Use of Herbicides to Control Weeds in or Near Water

ENVIRONMENT AGENCY

EA – NCEOS

Use of herbicides to control weeds in or near water

This document was produced for use by the Environment Agency and deals with procedures for proposed aquatic herbicide applications by external users, the Agency and companies under contract to the Agency. It covers relevant legislation, selection of herbicides, notification and consultation procedures, codes of practice, waste disposal and training.

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Contents

1 Introduction

2 Environment Agency policy on the use of herbicides in or near water

3 The legislative framework governing the use of pesticides

4 Selection of herbicides for use

5 Notification and consultation procedures

6 Users code of practice

7 Disposal of waste herbicides, containers and equipment

8 Training

9 Glossary

10 Useful publications

11 Useful Addresses

12 Appendix

1

Introduction

1) Introduction

Sometimes aquatic plants growing on floodbanks, riverbanks or in watercourses need controlling to prevent flooding, for fishery management or other reasons. Plants growing where they are not wanted are termed weeds. A number of methods are available to the Environment Agency and riparian owners to control these weeds. Alternative methods to herbicides include mechanical control, the use of barley straw to control algae, biological methods such as the use of grazing animals on banksides, and altering environmental conditions to reduce weed growth. It is essential that the most appropriate method is used in each situation. In some cases it may be appropriate to integrate a combination of different methods. Further details can be found in the R&D Project Note 189 Aquatic Weed Control Operations[4], the Agency leaflet Aquatic Weed Control Operation: Best Practice Guidelines[7] and the information sheets on Aquatic Weed Control[25] enclosed in the back of this guide. You should carefully consider all the weed control methods available and decide on the most practical and best environmental option.

If a herbicide is considered the most suitable method of control, this manual should be used to ensure that the correct procedures are followed. It aims to provide a clear and comprehensive framework to regulate herbicide use, to help operators determine the most appropriate herbicide to apply, and to provide procedures on correct use and safe disposal of herbicides.

It is a document for use by the Agency and deals with:

a) **herbicide use in or near water by the Agency;**

b) **use of aquatic herbicides under subcontract to the Agency;**

c) **proposed aquatic herbicide applications by external users.**

A large number of pesticides are in general agricultural use. Only a very small proportion are presently approved by the Ministry of Agriculture, Fisheries and Food (MAFF) for use in or near watercourses and lakes. **Situations defined for such treatment include drainage channels, streams, rivers, ponds, lakes, reservoirs, canals and dry ditches. They also cover the control of vegetation growing on the banks or areas immediately adjacent to water bodies, but not the control of vegetation growing on nearby cropped or amenity land.**

All products approved for use in or near water are listed annually in the MAFF/HSE Reference book Pesticides 19XX – Pesticides approved under the Control of Pesticides Regulations 1986 (The Blue Book)[27]. The list of approved products is occasionally amended (that is, some products have had their approval withdrawn) so regular enquiries should be made to ensure that the list is up to date. The UK Pesticide Guide[33] (published by CAB International and BCPC) lists all approved products and also lists separately those products approved for use in or near water.

Herbicides are one type of pesticide and are potentially poisonous, noxious and polluting, therefore strict guidance and regulation of their use by the Agency is necessary. The Agency has a statutory duty to protect and safeguard, water abstracted for potable supply, irrigation and stock watering, the diversity of aquatic life, the amenity of the water environment, and to maintain rivers and waterways to minimise flooding. This guide illustrates how the Agency can implement its statutory duties and comply with legislation governing pesticides when using aquatic herbicides itself, and regulating their use by others.

2)

Environment Agency policy on the use of herbicides in or near water

i) The use, storage and disposal of herbicides and their containers must be in accordance with legislation governing pesticides and this document.

ii) All Agency staff involved with the use and storage of herbicides or giving advice on herbicides must have the appropriate training.

iii) Herbicides should not be applied where there is a risk of contaminating potable water supplies or water used for agricultural spray irrigation without informing the licensed abstractors who could be affected by the herbicide application.

iv) A written application is required both from internal and external users before a herbicide can be used in or near water. This should be submitted to a designated officer in each region and appraised according to the procedures in this document.

v) Applications to use aquatic herbicides should be appraised by Environmental Protection (includes Water Quality), Fisheries, Ecology and Recreation (includes Biology, Fisheries and Conservat-ion) and Water Management (includes Water Resources and Flood Defence) functions if appropriate. Designated officers should collate the responses and give approval in writing where appropriate.

vi) Applicants should be informed in writing if an application is refused and the letter should include the reasons for the refusal.

vii) Once permission has been granted, the onus is on the USER to ensure that the interests of other water users are not adversely affected, and to inform:

- abstraction licence holders (where appropriate):

  those who may be affected should be notified prior to application of a herbicide;

- relevant conservation bodies:
  if an approved herbicide is to be applied to an area of conservation interest such as a Site of Special Scientific Interest (SSSI), English Nature or the Countryside Commission for Wales must be consulted four months prior to the application, as stated in the Wildlife and Countryside Act 1981;

- riparian owners and occupiers:

  all riparian owners and occupiers who may be affected should be notified.

- walkers and animals:
  public rights of way, including roads, footpaths and bridleways should not be oversprayed; where the product label indicates that people and animals should stay out of the treated area, warning notices should be put up (for example, THIS AREA HAS BEEN TREATED WITH A WEED KILLER, KEEP TO FOOTPATH); these should be removed as soon as it is safe to do so.

  A list of the names and addresses of relevant abstraction licence holders and conservation bodies should be supplied by the Agency if requested.

viii) Designated officers should inform Agency Pollution Control of approvals.

3)
The legislative framework governing the use of pesticides

Comprehensive legislation governs the use of pesticides in the UK. As a user of pesticides, the Agency has a statutory obligation to ensure that all relevant legislation is complied with.

Pesticide users are subject to the following legislation:

3.1) Control of Pesticides Regulations 1986

The Control of Pesticides Regulations 1986 (COPR) were made under the Food and Environment Protection Act 1985 (FEPA). COPR came into force in October 1986, replacing the Pesticides Safety Precautions Scheme (PSPS) and the voluntary Agricultural Chemicals Approval Scheme (ACAS).

