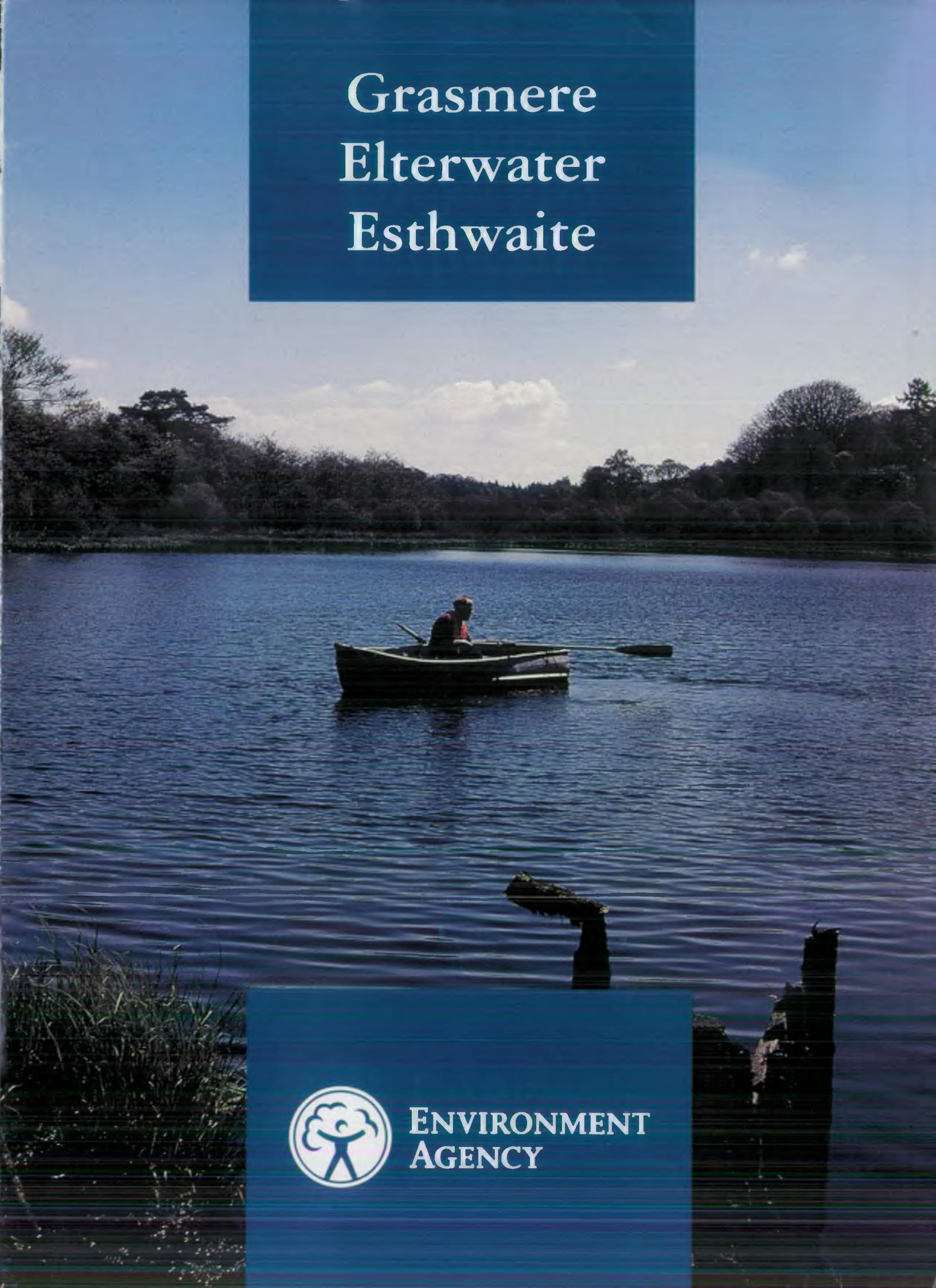
Grasmere
Elterwater
Esthwaite



ENVIRONMENT AGENCY

Grasmere

Grasmere is one of the smaller lakes of Cumbria. It has the following dimensions:-

Length	Maximum Width	Average Depth	Maximum Depth
1.6km	0.6km	7.74m	21.5m

The River Rothay is the principal tributary feeding Grasmere, entering the lake at its northern end. The River Rothay leaving the lake passes through Rydal Water before entering Windermere at Ambleside.

The most common species of fish in the lake are perch and roach. The pike average about five pounds in weight, but a few in excess of twenty pounds have been caught from time to time.

Today, there are some concerns about the water quality of Grasmere. Recent studies have shown that the lake contains increasing levels of nutrients, one of the key criteria which can lead to algal blooms.

One factor that helps Grasmere to prevent severe algal growth is the fact that the lake has a low flushing time; on average this is between 24 and 37 days. This compares to an average flushing time for Esthwaite Water of 90 days. (see section on algae).

The recent study confirmed Grasmere sewage treatment works as the only major source of nutrient input to the lake.

