Norrström Drainage Basin, Sweden

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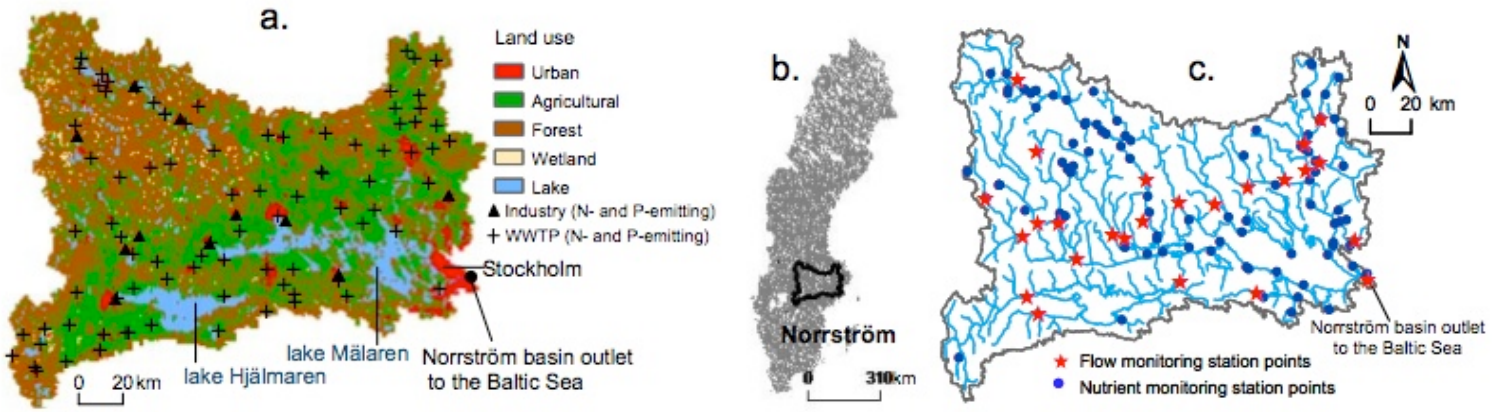

Figure. Norrström drainage basin (a) and its location in Sweden (b), with indicated water flow and nutrient monitoring stations (c). Panel (a) shows also the nutrient-emitting point sources (industrial, wastewater treatment plants - WWTP) and diffuse sources associated with different land cover/use within the basin. (Adapted from Destouni and Darracq, 2009)

Name and scale	Norrström Drainage Basin - 22,000 km^2.
Main research and management problems	Main ecohydrological problems are related to eutrophication and pollution of inland and coastal waters. The basin includes the Swedish capital Stockholm and the whole region is the most densely populated of the country. It has undergone rapid urbanization and industrialization and contains contaminated land sites around the large lakes Hjälmaren and Mälaren, where the latter is the main and only water supply for more than 1.5 Million people in the Stockholm region. Also agriculture and farming are extensive within this basin, which is part of the fertile Swedish belt. Together, the heavy population, agriculture and industry of this region imply large eutrophication and pollution pressures, which are mostly transferred to the inland surface waters and the

	coastal waters of the Baltic Sea through the soil and groundwater systems of the basin. These pressures need to be abated for several reasons: a) the high regional stakes associated with the only available main water supply for Stockholm, Lake Mälaren; b) the sensitive coastal and marine ecosystems of the Stockholm archipelago and the Baltic Sea, which must be remediated and safeguarded according to both international Baltic region agreements and Swedish environmental policy; and c) the requirements of the EU Water Framework Directive. Abatement may involve different measures, including wetland management and construction, in addition to source mitigation and other possible measures. With regard to GWEN, a main research question is: How do individual wetlands and wetland networks modulate the ecosystem services of filtering/attenuating waterborne nutrients and pollutants in this basin?
Possible end-users	The Norrström drainage basin is the administrative catchment of Lake Mälaren and constitutes the main part of the Swedish water management district Northern Baltic Proper, one of a total of five Swedish water districts that have been established in accordance with the requirements of the EU Water Framework Directive. The regional water authority for this district, as well as the main municipal water utility companies Stockholm Water and Norrvatten, and the overall Swedish sector organization of water utilities, Swedish Water, should be interested end users of research relevant research results. In addition, various other authorities, organisations, companies and NGOs, which have some responsibility for, or are in some way using and/or impacting the water resources of this drainage basin should be interested in either actively participating in, or using the outcomes from ecohydrological research projects at this site.
Site conditions	The Norrström drainage basin is rather flat, low-lying with numerous lakes, and underlain by granitic and gneiss-granitic bedrock covered by clay deposits and mostly thin (up to about 5 meters) till deposits; it has typical Swedish conditions of shallow groundwater table (one to few metres below surface). The basin consists of 4% built-up areas, 36% agricultural and open land, 49% forest (mostly in the north-west of the basin), 1.5% wetlands and 9.5% inland waters, including the third and fourth largest Swedish lakes Mälaren and Hjälmaren. The ecosystems of these lakes, as well of the coastal waters of the Stockholm archipelago are sensitive, threatened, associated with large socio-econonomic stakes, and need to be safeguarded.