COPR requires that:

- any user of a pesticide should take all reasonable precautions to protect the health of human beings, creatures and plants, and to safeguard the environment and in particular to avoid pollution of water;
- no pesticide may be supplied, stored or used unless it has been given provisional or full approval and the conditions of approval must be strictly observed and complied with;
- all users (except home gardeners) are required to ensure that they are competent in their duties and have received adequate instruction in the safe, efficient and humane use of pesticides; certificates of competence are also required by some specified users, that is, all users applying pesticides to either land or water which is not their property or that of their employers; and all users born after 31 December 1964, unless they are under direct supervision (that is, within eyesight and voice contact) of a certificate holder;
- a register of all pesticides used must kept for a minimum of three years;
- the use of adjuvants must conform to the conditions of approval;
- notification must be given to all potentially affected persons;
- English Nature and/or the Countryside Commission for Wales must be consulted by the owner/occupier at least four months prior to herbicide applications in Sites of Special Scientific Interest (SSSI). It is also advisable to consult over applications adjoining SSSIs. Applications in or near a Nature Reserve will require permission from the reserve owners and managers which may be completely independent of EN/CCW.
- Codes of practice are statutory and under Section 17 of FEPA they may be issued by ministers to give practical guidance in respect of FEPA.

3.2) The Plant Protection Products Directive (91/414/EEC)

This directive regulates the placing of plant protection products on the market. It was implemented in 1995 by means of the Plant Protection Products Regulations 1995 (SI 1995 No. 887), the Plant Protection Products (Amendment) Regulations 1996 (SI 1996 No. 1940) and the Plant Protection Products (Fees) Regulations 1995 (SI 1995 No. 888). Over a period of time agricultural pesticides will become regulated under these regulations and eventually, together with the proposed Biocidal Products Directive, replace COPR. European member states are reviewing all active substances with recommendations as to whether the substances should continue to be on the market or not. This work is expected to be completed in 2003. Existing national approvals continue to be valid until 25 July 2003 or the completion of the review of the active substance, whichever is earlier. Revised procedures are published in the Pesticides Register and in the new Registration Handbook. The Registration Handbook replaces the COPR Handbook.

3.3) Water Resources Act 1991

Under Section 85 of the Water Resources Act it is an offence to cause or knowingly permit any poisonous, noxious or polluting matter or any solid waste matter to enter any controlled waters. Given that a pesticide is potentially a "poisonous, noxious or polluting matter", this legislation applies to the use, storage and disposal of pesticides.

3.4) Control of Pollution Act 1974

Under this Act the dumping of pesticides or their containers in or near waterways, ditches, ponds and other areas of water is prohibited.

3.5) Dangerous Substances Directive (76/464/EEC)

This directive creates a framework for the elimination or reduction of pollution of inland, coastal and territorial waters by dangerous substances, including some pesticides.

3.6) The Water Industry Act 1991 and the Water Supply (Water Quality) Regulations 1989

The legislation provides a regulatory framework for securing the quality of drinking water supplies. The standards are based on the EC Drinking Water Directive 80/778/EEC which sets a maximum admissible concentration of 0.1 μg/l for individual pesticides and 0.5 μg/l for total pesticides and related substances.

3.7) Surface Water Directive (75/440/EEC)

This directive is implemented through regulations under the Water Resources Act 1991 and protects public water supplies. It specifies limits for the pesticides parathion, lindane and dieldrin in water.

3.8) Ground Water Directive (80/68/EEC)

This directive is implemented through regulations under the Water Resources Act 1991 and safeguards the quality of groundwaters in relation to abstraction for water supply.

3.9) Wildlife and Countryside Act 1981

This Act specifies the protection of certain plants, animals and their habitats from accidental or purposeful destruction or disturbance. Where a watercourse passes through land classified as a nature reserve, such as an SSSI, the Wildlife and Countryside Act 1981 states that English Nature and/or the Countryside Commission for Wales must be notified in writing if a pesticide is to be used. Pesticides should not be applied to any nature reserve without consulting the organisation responsible for its management. The Wildlife and Countryside Act also gives protection to certain aquatic plants and animals and if these occur in the locality of the proposed applications, EN/CCW should be informed.

3.10) Health and Safety at Work Act 1974

Under Section 2(2)(b) it is the responsibility of the employer to make arrangements for ensuring so far as is reasonably possible the safety and absence of risks to health connected to use, handling, storage and transport of pesticides.

3.11) Control of Substances Hazardous to Health Regulations 1988

The (COSHH) Regulations were made under the Health and Safety at Work Act 1974 and came into force on 1 October 1989. They lay down essential requirements and a step-by-step approach to the control of exposure to hazardous substances including pesticides. All employers, contractors, sub-contractors, and self-employed individuals are required to:

viii) make an assessment of the health risks involved with the operation to be performed, for example, the application of pesticides;

ix) ensure that the exposure of anyone likely to be involved with hazardous substances is prevented or, if this is not reasonably practical, adequately controlled.

The COSHH assessment must be comprehensive and should be made available to appropriate staff. The COSHH safety policy and training certificates of potential contractors should be checked. Contracts should specify the herbicides which may be used and the standards to which the contractor must operate. Working practices should be checked for both Agency staff and contractors and the effectiveness of herbicide monitored.

3.12) Fire Precautions Act 1971

The duties set out in this Act belong to the Home Office and are administered by the fire authorities and by the Fire Services Inspectorate. Therefore advice on these matters should be sought from the fire authority.

3.13) Health and Safety (Safety Signs and Signals) Regulations 1996

These regulations bring into force the EC Safety Signs Directive (92/58/EC) on the provision and use of safety signs at work. The aim is to standardise safety signs throughout the EU so that safety signs have the same meaning wherever they are seen. The regulations require employers to provide specific safety signs whenever there is a risk that has not been controlled or avoided by other means such as engineering controls and safe systems of work. For work with pesticides the following are the most important: pipework and containers containing dangerous substances have to be marked, and stores and areas containing significant quantities of dangerous substances have to be identified.

