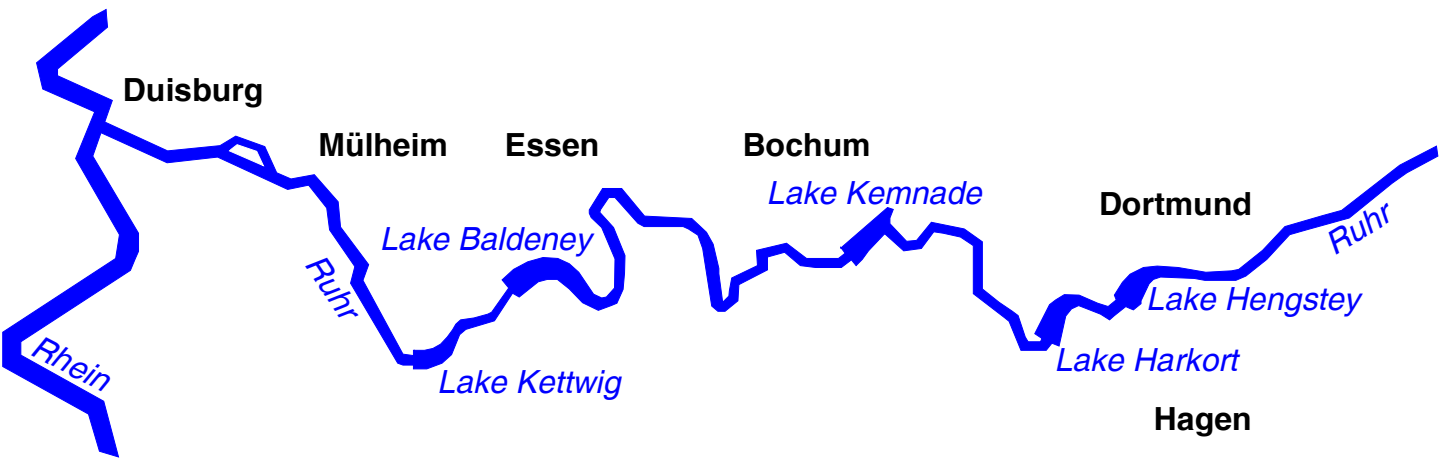




Reservoirs
Fish Passages
Hydropower Plants

Ruhrverband's
Reservoirs



The following reservoirs are operated by the Ruhrverband:		Lake Hengstey	Lake Harkort	Lake Kemnade	Lake Baldeney	Lake Kettwig
– Lake Hengstey,	first impounded in 1929					
– Lake Harkort,	first impounded in 1931					
– Lake Kemnade,	first impounded in 1979					
– Lake Baldeney,	first impounded in 1933					
– Lake Kettwig,	first impounded in 1950					
storage capacity of first impoundment (mil. m³)		3.3	3.1	3	8.3	1.4
lake surface (km²)		1.36	1.37	1.25	2.64	0.55
length (km)		4.2	3.2	3	7.8	5.2
average width (m)		296	335	420	355	130
average depth (m)		1.94	2.21	2.4	3.14	2.54
full supply level (m AMSL)		96.3	89.3	72	51.75	43
effective head (m)		4.6	7.8	2.6	8.7	6
number of weir gates		4	4	4	3	2
width of weir gates (m)		30	30.5	25	33.5	44
type of gate		roller drums	roller drums	flaps	roller drums	sector gates



Life needs water . . .

. . . the Ruhrverband takes care of that

The Ruhr River with its tributaries is seen as a single unit. Because management of entire river basins helps balance the often competing water uses and interests along rivers and lakes fairly. It generates cost benefits, promotes environmental protection, thus serving the public good as required under the European Water Framework Directive (WFD).

. . . thanks to dams it never runs short

Every day, more than five million people are supplied with adequate and safe drinking water from the Ruhr valley. With a system of dams and reservoirs, Ruhrverband is able to adjust the river's strongly fluctuating flow regimes, to reduce flood peaks, produce electricity, and provide supply security also during dry periods.