The Agency's future work will focus on reducing the input from this source.

Elterwater

Elterwater is limited in both its fishery and public access. The main species of fish found in the lake are eels, which are very common, and pike, which are only present in low numbers.. The lake is designated as a Site of Special Scientific Interest (SSSI) under the Wildlife and Countryside Act 1982 because of its important hydrosphere.

The lake has an unusual structure. It consists of three shallow, interconnecting basins. The inner basin is about half the size of the other two basins, but has the greatest depth of 7.4 m. The average depth of the whole lake is 5m and it's overall length is 0.9 km.

Elterwater has two main inflows and one main outflow. Great Langdale Beck drains water from the eastern side of the Langdale Fell, whereas Little Langdale Beck (also known as the Lower Brathay) drains the Tilberthwaite and Wrynose fells. A small tributary receives treated sewage effluent before flowing into the lakes inner basin.

The peculiar flow system of Elterwater means that the inner basin in particular is very poorly flushed. This, coupled with the input of treated sewage effluent, has resulted in high levels of nutrients accumulating in this basin. Excessive plant and algal growth have subsequently developed, absorbing the oxygen of the deeper waters as they decay.

Future work will initially concentrate on eliminating the sewage input to the inner basin and negotiations have already begun with North West Water to facilitate an early resolution to this problem.

It is envisaged that remediation of the inner basin may be necessary for restoration of water quality in the long-term and options are currently being evaluated.

Current Research

The Agency has developed a framework for formulating Action Plans to deal with algal problems and has recently completed proposals for a strategy to deal with specific eutrophication problems. A draft report evaluating the options for the management of these is imminent.

The Agency's R & D programme includes research into developing a Lakes classification scheme which will help the Agency to set water quality targets for individual lakes.

A partnership with European colleagues looking into the use of new, innovative monitoring and remote sensing technologies offers the prospect of us being able to keep a more watchful eye on the lakes than has been possible to date.

Computer models able to predict future possible impact situation have been developed for the Agency to allow in the potential benefit from e.g. the reduction of nutrients into a lake, to be assessed. This serves to provide a degree of confidence that decisions made will realise real benefits.

Core samples of lake sediments can be analysed using modern analytical techniques to provide evidence of the pollution history of a lake. This technique allows a lake's status to be assessed pre and post a particular activity or development on a lake (or its catchment), such as a sewage input. In addition, the information provides an indication of what could be considered the lakes's natural status (i.e. before man intervened), providing a possible baseline for rehabilitation of the lake if necessary.

Thermal imagery is used in certain circumstances for monitoring the extent of algal blooms and lake flow patterns.

The Institute of Freshwater Ecology have been commissioned to undertake 4 yearly monitoring of 20 Cumbrian Lakes for assessment of long-term trends. The report of the latest assessment is due in 1996.

A two year research study has been carried out by the Environment Agency's North Area. The study has investigated the water and sediment chemistry of eight major Cumbrian Lakes. The findings of this study have been recently completed (1996).

Continuous monitoring in Elterwater and Grasmere, initiated in March 1994, is still ongoing. Data is obtained every fifteen minutes, reporting the physico-chemical conditions at various depths in the lake. Algal activity in the lakes is also being monitored.

The conclusions of these other research studies will help the Environment Agency to define sound management options for each lake to combat prese[illegible] more effectively.

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Esthwaite

Esthwaite Water is situated at the southern end of Hawkshead, to the west of Lake Windermere. Grizedale Forest, a predominantly coniferous woodland, covers the major part of the catchment serving Esthwaite Water.

The lake was internationally acclaimed in the 1960's as it represented one of the best examples of a moderately enriched lake in England and Wales and was designated as a Site of Special Scientific Interest (SSSI) in 1987. Nationally rare species of plants can be found at Esthwaite Water and it holds significant importance for the breeding of local birds. Its population of the Slender Naiad waterweed is the only one in the U.K. Great crested Grebe, Teal, Tufted Duck, Red-breasted Merganser, Pochard and Sedge Warbler all breed within this site.

The main inflow to the lake is from Black Beck. This flows through the village of Hawkshead and receives treated sewage effluent from Hawkshead sewage treatment works (STW) before entering the lake at its northern end and drains the only significant area of farming land on the catchment.

Esthwaite Water is commercially stocked with rainbow trout but also has native populations of pike, perch, roach, gudgeon and brown trout, with reports of pike weighing over thirty pounds. To protect these from overfishing, a limited fishing period has been imposed.

The Environment Agency and North West Water have been pro-active in investigating the water quality of Esthwaite Water. Studies have looked at the impact of Hawkshead STW and the trout fish farm on the lake's water quality.

Past studies showed the nutrient levels in the lake increasing over the years, requiring North West Water to implement phosphate stripping at Hawkshead sewage treatment works in 1986. Improvements are likely to be realised in the long-term and early investigations are premature in confirming an improvement although the indications are optimistic.

In the short term, however, the lake has shown signs of problems related to the higher levels of nutrients including occurrences of algal blooms every summer from 1992 to 1995. Recent studies also indicate that there may be a significant nutrient contribution to the lake from both the fish farm and the lake catchment.

