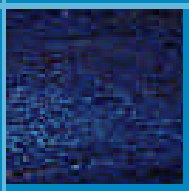
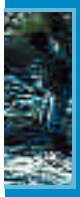
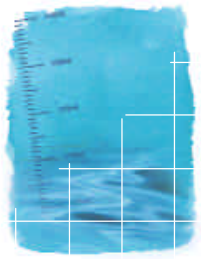
# Front Cover



## CONTENTS


| | |
|---|---|
| Introduction | 1 |
| Sensitive Areas | 3 |
| Buffer Zone Guidelines | 5 |
| Ground Preparation and Drainage | 6 |
| Fertiliser Application and Storage | 7 |
| Chemicals, Fuel and Machine Oils | 9 |
| Roads | 9 |
| Bridges, Culverts and Fords | 10 |
| Harvesting | 10 |
| Appendix: Examples of Water Quality Indicators | 12 |



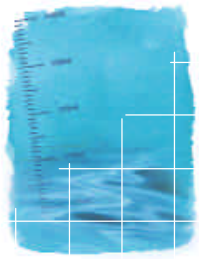
## INTRODUCTION

The maintenance and enhancement of water quality is of utmost importance. Forestry activities have the potential to interact both positively and negatively with aquatic resources. Careful planning and management will mitigate against potential negative impacts while maximising the positive aspects of forestry, such as aquatic biodiversity enhancement and the creation of appropriate riparian ecosystems.

> An aquatic zone is defined as a permanent or seasonal river, stream or lake shown on an Ordnance Survey 6 inch map.

Each river or lake has a unique drainage basin or catchment area. Some catchments are more vulnerable than others to changes in water quality, due to their particular soils and underlying geology. The type of landuses and associated operations within the overall catchment area can also have a major bearing on the volume and quality of water flowing into that particular river or lake. All land owners, including forest owners, have a responsibility to play their role in conserving and enhancing overall catchment quality.

> The FORESTRY AND WATER QUALITY GUIDELINES have been developed through extensive consultation with a wide range of relevant parties. They set out sound and practical measures based on the principles of Sustainable Forest Management (SFM), and are firmly rooted in the best available scientific information. The guidelines will be kept under review to facilitate amendment in the light of new research findings.
>
> To ensure the successful implementation of SFM in Ireland, it is important that forest owners adhere to the guidelines and undertake all work in a way which is compatible with the protection of the environment.
>
> The guidelines describe a range of measures intended to cover all situations relating to forestry and water quality. Not all of the measures outlined will be applicable to every site. However, it is the responsibility of forest owners to identify and apply those measures which are appropriate to their particular forest.
>
> The FORESTRY AND WATER QUALITY GUIDELINES apply to all grant-aided projects and to all activities associated with a Felling Licence. Any breach may result in the forfeit of grant aid and premium payment or the withdrawal of a Felling Licence.
>
> It is essential that all forest workers and machine operators involved in any forest operation are made aware of and understand the guidelines, all relevant environmental issues relating to the site, and working practices which minimise environmental disturbance. All operators should have contact telephone numbers onsite for all relevant agencies (Local Authorities, Regional Fisheries Boards, Dúchas The Heritage Service, National Museum of Ireland, Garda Síochána, etc.) in case of accidental damage to aquatic zones, archaeological sites, important wildlife habitats and other environmental features.



## SENSITIVE AREAS

### SPECIAL AREAS OF CONSERVATION, SPECIAL PROTECTION AREAS AND PROPOSED NATURAL HERITAGE AREAS

Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) are protected by European Union and national legislation. Proposed Natural Heritage Areas (pNHAs) have been identified by National Parks and Wildlife of Dúchas as areas of value in the national effort to conserve biodiversity.

- Planting is not permitted in SACs and SPAs.
- Approval for planting in pNHAs is dependent on formal consultation between the Forest Service and Dúchas The Heritage Service.

### AREAS SENSITIVE TO ACIDIFICATION

The Forest Service recognises the importance of water acidification arising from atmospheric pollution. It will continue its ongoing policy of consultation with Regional Fisheries Boards and Local Authorities on whether or not to proceed with forestry applications in areas where there is a perceived risk of acidification. These sensitive areas are designated on the basis of the following criteria:

- the aquatic zone is part of a recognised salmonid fishery and is a spawning, nursery or angling area, **and**
- the geology is base-poor, **and**
- in water samples taken regularly between 1st February and 31st May, **either**
  - pH readings are equal to or less than 5.5, **or**
  - water hardness, in mg calcium carbonate/litre, is less than 12, **or**
  - water alkalinity, in mg calcium carbonate/litre, is equal to or less than 10.

