CASE STUDY STATUS REPORT

ODENSE RIVER BASIN, DENMARK

(Deliverable D30)

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Introduction

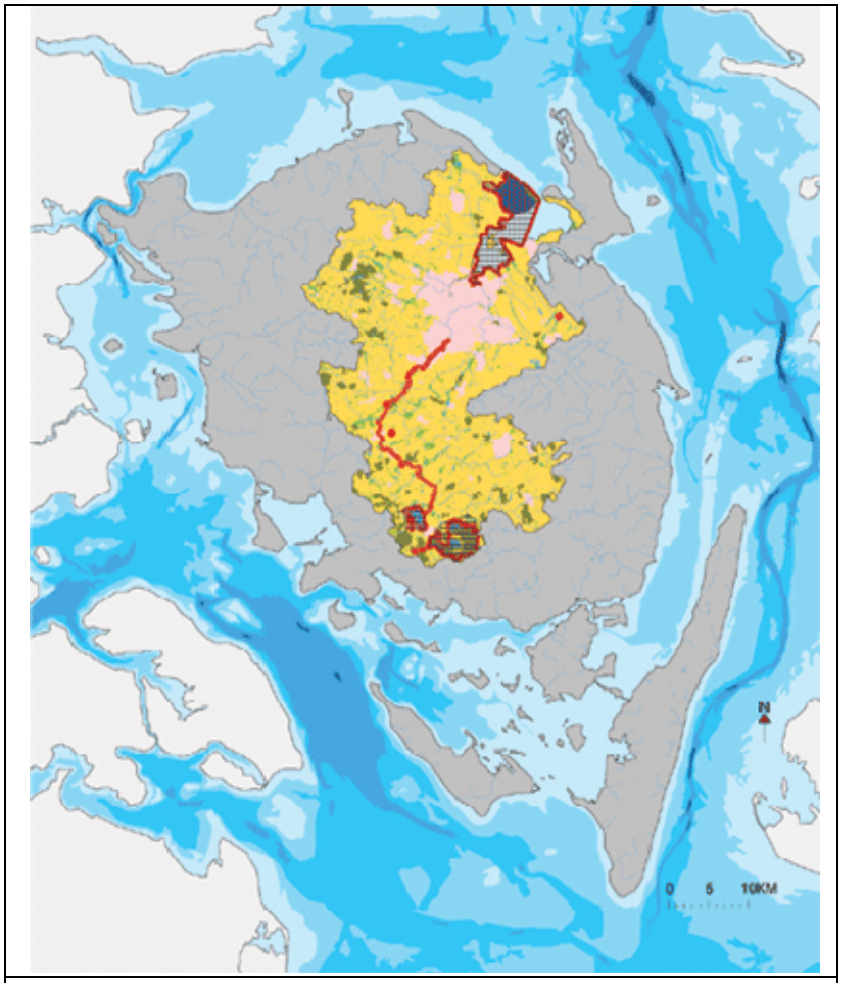
The Odense River Basin is a pilot area and test study for implementation of the WFD. As part of this test study, water bodies (surface water, wetlands, and groundwater) have been characterised and the pollutant loading of groundwater and surface water assessed including the impact of human activities on water status.

The descriptions of area characteristics, environmental pressure and environmental objectives in section 1) and 2) in this report are based primarily on extracts from the pilot river study report: **County of Funen (2003). Odense Pilot River. Provisional Article 5 Report pursuant to the Water Framework Directive. County of Funen.**

1) GENERAL CASE STUDY CHARACTERISTICS

1.1. Location of the case study area

Odense River basin is located on the island of Funen, the second largest Danish island. The basin comprises an area of approx. 1 046 km2 with about 246 000 inhabitants. The town Odense is the largest population centre in the basin area.



Map of the Odense River Basin

1.2. Geographical characteristics

Climate

The average monthly precipitation in Odense River Basin varies between approx. 40 mm (April) and 90 mm (December/January). A large part of the precipitation evaporates, especially in summer, and only a minor share reaches the watercourses. As a consequence, the variation in monthly riverine runoff is considerably greater than the variation in precipitation. In summer the riverine runoff is therefore typically only around 20% of that in the winter months.

In order to lead the water rapidly away from the typically clayey soils in wet periods, drainage has been established on a considerable part of the farmland in Odense River Basin. Although subject to some uncertainty, it is estimated that approx. 50% of the basin is drained. This has an (unknown) impact on the natural water cycle.

The average air temperature in Funen is 8.2°C (1961—1990). The wind usually blows from the west, and the power/energy with which the wind affects (stirs up) the water bodies varies.

Lithology

The last Glacial Period, 11 500-100 000 years ago, is the prime creator the landscape known on the Island of Funen today. Moraine planes covered by moraine clay are predominant. The clay soil types are slightly dominant and encompass approx. 51% of the basin, while the sandy soil types cover approx. 49%.

Typology

Odense River Basin encompasses an area of approx. 1 046 km2 and includes approx. 1100 km of open watercourse and 2 600 lakes and ponds (>100 m2).

Land uses

Land use in the Odense River Basin is dominated by farmland accounting for 68% of the area. There are approx. 1,800 registered farms in Odense River Basin, of which approx. 900 are livestock farms. Livestock production in the basin amounts to approx. 60,000 livestock units (LU), dominated by pigs (59%) and cattle (37%). The livestock density is 0.9 LU/ha.