3.14) Carriage of Dangerous Goods by Road Regulations 1996

These regulations apply to the carriage of dangerous goods other than explosives and radioactive materials which are subject to their own special regulations. They define what dangerous goods are and regulate all factors affecting the transport of such goods. These include the provision of information by the consignor, the operator and the driver, the duty to ensure that the goods are fit for carriage, vehicle marking, the suitability of the means of transport, the loading, unloading and stowage of such goods, emergencies, supervision and parking and the training of drivers.

4

Selection of herbicides for use

4) Selection of herbicides for use

4.1) Introduction

Before considering using a herbicide the objective of the proposed aquatic weed control must be clearly defined. This should lead to an assessment of the most appropriate form of control taking the likely environmental impact into account.

In some situations, using herbicides may cause rapid dieback of mature plants, leading to very low dissolved oxygen levels in the water and a consequent threat to aquatic life. Therefore, mechanical or physical methods may be more suitable for controlling aquatic weeds in these situations. However, sometimes mechanical removal of fully grown aquatic plants may remove the organisms which rely on the plants for shelter, or leave potentially poisonous plants on the banks which may become palatable to grazing animals. It is therefore essential that all the options are fully appraised for each individual situation and the most appropriate method of control used. If there is any doubt about the selection of the most appropriate method of weed control or any other aspects of aquatic weed control, the Aquatic Weeds Research Unit at Sonning should be contacted under the Agency's contractual agreement with them, which allows for the provision of technical advice on this subject. The address and telephone number can be found in Section 11.1. Further information can also be found in the leaflet Aquatic Weed Control Operations: Best Practice Guidelines[7].

This guide assumes that all methods have been considered and a herbicide is deemed the most appropriate.

Figures and tables are provided which should assist in the selection of the most suitable herbicide. Appendix 4.4.1 provides details of each herbicide including timing of application and restrictions for abstractions and livestock access. All these factors should be considered prior to application. Failure to follow the instructions on the product label may result in a prosecution under the Control of Pesticides Regulations 1986 (COPR).

4.2) Herbicides for use in or near water

4.2.1) Restrictions

Only products approved under the Control of Pesticide Regulations 1986 (COPR) for use in or near water can be used. These are listed in Tables 4.1 and 4.2. Further detailed information on these products can be found in Appendices 4.4.1. and 4.4.2.

Herbicides should not be used where there is a risk of contamination of potable water supplies and groundwater. Each application must be assessed on its merits. It is essential to obtain the advice of the appropriate Agency officer (see Section 5 Notification Procedure).

To comply with Sections 2(2),16 and 17 of the Water Resources Act 1991 (conservation of flora, fauna etc), prior notification of the intention to use a herbicide should be given to EN/CCW, if the application is to be in or near an SSSI.

No herbicides can be used to control planktonic algae. These must not be confused with filamentous algae (cott/blanket weed) which can be controlled with terbutryn or diquat.

4.2.2) Selection of herbicides for use

Before selecting a herbicide it is essential to correctly identify the target weed species. Where applicants are in doubt, refer to BASIS-trained Agency staff or other suitably qualified individuals.

Figure 4.1 gives a cross-section of a watercourse showing different types of vegetation and indicating the main areas of use of aquatic herbicides. NB. fosamine ammonium, maleic hydrazide and asulam are only approved for use NEAR water, for example, on banks and land adjacent to water, and therefore must NOT be applied directly to water.

Each herbicide is effective in different situations and on distinct plants, therefore it is very important that the appropriate herbicide is selected. The flow diagram (Figure 4.2) should assist in this process. If the final box contains more than one herbicide, the user should refer to the additional information in Appendix 4.4.1, which gives restrictions, irrigation intervals, timing of application and susceptibility of plants. The susceptibility of some of the more common plants is given in Table 4.3.

Products containing the same active ingredient are not always identical and ONLY products

specifically approved for aquatic use can be applied. For example, clarosan granules contain terbutryn, and are approved for use in or near water. Terbutryn is also the herbicide in Prebane, a product used by farmers to control terrestrial weeds. Prebane, however, does NOT have approval for use in or near water.

Several plants have been the subject of an R&D project "Control of Invasive Riparian and Aquatic Weeds". Details of the optimum control methods for *Reynoutria japonica* (Japanese Knotweed), *Impatiens glandulifera* (Himalayan Balsam) and *Heracleum mantegazzianum* (Giant Hogweed) are available in the Agency leaflet Guidance for the Control of Invasive Plants Near Watercourses.

It is recommended that users refer to Appendix 4.4.1 and Appendix 4.4.2, to check that the herbicide chosen is appropriate. However, this summary may not be fully comprehensive and the regulations demand that the instructions on the product label are read and adhered to.

4.2.3) General precautions

The risk of fish deaths, due to deoxygenation of the water by either the inhibition of photosynthesis by some herbicides and/or from the decay of killed vegetation, should be minimised by ensuring that the appropriate herbicide is applied early in the year for submerged weeds when weed growth is active but bulk is small.

Sealing off stretches of slowly moving watercourses can improve the efficacy of diquat, dichlobenil or terbutryn, although dichlobenil can also be used in slow moving water for partial treatment. The alginate formulation of diquat is suitable for use in flowing water.

Particular care should be given to the removal of potentially poisonous plants which may become palatable to livestock during decay and remain toxic after death. These plants are listed in Appendix 4.4.3.

Applications of foliar acting herbicides to emergent and bankside vegetation should not be made if wet weather is forecast, as this may reduce the effectiveness of the herbicide.

4.2.4) Partial weed control

Total weed removal is rarely desirable, except in the case of some land drainage channels. Normally areas of weed should be left to maintain food chains and to provide shelter for fish fry and invertebrates. A guideline of 40 percent remaining is suggested. However, if weed bulk is large there may be a risk of deoxygenation from weed decay in warm weather and treatment of only 20 percent or even 10 percent, at a time may be advisable. Treatments should be staggered with at least seven to 10 days interval. See manufacturers' recommendations for details specific to each product.

It is usually possible to achieve operational requirements without treating whole waterbodies, for example, only treating the area around a flow gauging weir, not the whole river upstream and downstream, providing clear areas for fishing, but leaving large areas of weed to provide fish cover; and only clearing areas around landing stages for boats.

Targeting partial treatment allows the optimal use of herbicides to remove the less desirable plant species and encourages the plants which provide better shelter for aquatic organisms, thereby improving the general diversity of habitat.