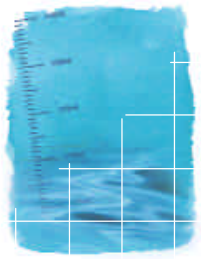
The Forest Service will also take account of new research findings as they become available.

### AREAS SENSITIVE TO EROSION

Where certain soil types (e.g. peat, sandstone-derived soils) and steep slopes occur together, there is a greater risk of soil erosion and subsequent sedimentation. It should also be noted that subsoils may be more prone to erosion than the associated topsoil. In such areas, due care should be taken when

Left: Research and consultation are key elements in protecting water quality.

Right: Forest owners, as with all landowners, have a responsibility to play their role in conserving and enhancing overall catchment quality.



planning all forest operations. Correct buffer zone management will help reduce the risk of sedimentation. Sensitivity to acidification or erosion can be local or confined to a sub-catchment. These sub-catchments may be identified by their particular geology, soil and terrain.

## BUFFER ZONE GUIDELINES

The buffer zone is an area adjacent to an aquatic zone and managed for the protection of water quality and aquatic ecosystems. A buffer zone includes the riparian zone, i.e. that area directly adjacent to an aquatic zone, representing the intermediate between the aquatic and terrestrial environments and having its own distinctive hydrological and ecological characteristics. The buffer zone may also occupy adjacent areas beyond the riparian zone. Within the buffer zone, natural ground vegetation is allowed to develop, with additional planting of suitable riparian tree species.

Within the buffer zone, ground preparation and other forest operations are curtailed in order to protect water quality. Furthermore, drainage channels leading from the site must taper out before entering the buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. Buffer zones further enhance and protect water quality by:

- physically stabilising banks;
- acting as a source of leaf litter input into aquatic zones, which represents an important food source for a number of aquatic animals;
- providing cover and dappled shade.

Buffer zones should be in place throughout the rotation, and have particular relevance to establishment, road construction and harvesting.

**Table 1.** Buffer zone widths.

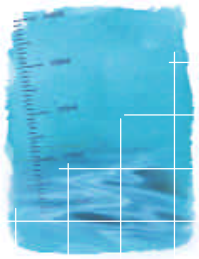
| Average slope leading to aquatic zone | Buffer zone width on each side of the aquatic zone | Buffer zone width for highly erodable soils |
|---|---|---|
| Moderate (even to 1 in 7 / 0-15%) | 10 m | 15 m |
| Steep (1 in 7 to 1 in 3 / 15-30%) | 15 m | 20 m |
| Very steep (1 in 3 / >30%) | 20 m | 25 m |

Buffer zone width is based on the following factors:

- the average slope of the area adjacent to the aquatic zone (buffer zone widths should be greater where slopes are steep);
- the sensitivity to erosion of the soil adjoining the aquatic zone.

- The width of the buffer zone may vary in certain situations, for example, to avoid straight edges for landscaping purposes. However, the minimum width, as set out above, must be maintained in all cases.
- Buffer zones should be actively managed to encourage sustainable vegetative growth and cover for the protection and enhancement of water quality. Well-vegetated banks are more resistant to undercutting and collapse. Vegetation shields the soil surface from rainfall impacts, slows run-off velocity and increases infiltration. Open and partially wooded conditions should be planned, so that bank vegetation thrives. Approximately half the length of a stream should be left open and the remainder kept under partial shade from trees and shrubs. Ground vegetation in buffer zones can be augmented by the planting of native tree species such as birch, willow and sally, with occasional alder, oak and ash. These species help to stabilise the riparian zone and protect it in times of flood. Such planting is permitted in the buffer zone and within 5 m of the aquatic zone, if this would, in the view of the Regional Fisheries Board, have a beneficial effect on that particular aquatic zone. On good fertile sites, natural regeneration of desirable species from local seed sources is likely to occur.

The development of natural riparian vegetation, including suitable tree species, will benefit water quality and aquatic life.



- All tree planting within the buffer zone should be carried out using pit planting only, except in wet areas where inverted mounding is allowed.
- Pruning and/or removal of undesirable trees should be carried out where required, inorder to maintain the riparian vegetation and aquatic conditions.