Future work will focus on maximising the potential from current sewage effluent treatment processes to further reduce nutrient inputs. Concurrent with this, fish farm management techniques to maximise the potential for reductions from this source and a review of farming practices will also be addressed as a priority.

Algae

The prolific growth of algae can have a detrimental impact on the lake's water quality. As algae and plants die, the decaying organic matter falls to the bottom of the lake. Here, bacteria use up oxygen to complete the decomposition process. This can result in oxygen depletion of the bottom waters in the lake.

The extent to which this occurs depends on many factors including:

- Depth of the lake
- Wind effects
- Extent of algal and other plant growth
- Water movements within the lake
- Flushing time of the lake

All these factors contribute to how quickly the bottom waters can be re-oxygenated. A shallow lake, with high wind speeds and low flushing time will generally disperse oxygen throughout the lake more effectively than a deep lake with low wind speeds and high flushing time.

Depletion of oxygen can have a detrimental effect on other aquatic life. Fish, in particular, are sensitive to oxygen levels. Fisheries scientists believe that lakes which deoxygenate in parts could seriously affect the lake fish population.

FLUSHING TIME

One feature of a lake that can help restrict the formation of algal blooms is if the lake has a low *flushing time*. Slower growing algae (predominantly blue-green) are flushed out of the lake before they become established in "bloom" proportions.

The flushing time can be defined as the time taken for the total volume of water to be displaced by incoming flow.

The flushing time depends on:

- The volume of the lake
- The lake's flow characteristics
- The rate of evaporation of water from the lake's surface.
- The overall rate of incoming flow.

Blue-Green Algae

Nutrients

Living organisms require around forty naturally occurring elements from the earth's crust and atmosphere to sustain growth and reproduction. The nutrients which are least available to plants and animals are known as the limiting nutrients. The levels of these nutrients broadly regulate the growth and reproduction of living organisms.

Much of the pollution entering lakes is organic in nature. These pollutants are rich in nutrients such as nitrogen and phosphorous which encourage the growth of vegetation, including algae, in lakes and rivers.

MAIN SOURCES OF NITROGEN AND PHOSPHORUS

- Discharges from sewage effluent.
- Agricultural discharges from diffuse sources e.g. slurry and silage.
- Fertilisers from land run-off.
- Fish farms.
- Weathering of igneous rocks and subsequent washing by rainfall.
- Decaying plant vegetation in the lake sediments.
- Nitrogen gas and nitrogen-related gases in the atmosphere.

Eutrophication

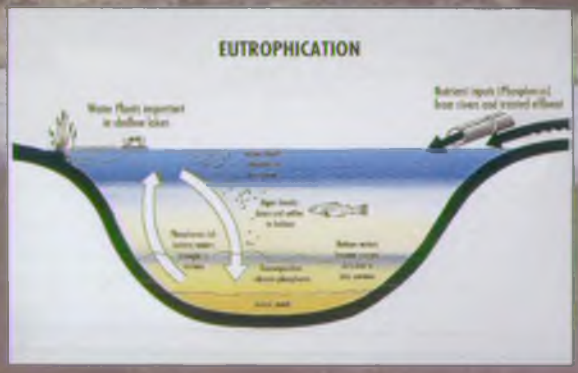
Conditions of extreme nutrient enrichment is known as *eutrophication*.

In itself this does not necessarily present any great problems. However, coupled with the correct environmental conditions, it can potentially lead to disaster for a lake's water quality, aesthetic quality and aquatic life.

The first direct impact of eutrophication is increased growth of small algae. These will flourish under conditions of:

- High temperatures
- High sunlight intensity
- Adequate oxygen levels in the lake

It is during the summer period that the effects of eutrophication usually manifest themselves. The rate of growth of these algae can increase to such an extent that algal blooms develop, and in certain cases blooms of the toxin producing blue-green algae may form.



BLUE-GREEN ALGAE

Blue-green algae are natural inhabitants of many inland waters, estuaries and coastal waters. In summer months, with the correct nutrient conditions, they may multiply sufficiently to cause *blooms*. When such algal blooms develop and persist, they can seriously affect the appearance, quality and use of the lake. The water may be discoloured making it appear green, blue-green, greenish-brown, or occasionally reddish-brown. Several species can produce earthy, musty or grassy odours.

During calm weather, several blue-green algal bloom-forming species can rise to the surface to form *scum*. This may look like paint, jelly or floc. These scums can disperse rapidly if wind and wave action increases.

Some of these algae contain tiny bubbles in their structure which gives them buoyancy and the ability to move with the motion of the wind and water. Thus the appearance of a blue-green algal bloom does not necessarily relate to the source of its origin or indeed its overall concentration and depth.

Toxins sometimes released by blue-green algae may be poisonous to animals and humans, causing symptoms such as skin rashes, eye irritation, vomiting, diarrhoea, fever and muscle pains. In all events, it is wise to avoid all contact with algal scums and also prevent animals from doing so.