Partial treatment of emergent or surface-floating plants is easily achieved with herbicides which are applied directly to leaves (2,4-D, glyphosate, diquat) as only the areas chosen for weed suppression are sprayed. Partial control of free floating weeds such as duckweed are not of value as the weeds can rapidly spread back into the treated area.

Localised control of submerged plants is more difficult as not all products are suitable. Dichlobenil is absorbed from the mud by plant roots so it can be used for partial treatment of submerged rooted plants such as *Potamogeton* (Pondweed), *Myriophyllum* (Milfoil) or *Ranunculus* (Water-crowfoot). A minimum area of 20m x 20m is suggested by the manufacturer. Dichlobenil is not effective for partial control of detached, free-floating weeds such as *Ceratophyllum* (Hornwort) and gives only poor control of weakly rooted plants, such as *Elodea*.

The alginate formulation of diquat (Midstream) is also suitable for partial treatment of submerged weeds and can also be used on non-rooted plants. The alginate sticks to the plants and restricts movement of the active ingredient, diquat, into the surrounding water. Hence accurate, localised treatment can be achieved, particularly in still waters.

Table 4.1:

Examples of approved products for use as herbicides on weeds *in* or *near* water

Chemical	Interval before irrigation	Approved product	Maff no	For control of
2,4-D	3 weeks	DORMONE ATLAS 2, 4-D MSS 2,4-D AMINE	05412 07699 01391	Floating and emergent water weeds and many broad-leaved weeds on banks of waterways or ditches
DICHLOBENIL	2 weeks	CASORON G (Zeneca Crop) CASORON G (Miracle) CASORON G (Zeneca Prof) CASORON G-SR (Miracle)* CASORON G-SR (Zeneca Prof)*	08065 07926 06854 07925 06856	Rooted floating-leaved and submerged weeds
DIQUAT LIQUID	10 days	REGLONE (Zeneca Crop)	06703	Floating and submerged weeds including algae
DIQUAT ALGINATE	10 days	MIDSTREAM (Zeneca Prof) MIDSTREAM (Miracle) MIDSTREAM (Imperial)	06824 07739 01348	Submerged weeds in still or moving water
GLYPHOSATE	Nil	ROUNDUP ROUNDUP PRO ROUNDUP BIACTIVE ROUNDUP BIACTIVE DRY ROUNDUP PRO BIACTIVE BARCLAY GALLUP AMENITY HELOSATE GLYFOS PROACTIVE GLYPER SPASOR SPASOR BIACTIVE	01828 04146 06941 06942 06954 06753 06499 07800 07968 07211 07651	Emergent and floating weeds including reeds and water lilies. All weeds on banks
TERBUTRYN	7 days	CLAROSAN 1 FG	08396	Floating and submerged weeds including algae

** The manufacture of this product has been discontinued world-wide.*

Table 4.2

Examples of approved products for use as herbicides on weeds *near* water but not *in* water

Chemical	Interval before irrigation	Approved product	Maff no	For control of
ASULAM	nil	ASULOX	05235	Bracken and docks on banks beside water
DALAPON + DICHLOBENIL	This product has been withdrawn and is due to be revoked			
FOSAMINE AMMONIUM	nil	KRENITE	01165	Deciduous trees and shrubs on banks
MALEIC HYDRAZIDE	3 weeks	REGULOX K	05405	Weeds and grasses on river banks

Sources: MAFF/HSE Reference Book: Pesticides 1998 – Pesticides approved under the Control of Pesticides Regulations 1986 (revised annually) and manufacturers information (labels, etc.)

Figure 4.1

Diagram of cross-section of watercourse showing types of vegetation and indicating the main areas of use of aquatic herbicides

Submerged weeds water or soil-acting herbicides	Emergent weeds – foliar acting herbicides
Terbutryn – submerged and floating weeds and algae	2,4 – D – broad-leaved weeds on banks and emergent weeds in water
Diquat – submerged and floating weeds, most algae	Glyphosate – water lilies, reeds and emergent weeds
Dichlobenil – rooted submerged weeds	Fosamine ammonium – trees, shrubs adjacent to water
	Maleic hydrazide – suppression of grass
	Asulam – bracken and broad-leaved weeds adjacent to water