. . . sewage treatment plants purify it

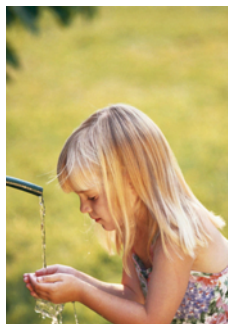
Currently, there are 72 wastewater treatment plants on stream in the Ruhr catchment that purify municipal, commercial and industrial sewage to prevent pollution of the waterbodies.

. . . water-related leisure activities make for a higher quality of life

Water and nature conservation are of utmost relevance for all recreational activities on the Ruhr River, the impounded lakes and reservoirs located in the Sauerland region.

. . . it remains affordable through the Ruhrverband

All members of the Ruhrverband – municipalities, waterworks, industrial enterprises and with that the community as a whole – benefit from the partnership due to an effective use of financial resources.



The Reservoirs

At the beginning of the last century, still not all wastewaters produced in the Ruhr basin were cleaned in treatment plants before being discharged. Moreover, the treatment technologies used at the time were essentially mechanical processes. To safeguard the river's good water quality such as it is needed to produce drinking water, Ruhrverband has built a series of impounded lakes that serve as in-stream purification facilities. Settleable substances are removed from the river water in the impounded lakes due to lower flow velocities and longer pass-through times. And thanks to the enlarged water surface, the effects of sunlight and wind are intensified, which benefits the oxygen uptake and, with that, the biological degradation processes taking place in the water.

In spite of today's excellent status of wastewater treatment, the storage lakes still play a positive role as in-stream fine purification stages, in particular for stormwater discharges. Thanks to the ongoing natural self-purification processes, the water quality improves while the river passes through the impounded lakes.

Already during the planning phase, Ruhrverband had put the idea of creating new opportunities for recreational activities on the agenda. And over the years, the reservoirs' role as local recreation areas has steadily gained in importance. Not only the waterbodies themselves, but also the riparian zones are attractive grounds for a variety of leisure activities, like e. g. cycling, hiking, jogging, inline skating, boating, sailing, canoeing and fishing.

As regards shoreline maintenance, the focus has shifted from mere reinforcement work – to protect the banks against waves and currents – towards an integrated ecological approach.

At all reservoirs – with the exception of Lake Kemnade where a hydropower plant is presently being planned – environmentally friendly energy is produced by hydropower. Besides that, there is a pumped-storage power plant at Lake Hengstey.



Lake Hengstey

Lake Hengstey is located close to the town of Hagen, below the point where the Lenne River meets the Ruhr. At the time of its completion, both sludge precipitation and water purification could be improved, because the acidic and ferrous Lenne water mixed with the alkaline Ruhr water.

Today, the Lenne water is of much better quality, following the construction of efficient wastewater treatment plants, and Lake Hengstey primarily serves as natural barrier for bed load and as fine purification stage. Besides that, the Lake is used as lower reservoir for the pumped-storage power plant of Herdecke (Koepchenwerk) built and operated by RWE Power AG. Due to the pumped-storage operations, the lake's water level may fluctuate by up to 70 cm. From 1988 to 1889, no less than 400,000 m³ of sediment that had accumulated by that time were dredged from the Lake.



Lake Harkort

The Stifsmühle weir – primarily used for hydropower production – lies next to the junction of the rivers Volme and Ruhr. Lake Harkort begins in the downstream water of this weir, with its barrage being located at the town of Wetter. The weir of Lake Harkort situated below the Ruhr bridge of road B 226, has four gates that can be closed with roller drums. Power station and sluice are situated just 800m further downstream and are fed via a headrace channel (upper channel). Here, in close proximity to the power station, a near-natural fish ladder went into service in 2004. It allows an undisturbed upstream migration of fish from the Ruhr River into Lake Harkort.