Urban areas account for approx. 16% of the area, woodland 10% and semi-natural areas for 6%, i.e. meadows, bogs/fens/swamp forests, dry grasslands, lakes and wetlands. Corresponding figures for farmland, woodland and natural/semi-natural areas for Denmark as a whole are 62%, 11% and just over 9%, respectively. Artificial drainage has been established on an estimated 55% of the cultivated land in Odense River Basin. The semi-natural areas including wetlands and watercourses have undergone major physical changes and many of them have disappeared in recent decades. Restoration of these areas is one of the measures to obtain good quality of the water-bodies in the basin.

The population of Odense River Basin numbers approx. 246 000. Approx. 90% of the population in the basin discharge their wastewater to a municipal wastewater treatment plant. The remaining 10% of the population live outside the towns in areas without access to sewerage.

Biotic framework

The aquatic environment within the Odense River Basin comprises a significant number of aquifers and surface water bodies in the categories of watercourses, lakes and fjords. These water bodies are subject to varying pressures to their biotic and environmental state.

The Odense Fjord holds some unique physical qualities which support a large range of species. The fjord constitutes an important habitat for birds and is as such subject to extensive environmental legislation independent of the WFD.

1.2. Water system characteristics

Within the Odense River Basin there are 31 aquifers of which some are overlapping each other as they are situated in different depths and some transgress the borders of the watershed and are thus situated in more than one river basin (County of Funen 2005c). The term aquifer relates to the subterranean layers containing the groundwater which is utilised as drinking water and for several other consumption as well as production purposes. In order to live up to qualitative good

status an aquifer must not contain more than 50 mg/l of nitrate and no more than 0.1 ug/l of phosphorus. In addition to the limitations on nutrient content synthetic compounds such as MTBE, BTEX, Phenol compounds and chlorine solvents, which do not appear naturally in the environment, should not be present at any detectable level in the groundwater.

County of Funen estimates that 1/3 (6,130 ha of the 18,391 ha) of the land area in the Odense River Basin is nitrate sensitive with respect to groundwater and requires additional measures to fulfil the nitrate requirements.

The water from the aquifers flows into watercourses and other water bodies. The County of Funen estimates that most of the water in the watercourses reaches these water bodies relatively quickly. If groundwater is polluted — for example via nitrogen loss from cultivated land — the pollution will rapidly reach the watercourses.
The water bodies in the Odense River Basin have been given individual WFD objectives which should be reached but it is important to realise that a water body is not a closed but an open and dynamic system which affect its surroundings and is affected by the surroundings in return. Transportation of polluting substances between water bodies is inevitable in the aquatic system which also means that any regulative measure taken with regards to any single water body will have an indirect effect on a number of other water bodies.

With respect to the interaction between water bodies County of Funen estimates that for nitrate the general retention is approximately 50 % in all the lakes. This estimate fits well with the estimates obtained from the ongoing fresh water surveillance programme undertaken by NERI although it is a bit larger (Jensen et al. 1994).

The County of Funen does measure the retention of phosphorus in lakes as their analysis at this point concentrates on nitrate. From the national fresh water surveillance programme the average phosphorus retention is estimated across 21 Danish lakes to be 11 %. This estimate however varies more than is the case for Nitrate retention and assumes for some of the lakes even a negative value. These discrepancies may originate from the substantial amounts of phosphorus compiled in the sediment through centuries which when released maintain a high phosphorus concentration in the lake regardless of the phosphorus inflow. When analyzing the Odense River Basin in the subsequent chapters the retention will be set at 50 % for nitrate and 11 % for phosphate indicating that any regulatory effect to a water body will constitute an effect of 50 % and 89 % respectively on the subsequent water body recipient.

The largest watercourse in Odense River Basin is the River Odense (catchment 630 km2), the main reach of which is just under 60 km long and up to 30 m wide. The density of open watercourses in the basin as a whole is approx. 1.0 km/km2. The original (natural) density of the watercourse network was probably somewhat greater (up to 1.5-fold).

The physical and hydrological attributes affecting the environmental state of watercourses include obstacles which prevent water flow and migration of fauna. Another factor is the diversion of watercourses from their natural paths either in the open or in the case of small streams often by encasing them in pipes. Furthermore the adjacent land which supplies the watercourse often suffers from widespread drainage which along with watercourse maintenance results in poor hydrological and ecological conditions.

The Odense River Basin also contains a significant number of lakes (approximately 2,620), all of them more than 100 m2. 1500 of these lakes occupy an area of less than 0.1 ha each, whereas only 21 lakes occupy an area of more than 3 ha each (County of Funen 2005a).

Odense fjord is by far the largest surface water body in the river basin. Odense fjord occupies an area of 6,500 ha which may be divided in an inner and outer part with diverse physical attributes. Both sections of the fjord are in general shallow but the innermost part is especially so with an average registered depth of only 0.8 meters (County of Funen 2005d). The fjord resembles a large estuary of the Odense River more than a typical fjord. The retention period of water is thus rather short at 17 days. Odense fjord may be categorised within the Odense River Basin as a terminal recipient of nearly all waterborne pollution which have not been remedied artificially or naturally. The fjord is subject to a substantial load of a multitude of polluting substances originating from both agricultural land in the entire river basin as well as several major industries including shipping and shipyard activities as well as waste dumps and other minor activities.

Sub-basins

The river basin can be divided into 12 sub-basins for the most important lakes. Each of the 11 lakes presented are assigned to an individual sub-basin in which the specific lake constitutes a sub-terminal water recipient. The remaining area within the Odense River Basin have been ascribed to the 12th sub-basin which has the Odense fjord as its first sub-terminal water recipient. The distribution of the 12 sub-basins in the Odense River Basin is illustrated in figure 4 below.

