

Green roofs and green walls can be used in Norwegian towns to improve local stormwater management and establish quality green space.

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“Blue-green” solutions combine a number elements that add to the quality of urban green spaces and reduce costs for dealing with storm water. However, we presently lack reliable quantitative figures for the effects expected from green roofs, infiltration zones of vegetation in different types of green space. The effects vary significantly depending on how well solutions are tailored to achieve the intended results. Therefore, increased knowledge and good planning is essential to attain the values green elements can provide. Local climate and weather conditions are an important factor affecting quantitative performance.



Discussion concerning the green roofs (10 pieces: 2 x 3 meters) at the seminar hosted by Nibio Særheim in September 2016. Each roof can easily be replaced and each unit is therefore a test station for runoff and other performance characteristics.

The project "Robust and sustainable communities; ROBÆR" is led by Stavanger Municipality in cooperation with the municipalities of Bergen, Randaberg, Sola and Sandnes. ExxonMobil, Bergknapp (green roof supplier) and The Skjæveland Group are sponsors contributing significant resources to the project. The project is led by Arne Sæbø of NIBIO, Department of Greening Solutions and Environmental Technology.

The goal of the project is to develop blue-green solutions as tools for comprehensive and sustainable stormwater treatment in both the present and future climate conditions of Western Norway. Specifically, the project aims to improve and develop design, plant selection and construction of blue-green infrastructure solutions such as green roofs, rain gardens and infiltration beds adapted to the climate of Western Norway. The project is committed to quantifying the effects of relevant design solutions based on experimentation and fine tuning. The “Blue green area factor” indicator will be tested. Demonstrations of local stormwater treatment will be established in local participating municipalities.



Installation of a green wall (Skjæveland Wall) by Nibio Særheim. The plants are tested on both the sun exposed and shade side. The tests employ two soil types and the use of irrigation containers to support plant growth and resilience.

The project has measured how much water green roofs can retain under the local conditions at Særheim (about 20 km south of Stavanger) and tested plant materials and substrates for green roofs and infiltration zones. NIBIO has a strategic commitment to developing blue-green solutions and is commissioned by the Norwegian National Environment Agency to study and evaluate various roof solutions established in the project "Cities of the Future." These two projects are under the management of Hans Martin Hanslin, NIBIO.

In a completed commission from Innovation Norway, NIBIO collaborated on a project for green roofs in Romania. These projects, for example the green wall shown above, require several years of operation to give useable quantitative results. More results will be published in 2017. In 2016, our present knowledge and results were presented at a well-attended seminar at Bryne Municipality. Researchers from Norway, Sweden, Denmark, Belgium and England presented the latest results from our field of work. The seminar gave rise to new collaboration among research actors. The seminar presentations (many in Norwegian) can be read at ROBÆR project's website: (<http://www.nibio.no/prosjekter/robuste-og-brekriftige-lokalsamfunn>). A seminal conclusion from the seminar and from preliminary results of ROBÆR is that the development of useful solutions is dependent on investigating a multitude of possibilities. It is the combined effect of individual interventions (treatment train) working as part of a greater system that can provide the most promising blue-green solutions.

During the course of the ROBÆR project several demonstrations have been established, including a pedestrian trail in Bergen, greening at the Emmaus / Rosendal nursing homes in

Bergen, the Stangeland sports arena in Sola. Others are under construction at Randaberg and Sandnes. The demonstration projects intend to show how using different solutions can reduce damages from extreme quantities of stormwater.

Table 1. Demonstrations established i participating municipalities

Place	Type of demonstration and purpose	Established
Bergen	Urban walking path with stormwater treatment functions	2013-2016
Sandnes	Stormwater filtering and retention along a city center street.	2017
Randaberg	Canal for plant species testing. Plans developed by NIBIO in 2015.	2017
NIBIO Særheim*	Ten green roofs and a green wall with extensive testing of water retention and release, and testing of substrates and vegetation.	2014 – 2017
Sola	Stangeland sports arena with permeable surfaces and retention in soil structures under the playing surface.	2016
Stavanger	Landscape greening combined with retention basin for storage of flood water at the Emmaus neighborhood area.	2016
ExxonMobil	A rain bed for collection of runoff from a parking area. Testing of substrate and soil contributions to infiltration and retention and testing of vegetation.	2015
Skjæveland group	The company has delivered a green wall at NIBIO Særheim and demonstrations of permeable surfaces, green roofs and green walls. The company's 4 green roofs are built with the same dimensions as NIBIO's.	2015 og 2016

At the Særheim test site, Nibio has recorded runoff at short time intervals from 10 green roofs. The measurements yield a comprehensive and detailed demonstration of the effects of substrate and vegetation on the quantity and quality of water discharge. One experiment compares performance results by using different substrates (with sedum delivered by the company Bergknapp). Another experiment compares results from different substrate depths, and investigates the potential for using a wider variety of plants on green roofs in the climate of Western Norway. The substrates tested are composed of materials presently in use in the industry. Additional testing includes new components, such as bio-char.



Rainbed established as a demonstration and test of soil types, infiltration and vegetation.

Established by ExxonMobil at their Forus campus.

In addition to experiments and demonstrations on green roofs, we have conducted many experiments under artificially controlled conditions greenhouses at Nibio's Særheim test site. This will provide new knowledge about plants' responses to substrates and includes plants useful on green roofs and infiltration solutions.

The concrete results of the ROBÆR project will be more extensively disseminated in 2017. Results will be published in both scientific journals and in popular sciences media. Information on publications and where they can be accessed will be provided on the ROBÆR web site.



We have a broad spectrum of native plants to choose from in Norway, particularly among the Sedum varieties and species found in coastal beaches and alpine areas where plant life has adapted to dry and often harsh conditions.