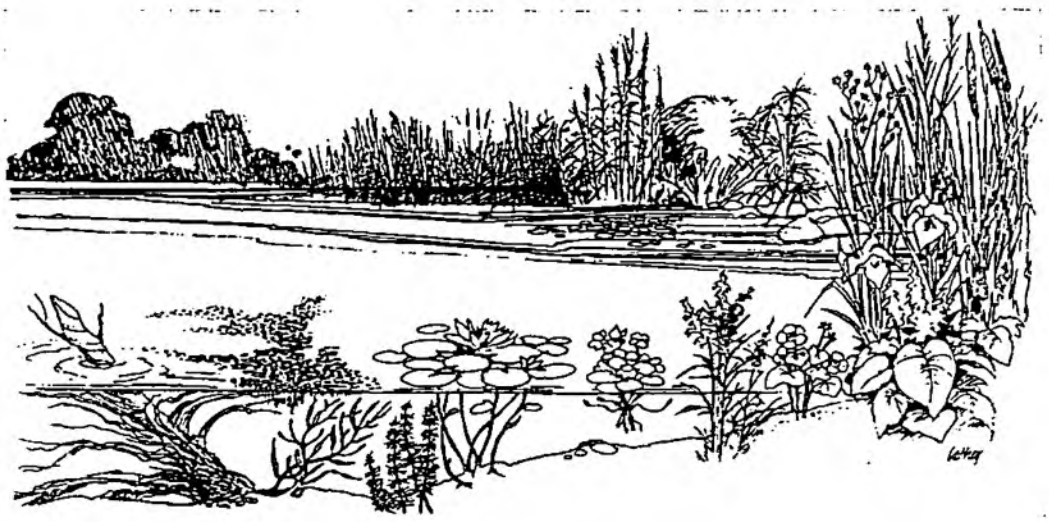


Figure 4.2

Diagrammatic guide to the choice of aquatic herbicides

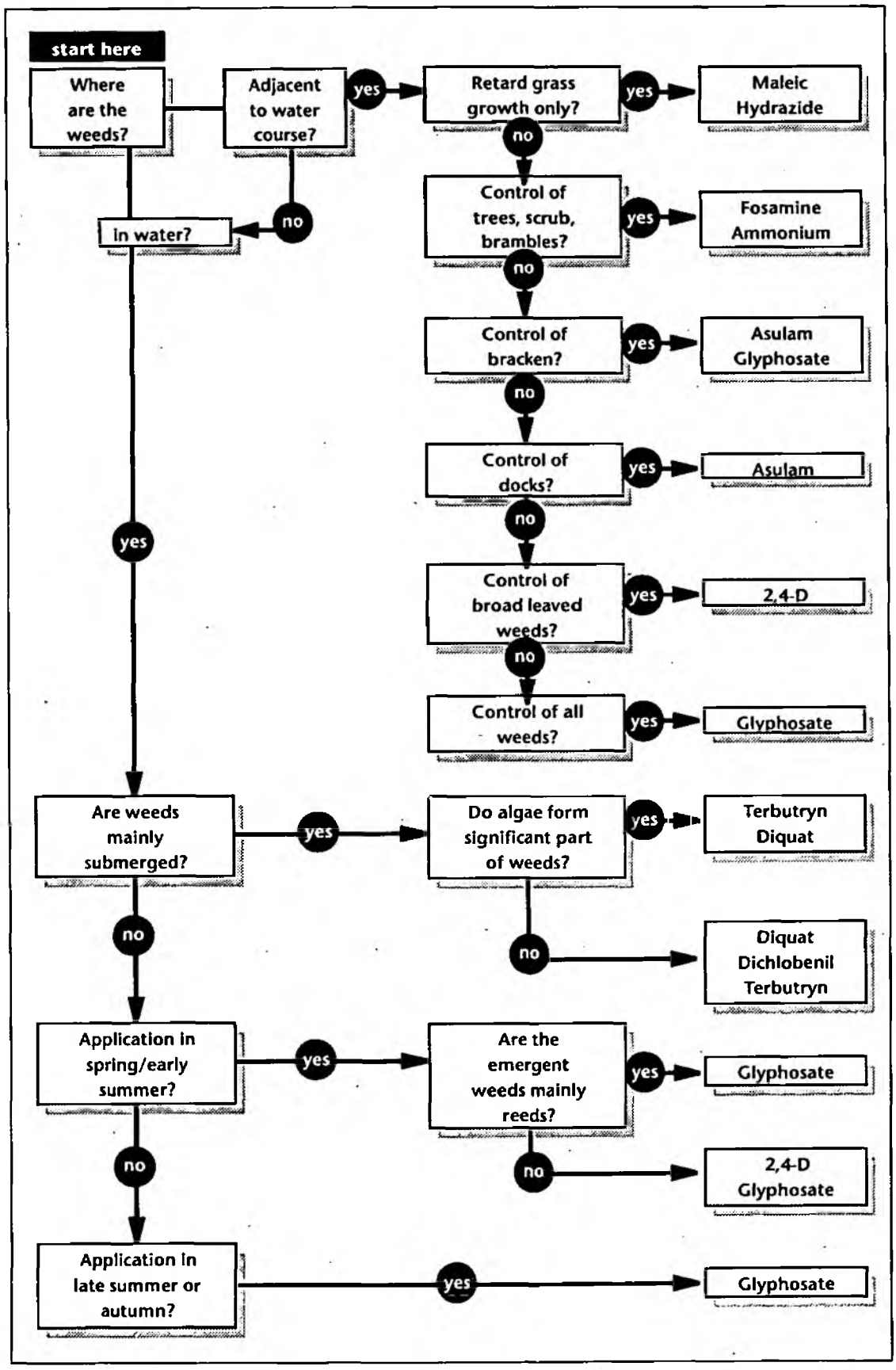


Table 4.3

Susceptibility of some commonly occuring aquatic weeds to herbicides

		2, 4-D	Diquat	Dichlobenil	Glyphosate	Terbutryn
EMERGENT MONOCOTYLEDONS (reeds/grasses)						
Butomus umbellatus	(Flowering rush)	-	R	R	-	R
Carex spp	(Sedges)	R	R	R	S	R
Glyceria fluitans	(Floating sweet-grass)	R	R	S	-	R
Glyceria maxima	(Reed sweet-grass)	R	R	-	S	R
Juncus spp	(Rushes)	-	R	R	S	R
Phalaris arundinacea	(Reed canary grass)	R	R	R	S	R
Phragmites communis	(Common reed)	R	R	R	S	R
Schoenoplectus lacustris	(Common clubrush)	R	R	R	-	R
Sparganium erectum	(Branched bur-reed)	MS	R	MR	-	R
Typha latifolia	(Reedmace)	-	R	R	S	R
EMERGENT DICOTYLEDONS						
Alisma plantago aquatica	(Water-plantain)	S	R	MS	-	R
Equisetum fluviatile	(Water-horsetail)	MR	R	S	-	R
Equisetum palustre	(Marsh horsetail	-	R	S	-	R
Hippuris vulgaris	(Marestail)	-	R	S	-	MR
Nasturtium officinale	(Watercress)	S	R	MS	S	-
Rumex hydrolapathum	(Water dock)	-	R	S	-	R
Sagittaria sagittifolia	(Arrowhead)	MR	R	S	-	R
FLOATING SPP						
Callitriche stagnalis	(Common water starwort)	-	S	S	-	S
Lemna minor	(Common duckweed)	-	S	R	-	S
Nuphar lutea	(Yellow water-lily)	MR	R	MR	S	MR
Nymphaea alba	(White water-lily)	MS	R	MR	S	MR
Potamogeton natans	(Broad-leaved pondweed)	-	MS	MS	-	MR
Polygonum amphibium	(Amphibious bistort)	MR	R	MR	-	R
Ranunculus spp	(Water-crowfoots)	-	S	S	-	S
SUBMERGED VASCULAR						
Ceratophyllum demersum	(Rigid hornwort)	-	S	S	-	S
Elodea canadensis	(Canadian pondweed)	-	S	MS	-	S
Hottonia palustris	(Water-violet)	-	-	S	-	S
Lemna trisulca	(Ivy-leaved duckweed)	-	S	S	-	S

		2, 4-D	Diquat	Dichlobenil	Glyphosate	Terbutryn
Myriophyllum spp	(Water-milfoils)	-	-	S	-	S
Potamogeton crispus	(Curled pondweed)	-	S	S	-	S
Potamogeton pectinatus	(Fennel-leaved pondweed)	-	S	S	-	S
Zanichellia palustris	(Horned pondweed)	-	S	MS	-	-
ALGAE						
Cladophora	(Cott)	-	MS	R	-	S
Enteromorpho intestinalis	(Bladderweed)		MS	-	-	S
Rhizoclonium spp)	)	-	-	R	-	S
Spirogyra spp)	) (Cott)	-	MS		-	-
Vaucheria spp)	)	-	-	R	-	S

S Susceptible : complete or almost kill. Little or no regrowth during season of application.