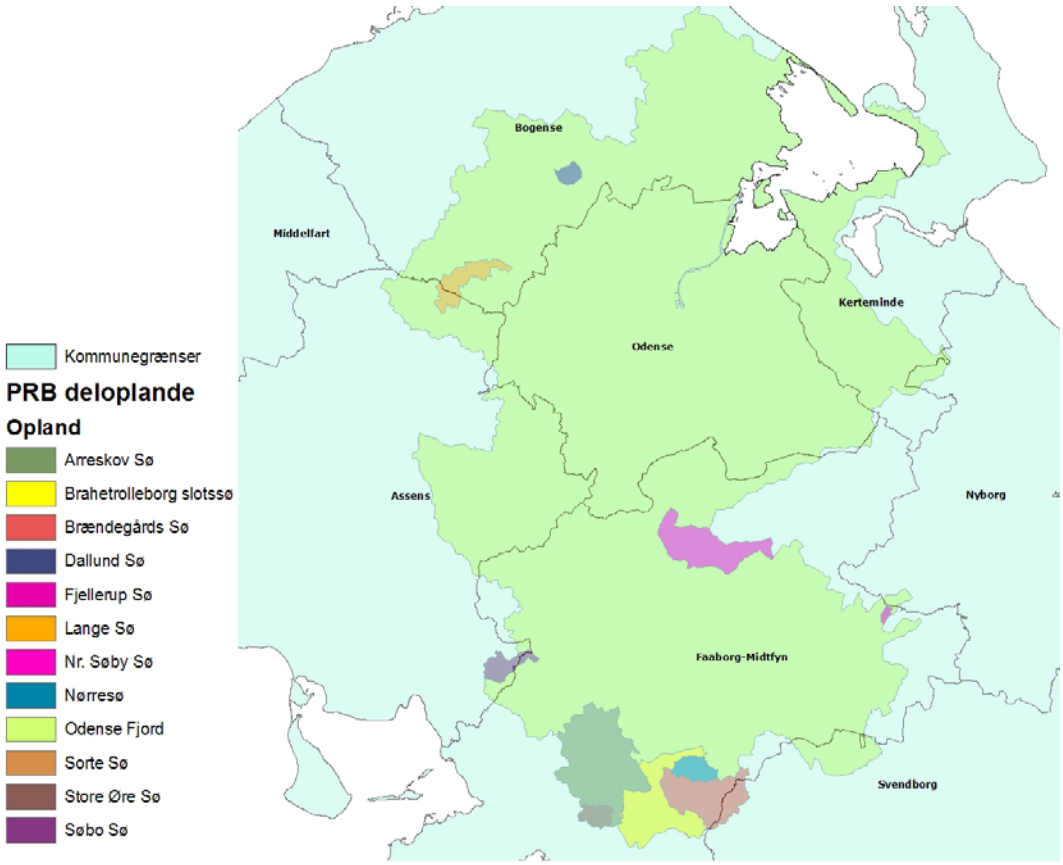


Figure 4: *Distribution of sub-basins within the Odense River Basin (County of Funen 2006).*

Several types of data can be compiled for each sub-basin as these represent the individual water bodies which are targeted by reductions.

Table 1. *Soil- and agricultural area distribution of the sub-basins within the Odense River Basin*

Sub-basins	Odense Fjord	Arreskov Sø	Brahe Trolleborg Slotssø	Brændegård Sø	Nørre Sø	Dallund Sø	Fjellerup Sø	Lange Sø	Nørre Søby Sø	Søbo Sø	Store Øre Sø
High land Soil, ha	27.826	637	369	305	19	60	33	207	686	194	98
Low land Soil, ha	18.665	235	203	53	2	3	2	84	321	18	11
Nitrate sensitive Soil, ha	18.200	91	71	0	0	5	0	23	0	0	0
Total Agricultural Area, ha	64.691	963	643	358	21	68	35	314	1.007	212	109

There are 24 wastewater treatment plants in the Odense River Basin that each receives wastewater from more than 30 persons. The great majority of the enterprises in the Odense River Basin lead their wastewater to municipal wastewater treatment plant.

1.4. Characterisation of water use

The water cycle in Odense River Basin is affected by a number of human activities, for example abstraction of water for various purposes Table . Most of this abstraction is accounted for by waterworks (20 mm). The share of water abstraction accounted for by farms and market gardens is relatively modest. Compared with water abstraction for these purposes in the sandy areas in western Denmark, the water requirements of the agricultural sector in Funen are considerably less. The abstraction carried out affects water flow in watercourses. The effect is modest if assessed solely on the basis of the total annual runoff in watercourses, but water flow in certain watercourses can be significantly affected during the summer when water flow in the watercourses is at its lowest level.

Table 2. Water abstraction in Odense River Basin

Category	**mm**
Public waterworks	19
Institutional wells	<1
Farm and market garden wells, etc.	4
Industrial wells	3
Minor waterworks (1-10 households)	1
Total abstraction	28

Each year in the County of Funen, approx. 38 million m3 of groundwater are abstracted for the drinking water supply. In addition, approx. 11 million m3 are abstracted for industrial purposes, crop irrigation, etc. (see also Section 4.1). The total amount of water abstracted corresponds to approx. 25% of the mean summer runoff in the watercourses of Funen County, or more than half

of the amount of water that flows in the watercourses in dry summers. A considerable part of the abstracted drinking water is "returned" to the watercourses in the form of treated wastewater, but not necessarily in the area from where it was abstracted. Within Odense River Basin large amounts of groundwater are abstracted, in some catchments amounting to over 50% of the median minimum water flow in the associated watercourses.