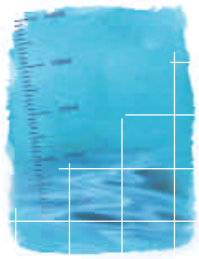
Afforestation plans should be made for all sites, regardless of size. Such plans should include the location and treatment of aquatic zones located on or adjacent to the site.

## GROUND PREPARATION AND DRAINAGE

An essential element of protecting water quality is to ensure that sediment contained in water draining from the site does not enter the aquatic zone. Incorrect ground preparation and drainage can result in soil disturbance and subsequent sedimentation of nearby aquatic zones, particularly if ground preparation is followed by prolonged and heavy rainfall. For these reasons, ground preparation must be well-planned and drain layout/sediment traps correctly designed and installed. Mounding, moling, ripping and subsoiling will result in less soil disturbance than ploughing.

- Do not carry out ground preparation within the buffer zone. Where trees are being planted to restore or create riparian woodland, pit planting must be used, except in wet areas where inverted mounding is allowed. In general, trees should not be planted within 5 m of an aquatic zone.
- Where possible, ground preparation should be carried out when there is less of a risk of heavy rainfall.
- Where possible, do not disturb existing drains.
- Drains and sediment traps should be installed during ground preparation.
- Collector drains should be excavated at an acute angle to the contour (0.3%-3% gradient), to minimise flow velocities.
- Main drains to take the discharge from collector drains must be provided with waterdrops and rock armour where there are steep gradients, and should avoid being placed at right angles to the contour.
- Make sure that all drainage channels taper out before entering the buffer zone. This ensures that discharged water gently fans out over the buffer zone before entering the aquatic zone, with sediment filtered out from the flow by ground vegetation within the zone. On erodable soils, install sediment traps at the end of the drainage channels tothe outside of the buffer zone.

Buffer zones play a major role in underpinning water quality.



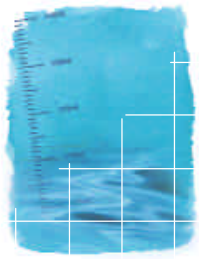
- Drains and sediment traps must be maintained throughout the rotation, ensuring that they are clear of sediment build-up and are not severely eroded. Correct drain alignment, spacing and depth will ensure that erosion and sediment build-up are controlled.
- Sediment traps should be sited outside the buffer zone and have no direct outflow into the aquatic zone. Their capacity can extend over the life of the forest or have limited storage. In the latter case, machine access is required to enable the accumulated sediment to be excavated. Sediment should be carefully disposed of away from all aquatic zones. Sediment traps must be clearly marked and securely fenced for safety.Where possible, sediment traps should be constructed on even ground and not onsloping ground.
- In areas particularly sensitive to erosion, it may be necessary to install double or triple sediment traps.

## FERTILISER APPLICATION AND STORAGE

Complete all planting before fertiliser application takes place. Species selection together with site type and conditions determine fertiliser type and application rates. Phosphorus (P) is the main nutrient fertiliser applied, with nitrogen (N) and potassium (K) occasionally applied as remedial fertilisation. The following practices should be followed to minimise the risk of fertiliser run-off and transport to aquatic zones.

- Proposed fertiliser types and application rates should be included in the afforestation application.
- Fertiliser should not be applied within the buffer zone or within 20 m of an aquatic zone, whichever is greatest.
- Fertilisers should be prepared and securely stored under shelter on a dry, elevated site at least 50 m from the nearest aquatic zone.
- Granular fertiliser formulations should be used, with the exception of muriate of potash which is not available in granular form.

Care in the storage and application of fertilisers and chemicals will avoid risk to water quality and aquatic life.



Watercourses are a major component of the environment, and their protection is an essential element of sustainable forest management.

- Phosphate application rates on peat soils should be kept to a minimum in any single application.
- Apply fertiliser manually or by ground-based machine, wherever possible. Fertiliser must be applied by hand in the 20-50 m area adjacent to the aquatic zone.
- Do not, under any circumstances, discharge fertilisers into an aquatic zone, drain orsediment trap.
- Where later fertilisation is required to counteract nutrient deficiencies, aerial application using helicopter can be considered where branch growth and onsite vegetation prevent manual application. However, a 50 m wide corridor adjacent to aquatic zones must be left unfertilised. Never undertake aerial fertilisation during high winds.
- Do not apply fertiliser during or following prolonged rainfall or if heavy rain is forecast.
- Fertiliser should only be applied during the months of April to August, inclusive.
- Remove all empty fertiliser bags and other rubbish from the site during and after the operation, for environmentally-acceptable off-site disposal.