Lake Harkort serves as in-stream fine purification stage for the water flowing in with the Volme River and the effluents discharged from the Hagen sewage treatment plant. These inflows mingle with the already treated waters from the Ruhr and Lenne. Moreover, Lake Harkort serves as compensating basin for the pumped-storage plant on Lake Hengstey. From Lake Harkort, just that amount of water is continually abstracted that enters the upper Ruhr impoundments, coming from the Ruhr, Lenne, and Volme.

During pumping operations, there is no water transfer from Lake Hengstey to Lake Harkort so that the water level may drop by up to 50 cm. As soon as the turbines of the pumped-storage power plant on Lake Hengstey start working, both lakes will begin to refill.

After almost 70 years of operation, large stretches of the lake had become silted up to such an extent that, at some points, the water depth fell below 50 cm. In response, comprehensive dredging works were carried out between 1999 and 2003. Removed were no less than around 450,000 m³ of sediment. Along with these dredging efforts, some substantial ecological improvements could be achieved in the surrounding riparian areas.

Worth mentioning are, for example, the new pike spawning grounds, a new chain of small islands that serve as refuge area for water birds, and some additional bodies of stagnant water.



Lake Kemnade

The last barrage built to date within the course of the Ruhr River is Lake Kemnade, completed in 1979. It has four gates that are closed by means of hydraulically driven flaps.

Situated alongside the weir, are a fish ladder and a boat channel. In case of great floods, the whole facility is overflown. Given the available low head, installation of a power station has so far not been considered for economic reasons. However, in the face of today's surging energy costs and the increasing need to use renewable energies, plans for the construction of a hydropower plant on the Kemnade barrage are currently under way.



The reservoir, located between Witten-Heven and Bochum-Stiepel, was built by Ruhrverband on behalf of the Freizeitzentrum Kemnade GmbH (FZK, Kemnade Leisure Centre). Though the Lake is mainly used for leisure activities, there is a very welcome side effect: enhanced water purification.

Ruhrverband has the right to lower the lake level by 20 cm to balance, if necessary, low flow conditions in the Ruhr. Since 1995, Lake Kemnade has been within Ruhrverband's sphere of competence. While all leisure operations are still being managed by the FZK.



Lake Baldeney

Lake Baldeney is located in the south of Essen, within the navigable section of the Ruhr. By the time of its completion in 1933, around 8.3 mil. m³ of water had been impounded. Due to the reservoir's role as in-stream water purification facility, huge amounts of sediment kept accumulating on its grounds over the years.

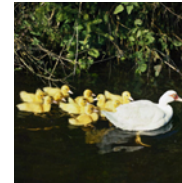
Consequently, nearly 50 years later, in 1981, the lake's storage capacity had decreased to 6.5 mil. m³, this so in spite of a slight increase in volume due to subsidence of the ground caused by underground mining operations.

The dredging works began in April 1983 and ended in May 1984. In total, some 1.1 mil. m³ of sediments were removed from the Lake. On completion of the dredging project, Lake Baldeney had regained a storage capacity of 7.6 mil. m³.

The Essen-Werden weir facilities are equipped with three gates which can be closed by roller drums. The mean head, used for hydropower production, is 8.7 m.

Between weir and power station, there is a sluice that can be passed by ships with a length of up to 38 m and a width of 5.20 m.

Over the last years, the bird sanctuary located in the upper reaches of the Lake has steadily gained in importance. Today, it is the breeding habitat for a variety of bird species, like for example the great crested grebe, the grey heron, the cormorant, the kingfisher, the rail, and various duck species. The nesting territory lies within a strip of protected wetland to which the public has no access.



Lake Kettwig

To ensure unhindered navigation on the lower reaches of the Ruhr, Lake Kettwig was built – Ruhrverband's smallest reservoir with a capacity of 1.4 mil. m³ – and besides that an unimpounded river section downstream of Kettwig had to be reconstructed, deepened and widened. So that a free passage is now possible for sports and passenger boats, as long as the flow regime does not exceed around 190 m³/s.