Origin of water use

From around the 13th Century some of the watercourses in the Odense River Basin were dammed for mill operation. This — together with the establishment of dams for meadow irrigation in the 19th Century — disrupted the continuity of the watercourses, thereby hindering fish such as trout and eel from their natural migration between fresh water and sea water. In newer times other obstructions have arisen too, for example culverts under roads.

The appearance of the watercourses has also been changed through other forms of regulation. Many naturally meandering or sinuous watercourses have been straightened and the beds excavated, and in places the slope has been neutralized by the construction of falls. These activities really started in the 18th Century and accelerated up through the 19th Century until the last major regulation project in 1960, which encompassed a considerable part of the Odense River (Riis et al., 1999). The aim of such regulation was to ensure improved drainage and thereby to increase the possibilities to use the adjoining land for agricultural production. At the same time, rapid removal of the water was further accelerated in many places through intensive maintenance in the form of clearance of all aquatic vegetation as well as vegetation along the banks and borders of the watercourses and dredging of the bed substratum.

List of protected areas

International protected areas encompass EC Habitat Sites and EC Bird Protection Sites. Within Odense River Basin there are seven international protected areas.

EC Habitat Sites: Within the Odense River Basin seven EC Habitat Sites have been designated specifying the water dependent habitats and species that these sites were designated to protect.
Basis for the selection of the EC Habitat Sites in Odense River Basin (habitats and species) ** indicates priority habitat types* **No. 94 Odense Fjord:s**andbanks which are slightly covered by sea water all the time, mudflats and sandflats not covered by seawater at low tide, large shallow inlets and bays, atlantic salt meadows, oligotrophic to mesotrophic standing waters with vegetation, water courses of plain to montane levels, wet heaths with Erica. **No. 97 The mires Urup Dam, Brabk Mose, Birkende Mose and Illemose;** orchids, oligo-mesotrophic waters with benthic vegetation, meadows on calcareous, peaty or clayey-silt-laden soils, calcareous fens, alkaline fens, alluvial forests. **No. 98 River Odense with River Hâgerup, River Sallinge and River Lindved;** desmoulin's whorl snail, common river mussel, brook lamprey, spined bach, watercourses of plain to montane levels with the Ranunculionfluitantis and CallitrichoBatrachion vegetation, hydrophilous tall herb fringe communities of plains and of the montane to alpine levels.

EC Habitat Sites: Within the Odense River Basin seven EC Habitat Sites have been designated specifying the water dependent habitats and species that these sites were designated to protect.

No. 103 Storelung; degraded raised bogs still capable of natural regeneration, bog woodland.

No. 104 Forests and lakes south of Brahetrolleborg; desmoulin's whorl snail, geat crested newt, natural eutrophic lakes, water courses of plain to montane levels with the Ranunculionfluitantis and CallitrichoBatrachion vegetation, bog woodland.

No. 105 Lake Arreskov; desmoulin's whorl snail, natural eutrophic lakes, water courses of plain to montane levels with the Ranunculionfluitantis and CallitrichoBatrachion vegetation, molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae),hydrophilous tall herb fringe communities of plains and of the montane to alpine levels.

No. 106 Lake Store Oreso, Lake Sorteso and Lake Igleso; natural eutrophic lakes,natural dystrophic lakes and ponds, transition mires and quaking bogs, peat, fens.

EC Bird Proctection Sites: Within Odense River Basin, three EC Bird Protection Sites have been designated specifying the bird species that the sites are designated to protect.

EC Bird Protection Sites in the Odense River Basin

No. 74 Lake Brudegârd, Lake Norreso and forests around Brahetrolleborg
Cormorant Phalacrocorax carbo
Grey lag goose Anser
Common pochard Aythyaferina
Tufted duck Aythyafuligula

No. 75 Odense Fjord
Arctic tern Sterna paradisea
Sandwich tern Sterna sandvicensis
Marsh harrier Circus aeruginosis
Avocet Recurvirostra avosetta
Mute swan Cygnus olor
Whooper swan Cygnus cygnus
Red-breasted merganser Mergus serrator
Goosander Mergus merganser
Coot Fulica atra

No. 78 Lake Arreskov
Marsh harrier Circus aeruginosis
Common tern Sterna hirundo
Grey lag goose Anser
Common pochard Aythyaferina

2) PRESSURE, IMPACT, AND RISK ANALYSIS WITH REGARDS TO THE WFD ENVIRONMENTAL OBJECTIVES

2.1. Significant pressures impacting on water status

(following IMPRESS and the DPSIR framework)

- Point and diffuse source pressures (leading pollutants and sources of pollution)
    - Discharge from wastewater treatment plants
    - Discharges from stormwater outfalls in separate and combined sewerage systems
    - Wastewater from sparsely bilt-up areas
    - Separatet industrial discharges

The water point-source dominated P load has since 1980s been reduced by a factor 6-7. The N-load, which is predominantly attributable to diffuse loading from farmland, has only been reduced by around 1/3.