MS Moderately susceptible: partial kill or effectively suppressed during season of application

MR Moderately resistant: temporary suppression – regrowth during year of treatment.

R Resistant: no effect.

– No information on product labels

No information available for Asulam.

Table 4.4

Terrestrial uses of aquatic herbicides and suggested products

Use	Suggested herbicides
1. Control or prevention of weeds in, on or near paths and drives.	Glyphosate[a] Diquat[b] Dichlobenil[c]
2. Retarding growth of grass.	Maleic hydrazide[d]
3. Bracken control.	Asulam[e], Glyphosate[a]
4. Control of trees, scrub, brambles.	Fosamine ammonium[f]
5. Control of broad-leaved weeds in amenity/landscape areas.	Glyphosate[a] (spot treatment) 2,4-D[g] Asulam[e]
6. Control of broad-leaved weeds in grass.	2,4-D[g] Asulam[e] (for docks)

A selection of products available:

a) Barclay Gallup Amenity, Helosate, Roundup, Roundup Pro, Roundup Biactive, Roundup Biactive Dry, Roundup Pro Biactive, Spasor, Spasor Biactive, Glyper, Glyfos Proactive

b) Reglone

c) Casoron G

d) Royal MH 180, Regulox K

e) Asulox

f) Krenite

g) Dormone, Atlas 2,4-D, MSS 2,4-D Amine, Agricorn 2,4-D

4.3) Controlled droplet applicators

Whilst none of the specially formulated pesticide products for use with controlled droplet applicators (CDAs) are currently approved for use in or near water, this does not mean that CDAs cannot be used to control weeds near water.

Several conventional glyphosate products approved for use in or near water are supported by the manufacturers to be used in CDAs (see Table 4.5). Literature from the manufacturers give details of how to use these products in CDAs. Manufacturers may also be contacted for further advice.

Table 4.5

Glyphosate products approved for use in or near water, that are supported by the manufacturers for use in CDAs

Product	Manufacturer	Maff no
Barclay Gallup Amenity	Barclay	06753
Glyper	Pbi	07968
Roundup Pro Biactive	Monsanto	06954
Roundup Pro	Monsanto	04146
Glyfos Proactive	Nomix Chipman	07800

4.4) Appendices

4.4.1) Herbicide data summary

The information presented in this Appendix is general information on the herbicides available for aquatic weed control. It is also appropriate when the herbicides are used in a terrestrial environment.

The information has been collated from data supplied by manufacturers and other sources. Whilst every attempt has been made to ensure the accuracy of the information, it should only be treated as a guide, and the details must be checked by reading the product label.

The numbers in the sections headed "suitable for" or "unsuitable for" refer to the plants listed in Appendix 4.4.2.

Moderately susceptible or moderately resistant plants are listed in brackets.

The dose rates are not included in the appendix because the information provided refers to the active ingredient and not the individual products. The products may have different application rates, and therefore it is essential to check the appropriate dose rate from the product and label.

Data on "Permitted" and "Safe" concentrations for environmental safeguards and irrigation apply to water analysis.

Data on toxicity refers to the toxicity of the active ingredient and NOT the formulation as these may be different.

Dalapon is no longer manufactured or available. It was withdrawn by the manufacturers and is about to be revoked. Glyphosate is an appropriate replacement.

1) Asulam (liquid)

Type	Translocated herbicide
Suitable for	Bracken, docks
Apply	i) Bracken – treat in full frond, usually between early July and late August. ii) Docks – treat when plants are actively growing, usually between April and September
Permitted concentration	1 mg/l
Safety interval before irrigation	None specified
Restrictions	Do not apply in drought or hot dry conditions. Do not apply less than three weeks after cutting. Keep livestock out of treated areas for at least two weeks after spraying bracken, and at least four – six weeks after docks, or until foliage has died and become unpalatable. Only one application per year permitted.
Special instructions to operators	Wear suitable protective gloves, rubber boots, coveralls and face/eye protection when handling equipment. Use suitable respiratory equipment during application.
Comments	Can give control for up to three years. The growth of some grasses may be affected. Short persistence in soil, half life six-14 days.
Toxicity data	LC50 (96hrs) for rainbow trout, goldfish >5000 mg/l Acute oral LD50 mallard ducks >4000 mg/l
Trade name/ manufacturer/ MAFF number	Asulox – Rhône Poulenc – MAFF No 06124 (05235 old MAFF No)

2) 2,4-D

Type	Translocated foliar/root herbicide. Distorts new growth.
Suitable for	Broad-leaved weeds on banks and some emergent weeds. Susceptible plants include: 1, (8), (9), 15, (16), 17, 18, (21), (25), (28), (37), (38), (39), (40), (41b), (57), (58). Plants such as 9, 16, 21, 25, 37, 38, 40, 57, and 58 may regrow and require another dose; 15 may be controlled if cut four weeks before or four weeks after spraying.
Unsuitable for	Grasses, reeds, rushes, sedges and therefore sometimes mixed with other herbicides for greater control.
Apply	Direct to foliage in early summer (May – September), but most effective when used early on fast-growing weeds. Only one application of Dormone may be used in or near water per year.
Permitted concentration	5 mg/l active ingredient
Safety interval before irrigation	Three weeks or until less than 0.05 mg/l active ingredient present.
Restrictions	At 0.001 mg/l can taint and colour water after chlorination. (Not to be used where any risk to potable supply). Do not spray during rain or when rain is imminent. Do not cut grass for 10 days. Keep livestock out of treated areas for at least two weeks until potentially poisonous plants present have died (See Appendix 4.4.3).
Special instructions to operators	Harmful to skin or if swallowed. Irritating to eyes. Wash concentrate from skin or eyes immediately. Wear suitable protective gloves, rubber boots and face/eye protection when handling concentrate.
Comments	Residual activity in the soil approximately six weeks.
Toxicity data	LC50 (96hrs) rainbow trout 100 mg/l Acute oral LD50 wild ducks >1000 mg/kg
Trade name/ manufacturer/ MAFF number	Dormone – Rhône Poulenc – MAFF No 05412 Atlas 2,4-D – Atlas Crop Protection Ltd – No 03052 MSS 2,4-D Amine – Mirfield Sales Services Ltd. – No 01391 Agricorn 2,4-D – Farmers Crop Chemicals Ltd – No 07349