## CHEMICALS, FUEL AND MACHINE OILS

The on-site use of chemicals (herbicides, pesticides and urea), fuel and machine oils (hydraulic, engine, gearbox, lubricant or cutting oils) should be kept to a minimum. Accidental spillage or leakage can be detrimental to aquatic flora and fauna and can impair water quality. Training and safety are of primary importance to avoid hazards and to ensure the correct use of herbicides and pesticides.

- Do not apply chemicals if heavy rainfall is forecast or during high winds.
- Do not apply chemicals within the buffer zone.
- Refer to *Guidelines for the Use of Herbicides in Forestry*[1].
- Prepare and securely store all chemicals, fuel and machine oils under shelter on a dry, elevated site at least 50 m from the nearest aquatic zone.
- Cleaning of equipment should not take place within 50 m of an aquatic zone. All wash waters must be disposed of carefully.
- Unused diluted herbicides must not be spread within the buffer zone.
- Remove all containers from the site and dispose of carefully.
- All maintenance and refuelling operations and machine repairs (if required and practical) should be carried out at least 50 m from the nearest aquatic zone on a dry, elevated site.
- Spent oil must be collected and retained for correct off-site disposal.
- Where possible, biodegradable oil should be used as a substitute for mineral oil.
- Do not, under any circumstances, discharge chemicals, fuel or machine oils into an aquatic zone.
- The relevant Local Authority must be informed promptly of any accidental chemical, fuel or machine oil spillage which threatens an aquatic zone.

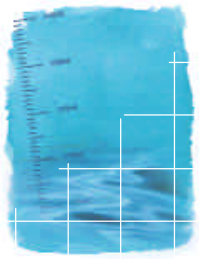
## ROADS

Each stage of forest road construction has implications for water quality. Before road construction begins, the road network within the forest must be planned and outlined in the plan required by the FOREST HARVESTING AND THE ENVIRONMENT GUIDELINES. Key actions required for this plan include:

- inspection of the area and the preparation of a map containing a broad terrain classification and details of all aquatic zones;
- determination of the appropriate density and spacing of the road network, based on the size and shape of the area, machinery employed and the nature of the terrain;
- delineation of aquatic zones and associated buffer zones.

- The FOREST HARVESTING AND THE ENVIRONMENT GUIDELINES require a road and track network scheme as part of the harvesting plan. This plan should include a terrain classification which indicates all aquatic zones and buffer zones together with sources of public and private water supplies, access points, landings and, if

[1]Ward, D. (ed.) 1998. Guidelines for the Use of Herbicides in Forestry. 2nd Edition. Coillte, Forest Protection, Newtownmountkennedy, Co. Wicklow.



necessary, proposed stream crossings. The map will identify the site location and provide directions and distances to the nearest national road.

- Roads should be located at least 50 m from an aquatic zone, where possible. Road layout should aim to direct off-road traffic away from streams. If there is no other option but to cross an aquatic zone, construct an appropriate bridge or culvert.
- Where possible, roads should follow the natural contours of the terrain.
- All ancillary drainage associated with road construction should be designed to divert water away from buffer zones and should not be allowed to discharge directly into aquatic zones. Sediment traps will be necessary. Roadside drains should not directly intercept run-off from higher ground. Cut-off drains should be constructed to a flat gradient at least 5 m back from the upper edge of the road formation, to avoid erosion.
- Carry out construction during dry weather, ideally from April to October.
- Cement must not be discharged into the aquatic zone.
- Do not remove gravel from an aquatic zone. Gravel may be removed from a buffer zone only after consultation with the Regional Fisheries Board and fishery owner. The opening of a new quarry requires planning permission.
- The maintenance of roadside drains and sediment traps is essential. Inspect periodically to ensure that they are free of debris and sediment, undertaking remedial action if necessary.

## BRIDGES, CULVERTS AND FORDS

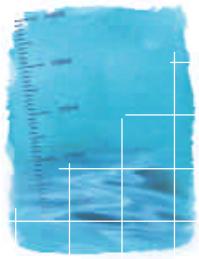
Aquatic zones may need to be crossed during forest operations. The construction of bridges and culverts, whether temporary or permanent, can cause soil and site disturbance, with subsequent soil erosion and the movement of sediment into the aquatic zone. The careful planning of these crossings is essential.