2.2 – 2.4. Impacts on surface and groundwater bodies - water bodies at risk of not achieving a good status, and diagnosis of water quality and ecological issues (aquatic and related terrestrial ecosystems)

Water courses

Based on the division in fauna classes currently applied to watercourses as a measure of environmental quality and the interpretation of what ecological good status is equal to in this index, the watercourses within the Odense River Basin have been investigated and their environmental status determined. The Odense River Basin contains approximately 931 km natural watercourses divided in three types where type 1 is the smallest and type 3 the largest. Furthermore 84 km of entirely artificial watercourse have been established in connection with human activities. The vast majority of watercourse kilometres investigated came out below the ecological standard required by the WFD (County of Funen 2005b).

The environmental state of the *lakes* within the Odense River Basin is in general below the requirements of good ecological status stated in the WFD. NERI estimates that nitrate concentration can not be in excess of 1 mg/L if a lake is to hold good ecological status (Søndergård *et al.* 2003). Furthermore phosphorous content of a lake should not exceed 0.05 mg/L in shallow lakes and 0.025 mg/L in deep lakes if good ecological state is to persevere. Due to extensive diffuse nitrate and phosphorus pollution mainly originating from agriculture and point source pollution originating from sewage most lakes experience a nitrate and phosphorous content significantly larger than what is specified as a requirement to uphold good ecological status. Although sewage is less responsible for the pollution than was the case before the first action plans were contemplated it is still a significant source of pollution as rural waste treatment has not been updated at the same speed as seen in urban areas. Phosphorous pollution influence

the ecological state of a lake much more than is the case for most other water body types due to the long retention periods of water present in lakes (County of Funen 2005a).

Ten lakes have been subjected to a full analysis by the County of Funen in relation to the pilot project, and given specific reduction objectives with regard to phosphorous- and nitrate emissions and -pollution. Although 10 lakes seem to be a low number it should be noticed that that these lakes equals a share of more than 50 % of collective lake surface area of the Odense River Basin. In table 1 the lakes are presented along with their reduction objectives.

Table 1: *N- and P-reduction targets of major lakes within the Odense River Basin*

	P-Reduction requirements, kg	N-Reduction requirements, tons
Arreskov Sø	152	0,0
Brahe Trolleborg Slotssø	224	13,4
Brændegård Sø	174	4,1
Nørre Sø	24	0,6
Dallund Sø	13	0,3
Fjellerup Sø	10	0,4
Lange Sø	58	4,0
Nørre Søby Sø	144	3,0
Søbo Sø	25	0,2
Store Øre Sø	18	0,1

A description of the objectives for the water bodies, types and reference conditions is depicted in table.

WB No.	Type	Provi-sional HM	Ref. status (FC)	Current status (FC)	Provis. ecol. status (FC/Phys.index)	Current objective	Provis. objective (WFD)	Expected provis. com-pliance (WWT/IPC)
O1	1	+	7	4	M / P	B_1/B_2	H *	+ / -
O2	1	-	7	7	H / H	B_1/B_2	H *	+ / +
O3	1	+	7	Unknown	? / ?M	B_1/B_2	H *	+ / -
(O4)	(Lake)	-	-	-	(B)	(A_1)	(H) *	(- /)
O5	2	+	7	3 - 4	P - M / P - B	B_1/B_2 - B_3	G *	- / -
O6	2	-	7	5 - 6	G - H / P - G	B_1/B_2	H *	+ / -
O7	3	-	7	5 - 6	G - H / M - B (pre)	B_1/B_2	H *	+ / + (Rest.)
O8	3	+	7	Unknown	? / ?P	B_1/B_2	G *	+ / -
O9	3	-	7	5 - 7	G - H / G	B_1/B_2	H *	+ / +
O10	3	-	7	5 - 7	(G - H / M - P)	B_1/B_2	H *	+ / -
O11	3	-	7	5 - 7	G - H / G - H	B_1/B_2	H *	+ / +
O12	3	+	7	3 - 4	P - M / ?P	B_1/B_2	G *	- / -
O13	3	-	7	5 - 6	G - H / G	B_1/B_2	H *	- / -
O14	3	+	7	3 - 5	P - G / ?P - M	B_1/B_2	G *	- / -
O15	3	-	7	4 - 6	M - H / M - G	B_3	H	- / -
O16	3	+	7	4	M / ?P	B_3	G	- / -
R1	1	+	7	4 + rør	M / M + pipe	B_1/B_2	G	+ / -
R2	1	+	7	5 + rør	G / P - ?G + pipe	A	H	+ / -
R3	1	+	5	Unknown + pipe	? / ?P + pipe	B_3	G	- / -
R4	1	+	7	Piped	Piped = B	-	G	- / -
R5	1	+	7	Piped	Piped = B	-	G	- / -
R6	1	+	7	4 - 5 + pipe	M - G / M - B + pipe	B_1/B_2	G	+ / -
R7	1	-	7	4 - 6 + pipe	M - H / M - G + pipe	B_3	H	+ / -
R8	1	+	7	4 - 5 + pipe	M - G / M - ?G + pipe	B_1/B_2 **	G	- / -
R9	1	+	7	Unknown + pipe	? / ?P + pipe	B_3	G	- / -
R10	1	-	7	5	G / M - G	B_1/B_2	H	+ / -
R11	2	-	7	5 - 7	G - H / M - G	B_1/B_2	H	+ / -
R12	2	-	7	6 - 7	H / M - G	B_1/B_2	H	+ / -
R13	2	+	7	4	M / P	B_1/B_2	G	- / -

Table 1 Overview of water bodies in the main course of the River Odense and Ryds Stream catchment indicating typology (provisional system), heavy modification (HM, provisional designation), reference conditions assessed from the macro invertebrates (fauna class, FC; provisional classification), current status assessed from the macro invertebrates (FC), ecological status assessed from the macro invertebrates and physical conditions (provisional, based on FC and modified Aarhus Index), current objective pursuant to the Regional Plan currently in force, future objective (provisional assessment) pursuant to the Water Framework Directive (WFD), and expected compliance with the objective (provisional assessment)in 2015. The WFD objectives are abbreviated H: High; G: Good; M: Moderate; P: Poor and B: Bad.