3) **Dichlobenil (granules)**

Type	Persistent, soil-acting herbicide, affecting growing points of roots and shoots. Powerful inhibitor of germination and of actively dividing meristems.
Suitable for	Rooted submerged or rooted emergent broad-leaved weeds including: (1), (3), 4, 9, 11, 12, 13, (18), (21), 23, 24, 25, (28), 29*, (31a), 33, 34, (37), (38), (41), 42, 43, 44, (47), 49, 50, 51, 52, 54, 55, 56, (57), (58), 61, (62), 63, 68, 69, 74, 76,
Unsuitable for	Flowering rush, marsh marigold, narrow-leaved weeds and free-floating, rootless weeds or algae (except *Chara sp.* Stonewort): 6, 14, 15, 19, 20, 31, 36, 70.
Apply	In still water use as soon as weed growth commences (late March, early May) because most effective and also minimises effects of decaying weeds later. In slowly moving water up to 90m/hour apply in May having attempted to stop flow for at least seven days. Apply by hand, air-assisted motorised knapsack or other mechanical applicator direct to water surface or mud. Even distribution of granules is important.
Permitted concentration	Not to exceed 3 mg/l active ingredient. Normally apply at 1 mg/l active ingredient.
Safety interval before irrigation	Two weeks or until concentration in water is less than 0.3 mg/l active ingredient
Restrictions	Threshold odour concentration 0.02 mg/l active ingredient, but unaffected by chlorination. Has a small safety margin with respect to its acute toxicity to fish and is accumulated in fish tissues. If fish are known to be present only partial treatment i.e. localised treatment is recommended. A single application will provide control of susceptible weeds for an entire season. Use is not permitted on reservoirs which form part of a water supply system.
Special instructions to operators	Normal hygiene precautions when handling concentrate and during application. Avoid contact with skin and eyes.
Comments	Water treated with dichlobenil may be invaded by algae to give an equally dense vegetation as before treatment. Needs extra care to avoid problems of deoxygenation and fish mortalities. Can be used for localised control, particularly for weeds having extensive root systems in mud e.g. *Myriophyllum* (water-milfoil), *Hippuris* (mares-tail), *Potamogeton* (pondweed).
Toxicity data	LC50 (48hrs) guppies >18 mg/l LC50 (8days) mallard duck > 5200 mg/kg diet EC50 (48 hrs) daphnia magna approximately 50 mg/l LC50 (96 hrs) fish (various species) 5 – 13 mg/l
Trade name/ manufacturer/ MAFF number	Casoron G – Zeneca Crop Protection – MAFF No 08065 Casoron G – Zeneca Professional Products – No 06854 Casoron G – Miracle Professional – No 07926 Casoron G – Uniroyal Chemical Ltd – No 08713 Casoron G-SR – Zeneca Professional Products – No. 06856 Casoron G-SR – Miracle Professional – No. 07925 Casoron G-SR – Imperial Chemical Industries plc – No 00451

Application rate (Casoron and Casoron G-SR)

Water depth (m)	Water depth (ft)	Casoron G			Casoron G-SR		
		kg/ha	g/m²	lb/acre	kg/ha	g/m²	lb/acre
1	3	45	4.5	40	-	-	-
2	6	84	8.4	75	28#	2.8#	25#
3	9	123	12.3	110	40	4	37
3+	9+	150	15	135	50	5	45

* In certain areas this plant is rare and of botanical interest. Where it is present, local naturalists should be consulted before treatment.

It is impractical to apply this rate to waterbodies less than 1.5 m (5 feet) in width or 60 cm (2 feet) in depth. In shallow and narrow waterways use Casoron G.

Note: The manufacture of Casoron G-SR has been discontinued world-wide

4a) Diquat (liquid)

Type	Contact herbicide, also translocated through leaves. Rapid defoliant.
Suitable for	Wide range of aquatic plants but especially submerged and floating weeds, including the blanketweed *Cladophora*. 23, 35, 36, (41), 43, 45, 45b, 47, 53, 54, 55b, 59, 61, (62), (63), 64, 65, 66, (67), 68, (73), 76.
Unsuitable for	Most algae except *Cladophora*, emergent vegetation.
Apply	May – September but early treatment advisable to avoid severe deoxygenation. Short persistence of herbicide may result in subsequent regrowth, especially of normally later-maturing weeds. Where repeated applications are necessary, treat only part of the area followed by the remainder two-three weeks later. Plants in water flowing up to 90m/hr can be treated but flow should be halted, if possible, for one day to improve contact. Diquat is rapidly inactivated in muddy water. Application may be direct to foliage, direct to water, or sub-surface injection as appropriate. Not effective in hard or turbid waters or where the plants are covered by epiphytic algae or silt on stem and leaves.
Permitted concentration	2 mg/l active ingredient
Safety interval before irrigation	Ten days or until concentration in water falls below 0.02 mg/l.
Restrictions	Livestock should be kept out of the treated area for 24 hours. Treated water should not be used for human consumption for 24 hours.
Special instructions to operators	Wash any contamination from skin or eyes immediately. Take extreme care to avoid spray mist. Wear protective gloves and face shield when handling concentrate. Harmful if swallowed. Irritating to eyes and skin. If clothing becomes contaminated remove immediately and wash underlying skin.
Comments	When duckweed (*Lemna*) is present, penetration is poor and respraying may be necessary. Booms may be used to prevent reinvasion until the total area has been treated. Regrowth of certain filamentous algae is possible. Rapidly and completely inactivated on contact with soil.
Toxicity data	LC50 (96hrs) rainbow trout 21 mg/l LC50 (96hrs) mirror carp 67 mg/l
Product name/ manufacturer/MAFF number	Reglone – Zeneca Crop Protection – No 06703

4b) Diquat (alginate)

The alginate formulation of diquat is similar in many ways but possesses certain advantages compared with the liquid formulation.