Where fish passage is important, e.g. spawning beds in the upper reaches of aquatic zones, bridge and culvert design should reflect this requirement. Fords are generally not appropriate, as their use can often result in the generation of considerable sediment and the restriction of fish passage.

Bridges are the most desirable structure as they allow unimpeded fish movement. Bridges also ensure that machines parts (and associated fuel and oils) are kept out of the aquatic zone.

Culverts can be open topped or embedded. In fish spawning aquatic zones, embedded culverts are favoured as they provide unrestricted passage for all fish sizes and retain the natural streambed and sediment. Embedded culverts are usually large diameter (greater than 1 m) culverts which aim to maintain the natural channel width, gradient and conditions.

- All water crossings should be marked and indicated in the road network plan.
- Minimise the number of crossings over a given aquatic zone. All crossings should be at right angles to the flow.
- Consult with the Regional Fisheries Board at the design stage of any crossing in a fish-bearing or potentially fish-bearing aquatic zone.
- Bridges should be constructed with minimum disturbance to the bank, channel or adjacent buffer zone.
- Do not build culverts or bridges over an aquatic zone in a way that would hinder fish passage.
- Use local stone for bridge kerbs and end treatments for culverts.
- Do not discharge cement into the aquatic zone. Uncured concrete can kill fish by altering water pH. When cast-in-place concrete is required, all work must be done in dry weather conditions and isolated from any water which may enter the aquatic zone, for a period sufficient to cure the concrete.
- Culvert ends should be tapered to match the embankment slope.
- Specifications for culvert design and size should reflect:
  - whether or not the aquatic zone is a spawning or fisheries watercourse;
  - the type of terrain;
  - the necessity to carry the ‘normal’ flow and to accommodate flash floods;
  - the requirement to embed culverts.



- Embedded culverts should be buried to a depth of 0.3 m or 20% of their height (whichever is greatest) below the streambed. The original bed material as well as boulder sized stones should then be placed in the culvert.
- Culverts should be maintained, removing debris which can cause clogging and eventual culvert failure.

## HARVESTING

Harvesting (thinning and final harvesting) and associated activities such as extraction have the potential to adversely impact on water quality, through increased erosion rates, sedimentation and nutrient losses. These impacts can be mitigated through good planning and the implementation of the FORESTRY AND WATER QUALITY GUIDELINES. The factors that affect water quality at harvesting can be summarised as follows:

- soil type, sensitivity and slope;
- number and type of machine passes.

- All harvesting and extraction operations must be carried out in accordance with the FOREST HARVESTING AND THE ENVIRONMENT GUIDELINES. Consult with the Regional Fisheries Board and Dúchas before commencing harvesting operations in areas of importance to fisheries and wildlife.
- Prepare a forest harvesting plan as detailed in the FOREST HARVESTING AND THE ENVIRONMENT GUIDELINES, which will include:
  - a broad terrain classification detailing: the location of areas of potentially high erosion risk; the location of all aquatic zones and buffer zones; the identification of

A brash mat which has been used several times and now in need of renewal.

public/private water supplies; and existing and planned road network, landings, turntables, bridges and extraction routes;
- the identification of appropriate machines to minimise adverse impacts;
- the location of machine maintenance areas and storage areas for chemicals (herbicides, pesticides, urea), fuel and machine oils.

- Construct sediment traps prior to harvesting and maintain these traps throughout operations.
- Plan felling operations with the shortest possible extraction routes, designed to be compatible with the avoidance of sedimentation.
- Always fell trees away from the aquatic zone.
- Avoid machine extraction within the buffer zone.
- On sites where risk of erosion is high, brash mats must always be used to avoid soil damage, erosion and sedimentation. Brash mat renewal should take place when they become heavily used and worn. Provision should be made for brash mats along all off-road routes, to protect the soil from compaction and rutting.
- Where there is risk of severe erosion occurring, extraction should be suspended during periods of high rainfall. Cable extraction may be an alternative in these situations.
- Do not refuel or maintain machinery within 50 m of an aquatic zone.

| | ***Classification*** | ***Chlorophyll (mg/m³) Annual max.*** | ***Total P (µg P/litre) Annual mean*** | ***Phosphate (MRP) (µg P/litre) Annual median*** |
|---|---|---|---|---|
| Lakes | Oligotrophic | Ž2.5 and <8 | >5 and •10 | |
| | Mesotrophic | Ž8 and <25 | >10 and •20 | |
| Rivers | Q5 | | | 15 |
| | Q4-5 Q4 | | | 20 |
| | | | | 30 |

S.I. 258 of 1998

- Do not pile logs within the buffer zone or on very low lying ground prone to water-logging. Select a dry area away from the aquatic zone.
- Do not allow branches, logs or debris to build up in aquatic zones. All such material should be removed when harvesting operations have been completed, but avoid removing natural debris deflectors.