Indicates that the reach is encompassed by the Habitats Directive, such that special requirements can be expected concerning safe guarding certain species or habitats. ** Indicates that the objective for the watercourse was first set during an inspection in spring 2003. Expected compliance with the objective has been assessed with respect to both improved water quality in connection with planned wastewater treatment in sparsely built-up areas (WWT) and improved physical conditions (IPC). Expected compliance is indicated by +, and non-compliance by —.

Reaching the objectives requires the use of at least one but most likely several environmental measures which differ in costs and effectiveness towards reduction of nitrate- and phosphorous

pollution. With regards to the twelve targeted lakes the analysis at hand provides different choice of measures and in many cases choice of application level of the individual measures. For the remaining lakes the measure is decided prior to the analysis and the level of application remains fixed.

Despite prior environmental legislation recent investigations in relation to the article 5 analysis have shown that the ecological status is significantly below good for the fjord. Setting the reduction target for the fjord is a tricky business as its importance as a unique habitat warrants an ecological status even above good whereas its commercial importance may prove to render costs disproportionate. In recognition of these issues the target is set at good ecological state for the fjord. Based on the analyses undertaken by the County of Funen annual reduction which would lead to the establishment of good ecological status has been estimated to be in the area of 880 tons of Nitrate and 21,5 tons of phosphorus (County of Funen 2005d). As was the case with the lakes, these reduction targets are uncertain but likely estimates based on the available knowledge which is why they must be applied cautiously in an analysis such as this and steps should be taken to take any potential discrepancy into account. The target reductions are furthermore based on an approach which takes into account any WFD independent measure which has been applied or is to be applied that would lead to a reduction in nitrate and phosphorus pollution. These as of yet unregistered reductions have thus been estimated and deducted from the target reduction estimated above.

The current phosphorus and nitrate pressure experienced by the Odense fjord originates mainly from agriculture providing 68 % and 43 % of the nitrate and phosphorus load respectively. Point sources such as households and industries provide 14 % of the nitrate load and 34 % of the phosphorous load whereas the remaining percentages are ascribed to reference loading. Figure 2 illustrates the origin of nutrient load to the fjord.

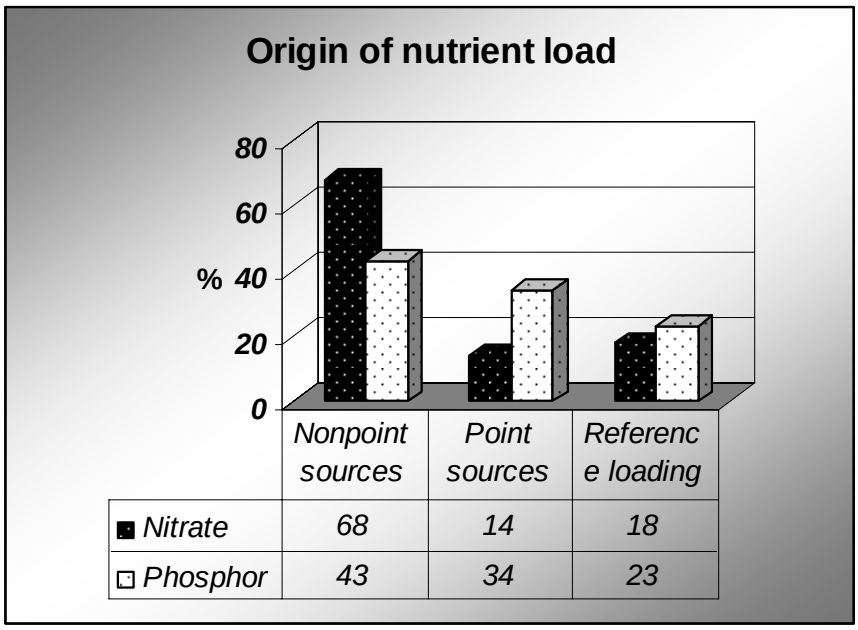


Figure 2: *The origin of N- and P-loading to the Odense Fjord*

For most of the point source pollution removal projects have been planed prior to the WFD and figures thus under the projects defined as baseline measures.

2.5. General trends and future pressures

The water quality is improving, but it still is not good in a majority of the surface water bodies in the basin. Most lakes, water courses and other surface water bodies do not fulfil the objectives in WFD.

3) ERC ANALYSIS AND METHODOLOGICAL ISSUES

3.1. List of main water-related goods and services provided in the basin

The non market use values related to the water bodies in the river basin comprise recreation, both bathing waters and fishing waters. The following maps and tables indicate the localisation of these sites.

Recreational fisheries

The map shows localities suitable for recreational fisheries at the island of Funen.

Table 1 describes the type of fishing at these localities.

