</td>
<td>191,3</td>
</tr>
<tr>
<td>60</td>
<td>316</td>
<td>10</td>
<td>306</td>
<td>612,8</td>
</tr>
</tbody>
</table>
Below follows rest of the table.

<table>
<thead>
<tr>
<th>Unit Hydrograph (l/s)</th>
<th>UH + base flow</th>
<th>Maximum runoff: 1 year rain</th>
<th>Maximum runoff: 10 year rain</th>
<th>Maximum runoff: 100 year rain</th>
</tr>
</thead>
<tbody>
<tr>
<td>0,0</td>
<td>10,0</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>38,3</td>
<td>48,3</td>
<td>85,83885369</td>
<td>131,4187708</td>
<td>176,998879</td>
</tr>
<tr>
<td>153,0</td>
<td>163,0</td>
<td>312,9593894</td>
<td>495,0410426</td>
<td>677,1226959</td>
</tr>
<tr>
<td>459,8</td>
<td>469,8</td>
<td>920,4622696</td>
<td>1467,65929</td>
<td>2014,856311</td>
</tr>
<tr>
<td>689,7</td>
<td>699,7</td>
<td>1375,693404</td>
<td>2196,488935</td>
<td>3017,284466</td>
</tr>
<tr>
<td>1149,6</td>
<td>1159,6</td>
<td>2286,155674</td>
<td>3654,148225</td>
<td>5022,140777</td>
</tr>
<tr>
<td>996,3</td>
<td>1006,3</td>
<td>1982,602247</td>
<td>3168,156122</td>
<td>4353,709997</td>
</tr>
<tr>
<td>842,6</td>
<td>852,6</td>
<td>1678,256768</td>
<td>2680,895937</td>
<td>3683,535106</td>
</tr>
<tr>
<td>689,7</td>
<td>699,7</td>
<td>1375,693404</td>
<td>2196,488935</td>
<td>3017,284466</td>
</tr>
<tr>
<td>306,5</td>
<td>316,5</td>
<td>616,9088422</td>
<td>981,6671867</td>
<td>1346,425531</td>
</tr>
<tr>
<td>153,3</td>
<td>163,3</td>
<td>313,5534274</td>
<td>495,9921035</td>
<td>678,4307796</td>
</tr>
<tr>
<td>76,7</td>
<td>86,7</td>
<td>161,87572</td>
<td>253,1545619</td>
<td>344,4334037</td>
</tr>
<tr>
<td>0,0</td>
<td>10,0</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>

**Effective rainfall (P effective) mm**

\[ P_{effective} \approx 2 \]

**Pollutants from rural areas**

The volume of water multiplied with the concentration of said pollutant makes the amount of pollutants in kilograms.

Runoff \( m^3/\text{year} \):

\[
31536000 \times 0.058 \text{m}^3/\text{s} = 1829088 \text{m}^3/\text{year}
\]

Calculation of two pollutants, nitrogen and phosphorus can now be done.

- **Nitrogen:**
  - Concentration: 5-10g/m³
  - Annual mean runoff: 0.058m³/s

- **Phosphorus**:
  - Concentration: 0.1-0.3g/m³
  - Annual mean runoff: 0.058m³/s

Estimated amount transport from Riseberga road \( \text{year} \):

- **Nitrogen:** 9100-18300kg/year
- **Phosphorus:** 180-550kg/year

These amounts of pollutants go straight out in the Baltic sea and add to the eutrophication of its waters, reducing them will give a better status for käglinge road area and, during a longer time perspective, the Baltic sea.
Pollutants from stormwater in urban areas

Runoff volumes depend on how impermeable the surfaces of the area are. For calculating purposes the area is divided into four categories, based upon impermeability and concentration of pollutants. Impermeability will differ the storm water volume accordingly to the amount of asphalted surface, roof areas, concrete grounds etc.

The annual storm water volumes for the different areas of Käglinge road catchment are:

<table>
<thead>
<tr>
<th>Area</th>
<th>Annual runoff (billion m³):</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic</td>
<td>144-180</td>
</tr>
<tr>
<td>Industrial</td>
<td>24-30</td>
</tr>
<tr>
<td>Sparsely populated (&lt;50p/ha)</td>
<td>22.5-27</td>
</tr>
<tr>
<td>Central, h. populated (&gt;50p/ha)</td>
<td>27-31.5</td>
</tr>
<tr>
<td>TOTAL:</td>
<td>217.5-268.5</td>
</tr>
</tbody>
</table>

Typical urban pollutants are for example nitrogen, phosphorous and heavy metals. The concentration of these differs within the city in relation to area usage. Naturally, concentrations will be higher in industrial areas but it is with the context of impermeability the concentration of pollutants in storm water runoff can be calculated.

### Calculations for pollutants

\[ Q_{vol} = (a \times A) \times (P - b) \times 10^3 \]

\[ (a \times 5 \times 10^5 \text{m}^2) \times (700 \text{mm}-100\text{mm}) \times 10^3 = a \times 3 \times 10^11 \text{ m}^3 \]