## APPENDIX
## EXAMPLES OF WATER QUALITY INDICATORS

Catchment waters may be used for some or all of the following purposes: salmonid water; drinking water; or bathing water. Statutory Instruments are in place which set standards for each of these categories. The following water quality parameters may be measured by the Local Authority, depending on the intended use and the respective Statutory Instruments. The relevant Statutory Instrument for each indicator is quoted in brackets. Indicators marked with (*), although not mentioned in Statutory Instruments, denote the lowest standard *which current knowledge suggests* will not indicate damage to water quality.

The objective at all times is to ensure that forest operations do not cause a deterioration in water quality.

**Eutrophication**

Biological parameters

- *Phytoplankton/Cyanobacteria (lakes):* Critical limit: Composition and abundance consistent with those in unpolluted lakes(*).
- *Macrophytes (lakes and rivers):* Critical limit: Composition and abundance consistent with those in unpolluted lakes(*).
- *Macroinvertebrates (rivers):* Maintenance of existing EPA Quality (Q) rating, where it is Ž Q4 (Statutory Instrument 258 of 1998).
- *Fish:* Critical limit: Presence of 0+ salmonids(*).

Physico-chemical parameters

"The existing trophic status for any part of a lake shall be maintained" (S.I. 258 of 1998).

- *Nitrate ($NO_3$):* Critical limit: 11.3 mg N/litre (S.I. 81 of 1988).
- *Un-ionised ammonia:* Critical limit: <0.02 mg $NH_3$/litre (S.I. 293 of 1988).
- *Dissolved oxygen:* Critical limit: 80-120% saturation(*).

**Acidification**

Biological parameters

Production: Magner Communications

The Forest Service gratefully acknowledges the contribution of Dr Miriam G. Ryan, COFORD, National Council for Forest Research and Development, to the development of the FORESTRY AND WATER QUALITY GUIDELINES, made through the preparation of a commissioned report. Copies of this report can be obtained from the Forest Service, Department of the Marine and Natural Resources, Leeson Lane, Dublin 2.

Photos: All photos Forest Service, except COFORD, National Council for Forest Research and Development (pages 2 and 6) and T. Cummins, Forest Ecosystem Research Group, UCD (page 11).

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- *Macrophytes (lakes):* Critical limit: Presence of *Lobelia* and *Isoetes* spp.(*).
- *Macroinvertebrates:* Critical limit: Presence of several specimens of any or all of the following: *Baetis rhodani*, *Gammarus* spp., *Caenis* spp., *Centroptilum luteolum* and *Cloeon* spp. (Raddum,1999).
- *Fish:* Critical limit: Presence of 0+ salmonids(*).

Physico-chemical parameters

- *Total aluminium:* Critical limit: 0.2 mg Al/litre (S.I. 81 of 1988).
- *Labile monomeric aluminium:* Critical limit: 0.04 mg Al/litre (S.I. 293 of 1988).
- *pH:* pH Ž 6 and • 9 (S.I. 293 of 1988). pH between 5.5 and 8.5 (S.I. 294 of 1989).

**Sedimentation**

Parameter

- *Suspended solids:* Critical limit: <25 mg/litre (S.I. 293 of 1988).

**Hydrology**

Hydrological parameter

- *Flow:* Critical limit: Maintenance of base flow level throughout the catchment(*).

S.I. 81 of 1988 European Community (Quality of Water Intended for Human Consumption) Regulations 1988.
S.I. 293 of 1988 European Communities (Quality of Salmonid Waters) Regulations 1988 (Note: List of relevant water bodies is included).
S.I 294 of 1989 European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations 1989.
S.I. 258 of 1998 Local Government (Water Pollution) Act 1977 (Water Quality Standard for Phosphorus) Regulations 1998.
Raddum, G.G. 1999. Large scale monitoring of invertebrates: Aims, possibilities and acidification indexes. *In* Proceedings of Workshop on Biological Assessment and Monitoring, Evaluation and Models. Raddum, G.G., Rosseland, B.O. and Bowman, J. (eds.) Zakopane, Poland. ICPWaters Report 50/99, NIVA, Oslo.