Table 1 Localisation and type of fishery

Name	Town	Type of fisheries
Agernæs - Flyvesandet - Egebjerggård	Otterup	Coastal
Agernæs saltvandssøer	Ebberup	Lake, Put & take
Avernakø & Lyø	Faaborg	Coastal
Bøgebjerg Strand	Dalby	Coastal
Børge's Put and Take	Aarup	Lake, Put & take
Båring Strand	Asperup	Coastal
Enebærodde	Otterup	Coastal
Fyns Fiskevand	Odense SØ	Put & take
Fyns Hoved	Martofte	Coastal
Fønsskov	Nørre Aaby	Coastal
Faaborg & Horne Land	Faaborg	Coastal
Gabet	Mesinge	Coastal
Gals klint	Middelfart	Coastal
Gl. Slot v. Hindsgavl Slot	Middelfart	Coastal
Ibjergvejens Fiskevand	Årslev	Put & take
Kerteminde	Kerteminde	Coastal
Langelands Lystfiskersø, Tryggelev	Humble	Put & take
Lindegårdens Fiskesø	Otterup	Lake, Put & take
Middelfart Havn	Middelfart	Coastal
Mosegårdens Put & Take	Søndersø	Bog, marsh, Lake, Put & take
Odense Å - opstrøms Bellinge Bro	Odense C	Water ways, streams
Spodsbjerg Lystfiskersø	Tranekær	Put & take
Stavre Hoved	Kerteminde	Coastal
Stavrs Hoved ved Røjle Skov	Middelfart	Coastal
Strib Fyr	Middelfart	Coastal
Strib Nordstrand	Middelfart	Coastal
Svinø, sydvestsiden	Middelfart	Coastal
Tybrind Vig	Ejby	Coastal
Wedellsborg Hoved	Ejby	Coastal
Aalsbogaard Lystfiskersø	Aarup	Lake, Put & take

Bathing resorts/beaches (58 results)

The map indicates the bathing resorts at the island of Funen**.**

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Table 2 describes the bathing resorts, the localisation and the type of resort, incl. whether the beach has a blue flag.

Name	Town	Blue flag
Aborg Strand	Assens	Yes
Assens Næs	Assens	Yes
Assens/Mariendal	Assens	Yes
Bogense Strand	Bogense	No
Brydegård Strand	Haarby	Yes
Bukkemose Strand	Humble	No
Bækskilde strand, Drejø	Svendborg	No
Bøgebjerg Strand	Dalby	No
Bøjden Strand	Faaborg	No
Bøsøre Vormark Strand	Hesselager	No
Båring Strand v/Molevej	Asperup	Yes
Christiansminde Strand	svendborg	Yes
Dageløkke Strand	Tranekær	No
Drejet, Spodsbjerg	Rudkøbing	Yes
Drejø Strand	Svendborg	No
Dyreborg Strand - Knold, Drejet	Faaborg	No

Elsehoved Strand	Vejstrup	No
Erikshale	Marstal	Yes
Flyvesandet	Otterup	No
Fuglsang	Otterup	No
Fyns Badestrand	Nyborg	No
Fynshoved Strand	Martofte	No
Føns Strand v/Føns Strandvej	Nørre Aaby	Yes
Hasmark	Otterup	No
Helnæs Made	Ebberup	Yes
Helnæs Strand	Ebberup	Yes
Hesselbjerg Strand (Østersøbadet)	Humble	Yes
Hesseløje Strand	Faaborg	No
Horne Sommerland	Faaborg	No
Hou Nordstrand	Tranekær	No
Kerteminde Nordstrand	Kerteminde	Yes
Kerteminde Sydstrand	Kerteminde	Yes
Klinten Strand ved feriehotel Klinten i Faaborg	Faaborg	Yes
Klintholm Vormark Hesselager	Hesselager	No
Lehnskov Strand	Svendborg	No
Middelfart Marina	Middelfart	Yes
Nab Strand	Faaborg	No
Revsøre Strand	Hesselager	No
Ristinge Strand	Humble	Yes
Saltofte Strand	Assens	Yes
Sandager Næs	Assens	Yes
Sinebjerg Strand	Faaborg	No
Skårupøre Strand	Skårup Fyn	No
Skåstrup Strand	Bogense	No
Slotshaven Strand v. Valdemars Slot	Svendborg	Yes
Smørmosen	Svendborg	Yes
Snøde/Hesselbjerg Strand	Tranekær	No
Stoense Udflytter Strand	Tranekær	No
Strandholmen ved Faldsled by	Millinge	No
Strib Nordstrand	Middelfart	Yes
Sønder Aaby Strand	Ejby	No
Thurø Rev	Svendborg	No
Tørresø	Otterup	No
Varbjerg Strand	Ejby	No

Vejlby Fed	Middelfart	Yes
Vesterstrand, Ærøskøbing	Ærøskøbing	No
Åbyskov Strand	Skårup Fyn	No
Å-Strand	Ebberup	Yes

Non use values

The non use values can be described from the protected areas description and from the description of biotic content. This is currently elaborated upon in the case study.

3.2. List possible benefits and cost from water services [see Annex]

These will be described using the former information in the blue print of the case study.

3.3. Proposed methods and tools for the valuation of ERC:

The cost estimations

Detailed analyses of impact of measurers and the related costs have been conducted for the Odense River Basin. The conclusion was that a reduction in N-loss of 1.200 tons N to Odense Fjord was needed to reach the likely target in The Water Framework Directive

The analysis of the costs described in Jacobsen et al., 2004 shows that the costs using a range of predefined measures including more catch crops, wetlands, afforestation, organic farming and reduction in livestock lead to a yearly direct cost of 8.6 million € (8 € per kg N reduced loss). Choosing the most cost effective measures the costs were reduced to around half of this amount. In order to achieve this, the area with wetlands was increased from 4,000 to 5,400 ha in model runs, which is 8 percent of the total agricultural area. Furthermore, reductions in livestock and afforestation were replaced by higher utilization of N in animal manure.