<table>
<thead>
<tr>
<th>Area Use</th>
<th>Share</th>
<th>a Min.</th>
<th>a Max</th>
<th>Q min</th>
<th>Q max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic</td>
<td>0.6</td>
<td>0.8</td>
<td>1</td>
<td>1,44E+11</td>
<td>1,8E+11</td>
</tr>
<tr>
<td>Industry</td>
<td>0.1</td>
<td>0.8</td>
<td>1</td>
<td>24000000000</td>
<td>30000000000</td>
</tr>
<tr>
<td>Resid. &lt;50</td>
<td>0.15</td>
<td>0.6</td>
<td>0.7</td>
<td>22500000000</td>
<td>27000000000</td>
</tr>
<tr>
<td>Resid. &gt;50</td>
<td>0.15</td>
<td>0.6</td>
<td>0.7</td>
<td>27000000000</td>
<td>31500000000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area Use</th>
<th>Share</th>
<th>a Min.</th>
<th>a Max</th>
<th>Q min (m³/year)</th>
<th>Q max (m³/year)</th>
<th>N min (mg/l)</th>
<th>N max (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic</td>
<td>0.6</td>
<td>0.8</td>
<td>1</td>
<td>144000</td>
<td>180000</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>P.C.Min.</td>
<td>P.C.Mean</td>
<td>P.C.Max.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>216</td>
<td>333</td>
<td>450</td>
<td></td>
</tr>
</tbody>
</table>
### Retention of nitrogen and phosphorous

Calculations:

**Mean value:**
- $N$: $13900 \text{ kg/year} \times 0.35 = 4865 \text{ kg/year}$
- $P$: $445 \text{ kg/year} \times 0.27 = 120 \text{ kg/year}$

**Interval 1 year basis:**
- $N_{\text{max}}: 18500 \times 0.37 = 6845 \text{ kg/year}$
- $N_{\text{min}}: 9300 \times 0.23 = 2139 \text{ kg/year}$
- $P_{\text{max}}: 550 \times 0.38 = 209 \text{ kg/year}$
- $P_{\text{min}}: 180 \times 0.01 = 1.80 \text{ kg/year}$

**Interval 5 year basis:**
- $N_{\text{max}}: 18500 \times 0.35 = 6475 \text{ kg/year}$
- $N_{\text{min}}: 9300 \times 0.35 = 3255 \text{ kg/year}$
- $P_{\text{max}}: 550 \times 0.27 = 149 \text{ kg/year}$
- $P_{\text{min}}: 180 \times 0.27 = 49 \text{ kg/year}$

---

The total amount of pollutants from the catchment (rural areas + urban areas):
- **Nitrogen:** $9300-18500 \text{ kg/year}$
- **Phosphorous:** $180-550 \text{ kg/year}$

Mean: $13900 \text{ kg/year}$
Mean: $445 \text{ kg/year}$
Costs and further details

The sedimentation pond will cover about 23% of the total area, the rest (meander, root zone etc.) 77%. The mean depth in the pond will be 0.9 m and the rest of the area 0.25 m. The size of the total area at base flow is 1 ha.

\[ 0.23 \times 0.9 + 0.77 \times 0.25 = 0.4 \text{m} = \text{mean depth of the total area}. \]

Details and retention

To even out the ground: \(60 \times 60 \times 1 + 100 \times 50 \times 1 = 8600 \text{ m}^3\)
To get the right form of the area: \(1.1 \times 5000 + 1.5 \times 5000 = 13000 \text{ m}^3\)
Other digging: \(0.3 \times 25000 = 7500 \text{ m}^3\)

Costs:
To move 1 m³ of soil: 50 SEK
\((8600 + 13000 + 7500) \times 50 = 1.46 \text{ MSEK}\)

Soil- and groundwater

“Hortons equation” for area Käglinge Road will look like:

Hortons infiltration equation (how quickly water infiltrates): \(f(t) = f_c + (f_o - f_c) \times e^{-kt}\)

Where \(f_o = \) infiltration capacity at \(t = 0\) (dry conditions; mm/min)
\(f_c = \) final infiltration capacity (mm/min)
\(k = \) time constant that decides how quickly the infiltration capacity is reduced (1/mm)
\(t = 10 \text{ min}\)

Area of infiltrometer: \(314 \text{ cm}^2\)

\(f_o = 0.382 \text{ mm/min}\)
\(f_c = 0.076 \text{ mm/min}\)

To determine \(k\):
\(f(5) = 60 = 0.076 + (0.382 - 0.076) \times e^{-5k}\) which gives \(k = -1.055\)

This gives: \(f(t) = 0.076 + (0.382 - 0.076) \times e^{-0.055t}\)

\(F(t) = \text{height of infiltrated water (mm)} = f_c(t) + (1-e^{-kt})(f_o - f_c)/k\)

After 83 min: \(F(t)\) for a 100-years rainfall: 68.9
\(F(t)\) for a 10-years rainfall: 68.9
\(F(t)\) for a 1-year rainfall: 68.9
After 166 min \( F(t) \) for a 100-years rainfall: 138
\( F(t) \) for a 10-years rainfall: 138
\( F(t) \) for a 1-year rainfall: 138

Volume of infiltrated water (m\(^3\)):

After 83 min: for a 100-years rainfall; 758
for a 10-years rainfall: 689
for a 1-year rainfall: 551

After 166 min for a 100-years rainfall; 2899
for a 10-years rainfall: 2327
for a 1-year rainfall: 1795

The major risk for pollutant spread (e.g. oil) with groundwater would be a road accident at the highway E6. The closest point at road E6 is situated approximately one kilometre from the wetland at Skogholms meadows.

The soil on the area Käglinge Road mostly consists of silt and clay. However, the soil has a lot of large cracks where the water is transported. DeCo has used “Soil’s hydraulic parameters” given during a lecture by Ronny Berndtsson, Lund University 17-11-2006.

\[
S = \frac{K \cdot dh/dx}{\Phi}
\]

Where \( S \) = velocity of the transported pollutant (m/s)
\( K \) = hydraulic conductivity (m/s)
\( dh/dx \) = slope of the area
\( \Phi \) = porosity = pore volume/total volume (%)

Time of this pollutant transport:

\[
S = \frac{4 \times 10^{-3} \times 0.01}{0.28} = 1.428 \times 10^{-4} \text{ m/s}
\]

This means that the pollutant transport from the road to the wetland takes approximately 80 days.
DeCo base the dimensions of the weir on following diagrams:
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