The sector weir of Kettwig was the second of its type installed in Germany. Its hydraulic drive makes winch structures redundant. Therefore, a new road bridge could be built directly above the weir piers. Owing to the given design features, the dynamics of effective water pressure acting directly upon the weir foundations are extremely favourable.

And as a result, just two weir openings, each 44 m in width, were needed. The effective head available at the weir facilities is used to generate electricity in a hydropower plant.



Leisure Attractions on the Ruhr Reservoirs

Meanwhile, the artificial lakes have developed into popular holiday attractions for millions of people living “next-door” in the conurbation of the Ruhr Area. There are scenic paths and cycle trails along the Ruhr and the reservoirs which can be used for hiking, jogging, cycling and in most cases also for

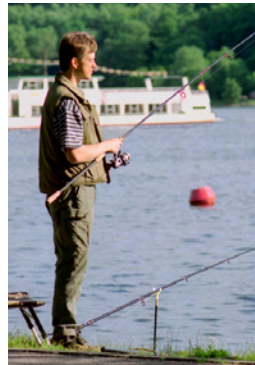


inline skating. For many years the lakes have attracted the attention of nature observers and ornithologists who love, in particular, the quiet early morning hours when there is a good chance to study species of waterfowl at close quarters like, for example, canada geese, grey herons, as well as swans and cormorants.

The concentration of angling clubs dotted

along the Ruhr and the lakes is an indicator for an abundant fish stock. All fishing rights are being held by the Ruhr River Fishery Cooperative that will hand out fishing licenses to the different angling clubs. Interested individuals can obtain licences through the clubs. To learn more, please visit www.ruhrfischereigenossenschaft.de.

Watersport is another important leisure attraction. In particular Lake Baldeney is known as home territory of many water sportsmen and women who are



successful on both a national and an international scale. And it is also a centre of sports promotion and fostering of young talent in the Ruhr Area. Surfing, boating, canoeing and kayaking activities are possible on all lakes without restrictions. As regards sailing, the necessary permits can be obtained via the local sports clubs.

The lower reaches of the Ruhr are navigable – also by engine-driven vessels – from the river mouth up to Ruhr kilometre (Rhr-km) 41.6 at Essen-Rellinghausen. The stretch between the junction of the rivers Ruhr and Rhine and Rhr-km 12.208 at Mülheim, has been deepened and widened to serve as Bundeswasserstraße (federal waterway). Further upstream, up to the limit of navigability, the course has been classified as Landeswasserstraße (state waterway) that can be used by ships with a maximum draught of 1.70m, a length of 38m, and a width of up to 5.20m. For more information about, e.g., navigation on the Ruhr and the reservoirs, please go to www.elwis.de and www.talsperrenleitzentrale-ruhr.de.

Hydropower Plants

All impoundments, except for the weir of Lake Kemnade – where a hydropower plant is currently being planned – are used to produce regenerative energy by hydropower.

The overall installed capacity of the power plants built on the different impoundments comes to around 28 MW, which allows an average annual power production of 90 mil. kWh.

Moreover, Lake Hengstey offered the opportunity to build a pumped-storage plants, the Koepchenwerk, as it is called after its designer Arthur Koepchen. The plant stores energy in the form of water, which is pumped at off-peak hours from the reservoir to a higher elevation, which allows the plant operator, RWE Power AG, to use low-cost power to run the pumps. It takes about 4.5 hours to pump an amount of around 1.5 mil.m³ of water from the Lake into the upper reservoir, situated at a by 165 m higher level.