When large decreases in nitrogen losses is the aim, it is very important to analyze the effect of measures in conjunction with the effect of other measures as a partial analysis might overestimate the effect of some measures. The analyses showed that measures, such as wetlands, aimed at reducing both nitrogen and phosphors losses, can be very cost efficient. The future analyses will look more closely at the realistic level of given measures, the costs, and the implication for animal production in order to achieve the targets in the WRD. Also comparisons between measures aimed at reducing nitrogen or phosphorus loss might be possible, but this requires models aimed at describing the P-transport from land to the water bodies and they are to be developed further.

With respect to lakes it is estimated that only one of 12 large lakes might fulfil the WRD requirement in 2015. Good ecological conditions are set at 0.025–0.05 mg P/l depending on the depth of the lake. The quality of the lakes can only improve if nutrient losses from agricultural and households are reduced. Also for streams there is a need for a further reduction in mainly N-losses as a majority of the streams are not expected to reach the required standard in 2015. The conclusion is that a range of measures will be required in order to achieve the targets in the WRD set for Odense Fjord, the lakes and the streams in the Pilot River Basin. Costs analyses will therefore be broader than the cost analysis included in the Pilot River Basin analyses.

A) Inductive methods for valuing water goods/services

Stated preferences methods

The case study comprises a primary valuation survey based on the choice experiment method. This method is suitable for valuing a multi-attributed environmental project like the protection of the Odense River Basin. Value estimates will be obtained for management benefits at different geographical scales, i.e. the total river basin and the water bodies in the river basin systems. The valuation will consider the major environmental damage categories in the river basin, i.e. groundwater contamination and chemical status related to drinking water quality, physical and chemical pressures and pollutant loading of watercourses, the Odense River, the lakes wetlands and coastal waters, and the effects of these damages on the ecological status of these water bodies. These effects comprise the quality of the living conditions for fauna and flora, as well as indicators like sight depth, swimming and bathing quality and fishing water quality. As mentioned there are available data for all these damage types and the related effects.

Benefit transfers

The Danish case-study area will serve as a primary focus area for the benefit-transfer evaluation and calibration exercise in this project. Cost and benefit measures obtained in the primary study and the area specific analyses described above will serve as a benchmark for evaluating the transfer of benefit and cost estimates from other studies. This allows for an evaluation and calibration of benefit transfer methods within the WFD-activities. This is needed to secure that the project will provide values that can be legitimately used for water pricing and CBAs, i.e. a set of "standard" values which are generally and broadly supported by the different stakeholders involved.

The benefit-transfer exercise will be undertaken in two version: One using national studies for benefit transfer, and one using international studies all together. Furthermore, the benefit transfer will evaluate the results of using primarily other wetland-studies as information basis, and of using a broader set of studies, transferring estimates on a ‘function’ or ‘attribute’-level, like e.g. the value of biodiversity and recreational aspects, the cost of land restoration and tending-activities etc. etc.

The number of relevant studies internationally is very large and the relevant studies to include here should be critically selected relying on the specific knowledge among the partners of this project. During the last couple of years there has been an upsurge in valuation studies and environmental cost-benefit analyses in Denmark – sponsored to a large extent by the Danish Environmental Protection Agency and the Forest and Nature Protection Agency. In the following we will briefly describe a number of recent studies – apart from those mentioned above – has been (or will be) concluded in the past (or coming) few months:

The investigations will draw on the experience from a recent Danish cost-benefit analysis of a major river basin restoration undertaking – the Skjern River project (see Dubgaard et al.). The emphasis in this project was on biodiversity restoration and the re-creation of the ability of natural wetlands to filter nutrients and other particles in the river water. A Danish groundwater valuation study, valuing the effects on groundwater protection on drinking water quality and surface water quality (flora and fauna in watercourses and lakes) was conducted in 2004, and the results are available for benefit transfer test in the case study (Hasler et al, 2005). A Danish valuation study of wetland (river basin) restoration projects with focus on biodiversity, recreational values, aesthetics etc. will be concluded June 2005. A recent study on the value of

biodiversity on the Danish moors provide further support for transfer (Boiesen et al. 2005), and in 2005 a number of new studies will be undertaken. This include a study on the value of wildlife in different habitats – one being wetlands, a valuation study of a specific wetland restoration project and a larger valuation study of the new national parks – some of these have significant impact on watershed management and values. Thus, a number of up-to date local studies will be available for testing the use of benefit- (cost-) -transfer within the local (national) setting and a number of these will be on quite similar cases, whereas others will have a more general or different focus.

3.4. Available studies/information on cost/benefits and expected problems of information

- Odense Pilot River Basin Provisional Article 5 report (http://odenseprbuk.fyns-amt.dk/wm134077).
- Work prior to the Aquatic Action Plan III (2004) (www.vmp3.dk), cost-effectiveness of measures and environmental effects (in Danish).
- Choice experiment study will be carried out, start in 2006. Choice experiment on groundwater has been carried out for Denmark in 2004/2005.
- Ministry of Environment (Forest and Nature protection agency, Environmental Protection Agency, The County of Funen).

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