Data and modelling	Currently available monitoring points for stream flows and nutrient concentrations are shown in the Figure above. Some additional local data are available for different sub-catchments and could be provided by involved end users. Model interpretations exist of available water flow and nutrient concentration/load data back to 1940 and for various projected future scenarios. Stream flow and nutrient concentration data are relatively readily accessible. Groundwater flow and quality data are less accessible because there is not much groundwater monitoring in the basin. Model analyses so far include (see references below): numerical modeling of water flow, nutrient transport and non-reactive solute (water) travel (transit) times through the catchment; climate and other regional change analysis; management analysis of inland and coastal nutrient loads, and their abatement possibilities. Results from modeling and interpretation of available data show that nutrient loading to inland and coastal waters may continue at current levels for long time (10ths of years) even after active source emission abatement. The rates and time scales of nutrient transport and mass transfer processes, their spatial-temporal variability and possible correlations and responses to climate and other types of change in the region need to be further investigated. In forthcoming work, investigations will focus on wetlands within this drainage basin, and previous results will be used for regional inter-comparisons, and analyses of changes in hydroclimatic conditions and ecosystem services.
Site-related publications by GWEN participants	**Journal articles:** • Destouni G., Persson K., Prieto C., Jarsjö J., ***General quantification of catchment-scale nutrient and pollutant transport through the subsurface to surface and coastal waters***, *Environ. Sci. Technol*., 44, 2048–2055, 2010. • Darracq A., Destouni G., Persson K., Prieto C., Jarsjö J., ***Scale and model resolution effects on the distributions of advective solute travel times in catchments***, *Hydrological Processes*, 24(12), 1697-1710, 2010. • Darracq A., Destouni G., Persson K., Prieto C., Jarsjö J., ***Quantification of advective solute travel times and mass transport through hydrological catchments***, *Environmental Fluid Mechanics*, 10, 103–120, 2010. • Destouni G., Darracq A., ***Nutrient cycling and N2O emissions in a changing climate: the subsurface water system role***, *Environmental Research Letters*, 4, 035008 (7pp), 2009. • Olli G., Darracq A, Destouni G., ***Field study of phosphorous transport and retention in drainage reaches***, *Journal of Hydrology*, 365, 46–55, 2009. • Darracq A., Lindgren G.A. and Destouni G., ***Long-term development of Phosphorus and Nitrogen loads through the subsurface and surface water systems of drainage basins***, *Global Biogeochemical Cycles,* GB3022, 2008. • Olli G., Destouni G., ***Long-term heavy metal loading to near-shore sediments***, *Water, Air, and Soil Pollution*, 192,

105-116, 2008.
- Destouni G., ***The subsurface water system role for surface and coastal water pollution***, *Ecohydrology & Hydrobiology*, 7(2), 157-164, 2007.
- Darracq A., and Destouni G., ***Physical versus biogeochemical interpretations of Nitrogen and Phosphorus attenuation in streams and its dependence on stream characteristics***, *Global Biogeochemical Cycles*, 21, GB3003, 2007.
- Lindgren G.A., Destouni G., Darracq A., ***Inland subsurface water system role for coastal nitrogen load dynamics and abatement responses***, *Environ. Sci. Technol.*, 41(7), 2159-2164, 2007.
- Baresel C. and Destouni G., ***Estimating subsurface nitrogen accumulation-depletion in catchments by input-output flow analysis****, Physics & Chemistry of the Earth*, 31, 1030–1037, 2006.
- Destouni G. and Darracq A., ***Response to Comment on "In-Stream Nitrogen Attenuation: Model-Aggregation Effects and Implications for Coastal Nitrogen Impacts"***, *Environmental Science & Technology*, 40, 2487-2488, 2006.
- Baresel C., and Destouni G., ***Novel quantification of coupled natural and cross-sectoral water and nutrient/pollutant flows for environmental management***, *Environmental Science & Technology*, 39(16), 6182 – 6190, 2005.
- Darracq A., and Destouni G., ***In-stream nitrogen attenuation: model-aggregation effects and implications for coastal nitrogen impacts***, *Environmental Science & Technology*, 2005.
- Darracq A., Greffe F., Hannerz, F., Destouni G., and Cvetkovic V. ***Nutrient transport scenarios in a changing Stockholm and Mälaren valley region***. *Water Science & Technology*, 51: 3-4, 31 – 38, 2005.

PhD theses (supervised by GWEN participant G. Destouni):
- Persson K., ***Quantifying pollutant spreading and the risk of water pollution in hydrological catchments: a solute travel time-based scenario approach***, *PhD thesis*, Department of Physical Geography and Quaternary Geology, Stockholm University, 2011.
- Olli G., ***Waterborne sediment and pollutant transport into lakes and accumulation in lake sediments***, *PhD thesis*, Department of Physical Geography and Quaternary Geology, Stockholm University, 2008.
- Darracq A***., Long-term development, modeling and management of nutrient loading to inland and coastal waters***, *PhD thesis*, Department of Physical Geography and Quaternary Geology, Stockholm University, 2007.
- Baresel C., ***Environmental management of water systems under uncertainty***, *PhD thesis*, Department of Land and Water Resources Engineering, Royal Institute of Technology, Stockholm, 2007.
- Lindgren G., ***Physical process effects on catchment-scale pollutant transport-attenuation, coastal loading and abatement efficiency***, *PhD thesis*, Department of Land and Water Resources Engineering, Royal Institute of Technology, Stockholm, 2006.