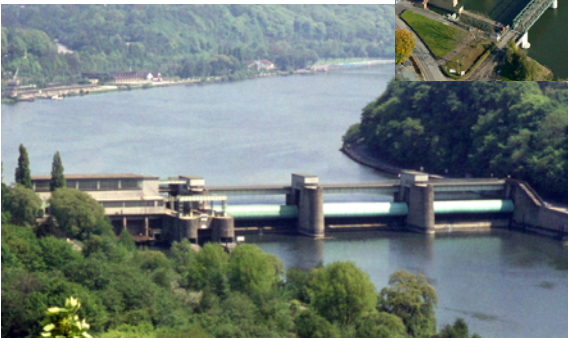


With the power station’s rehabilitation in 1989, it has become possible to generate, within just 70 seconds at peak hours, a capacity of 153 MW that can be fed into the transmission grid. At a flow rate of 110 m³/s (full load), the new turbine will empty the reservoir in around four hours.

The rapid expansion of renewable-generated electricity we see today, in particular of wind energy, causes fluctuations in power output which have to be compensated for. As a consequence, the need for new pumped-storage power plants is set to rise in the future.

Hydropower Plants

	Lake Hengstey	Stifts-mühle	Lake Harkort	Lake Baldeney	Lake Kettwig
mean head (m)	4.6	2	7.8	8.7	6
turbines	3 Kaplan	3 Kaplan	3 Kaplan	2 Kaplan	3 Kaplan
design flow (m ³ /s)	100	110	120	140	145
capacity (MW)	3.3	2.2	6.6	10	5.3
mean annual energy output (mil. kWh)	13	7.5	24	28	16

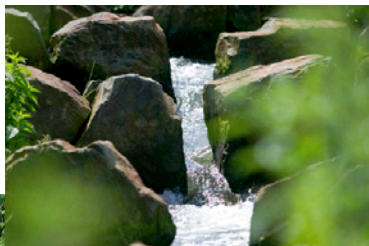


Fish Passages

The EU Water Framework Directive has defined biological continuity as a prerequisite for achieving good ecological status of flowing bodies of water. Upstream and downstream migration of fish and other aquatic organisms in the fluvial systems shall not be disrupted.

With the surging industrial development in the past and the increased pressure on water use, dams and other river obstructions became larger and more common, disturbing the rivers’ continuity and leading to the need for more efficient fish passes. Meanwhile, several environmentally effective projects have been implemented, or are still under way, along the Ruhr.

For example, at the Stiftsmühle weir – a barrage located between lakes Hengstey and Harkort – a so-called vertical-slot pass was built in 1999 as Ruhrverband’s first fish passage. With a maximum difference between water levels of 2.56m, the fish-way consists of a series of 19 ascending basins made of concrete – each 2 m wide and 3.15 m long – through which the water is run at 350 l/s. For the benthic fauna, an additional roughened channel, designed for a passage of 150 l/s of water, has been provided for.



Fish Passages

	Lake Hengstey	Stiftsmühle		Lake Harkort
type	vertical-slot	vertical-slot	roughened channel	nature-like diversion brook
construction & start-up	2008	1999	1999	2004
difference in elevation (m)	5.15	2.56	2.56	5.3
total length (m)	136	65	32	380
number of basins	39	19	16	57
flow rate (l/s)	570	350	100	700

In July 2004, the Lake Harkort fishway was put into operation. Close to the Wetter power station, a meandering 350-m-long artificial brook course, designed for a water passage of 700 l/s was completed. To bridge the elevation gap of 7.8m, some 56 separate pools were built, formed by transverse-placed natural rock. And to achieve a nature-like structured pathway, rough materials, like rootstock, fascines, dead wood, and gravel banks were used.

In June 2008, a vertical-slot pass was built on Lake Hengstey to allow unhindered fish migration. Due to the lack of space on site, only a ,technical’ structure could be realised. Thanks to this pathway, fish and other living organisms can now freely migrate between the upper Ruhr impoundments and the adjoining stream stretches.

Recent comprehensive investigations carried out into the matter have confirmed the fishways’ good performance.