Advantages:

i) can be used in flowing water to clear the whole of, or part of, the channel width;

ii) can be used for accurate localised control in still waters;

iii) controls certain plants more effectively (especially filamentous algae) due to the adhesion of the herbicide to the plant;

iv) alginate formulation does not drift;

v) no dilution necessary.

Disadvantages:

i) needs to be applied using a specially modified knapsack sprayer (Modified Solo Jetpack 425 Sprayers – Claxton Engineering, Skillington, Grantham, Lincs).

Type	Contact herbicide, also translocated through leaves. Rapid defoliant.
Suitable for	(41), 42, 43, 45b, 47, (48), 55b, 61, (62), (63), 68, (71), (73), 76.
Unsuitable for	All emergent plants and 11, 37, 38, 40.
Apply	Spring to early summer when weeds are actively growing but before plants become covered with protective layer of epiphytic algae. Avoid stirring up mud from lake or river bed during or after application. Inactivated by mud, suspended solids and organic matter, for example, d/s of STW. A full season's control of susceptible plants may be expected from one correctly timed application.
Permitted concentration	2 mg/l active ingredient
Safety interval before irrigation	Ten days or until concentration in water falls below 0.02 mg/l.
Restrictions	Livestock should be kept out of the treated area for 24 hours. Treated water should not be used for human consumption for 24 hours.
Special instructions to operators	Wash any contamination from skin or eyes immediately. Take extreme care to avoid spray mist. Wear protective gloves and face shield when handling concentrate. Harmful if swallowed. Irritating to eyes and skin. Remove contaminated clothing immediately and wash skin.
Comments	Product should not be diluted and spraying equipment will require special cleaning. When duckweed (*Lemna*) is present, penetration is poor and respraying may be necessary. Booms may be used to prevent reinvasion until the total area has been treated. Regrowth of certain filamentous algae is possible. Rapidly and completely inactivated on contact with soil.
Toxicity data	LC50 (96hrs) rainbow trout 21 mg/l LC50 (96hrs) mirror carp 67 mg/l
Product name/ manufacturer/ MAFF number	Midstream – Zeneca Professional Products – No 06824 Midstream – Miracle Professional – No 07739 Midstream – Imperial Chemical Industries – No 01348

5) **Fosamine ammonium (liquid)**

Type	Contact growth retardant/herbicide, with slight translocation, which inhibits cell division in buds.
Suitable for	Control of most deciduous trees and shrubs including brambles. Cleared for use on plants adjacent to water but should not be sprayed onto water.
Unsuitable for	Evergreen trees, heather, broom, willows (suppressed), rhododendron, gorse, heath, heather, honeysuckle, dogwood (suppressed), maple (suppressed), rowan (suppressed), sycamore (suppressed), broad-leaved and grassy terrestrial weeds.
Apply	To foliage between August and October, but before the onset of natural autumn discolouration of leaves. An approved non-ionic wetting agent should be added to improve leaf wetting.
Permitted concentration	None specified.
Safety interval before irrigation	None specified.
Restrictions	Do not spray in windy weather or when foliage is wet. Rainfall within 24 hours of application may reduce performance.
Special instructions to operators	Do not apply excessively high volumes of water which are liable to run off and waste chemical. Do not leave chemical in machine overnight. Wash concentrate from skin or eyes immediately. Normal hygiene precautions when handling or using herbicide.
Comments	No immediate effect is visible after application but, following normal leaf drop, spring bud and shoot development is severely or completely limited. Can be used for chemical pruning, that is, to kill only certain branches without destroying whole bush or tree. Fosamine ammonium is of low toxicity and is rapidly decomposed in the soil. Half life in soil approximately 10 days. Store away from frost.
Toxicity data	LC50 (96hr) rainbow trout >415 mg/l (formulated product). Acute oral LD50 mallard duck >4150 mg/kg (formulated product).
Trade name/ manufacturer/ MAFF number	Krenite – DuPont UK Ltd–No 01165

6) Glyphosate

Type	Foliar-acting herbicide which is translocated from treated vegetative growth to underground roots, rhizomes and stolons.
Suitable for	Control of emergent and floating species including reeds, rushes, sedges, waterlilies and grass weeds on banks including creeping bent and whort grass: 5, 6, 10, 15, 18, 19, 20, 26, 37, 38.
Unsuitable for	Algae, submerged weeds.
Apply	To foliage from mid July to mid August for floating plants and from mid August to mid September for reeds. Optimum timing for watercress is June: treat when plants are actively growing and fully developed, preferably just before beginning to die back naturally. Only one application per season. Can be applied early summer but control may be reduced compared to late summer treatments.
Permitted concentration	Up to 0.2 mg/l active ingredient in the water
Safety interval before irrigation	Nil
Restrictions	Do not spray in windy conditions or use high pressure. Drift on to crops can severely damage them. No taint detectable up to 10 mg/l a.i. A rain-free period of at least six hours (preferably 24 hours) must follow spraying. Must not be used on raw water to be used for domestic purposes of drinking, washing and cooking.
Special instructions to operators	Wash any contamination from skin or eyes immediately. Take extreme care to avoid spray mist. Wear protective rubber boots, gloves and face shield when handling concentrate, and wash all protective clothing thoroughly after use especially inside of gloves. Do not mix, store or apply in galvanised or unlined mild steel containers or spray tanks since an inflammable gas (hydrogen) may be produced. Store away from frost. May be used with CDA equipment with appropriate protective clothing. In confined areas wear breathing apparatus.
Comments	Can be used successfully for partial clearance, that is, spraying only those patches needing to be cleared. Glyphosate is rapidly inactivated in soil and degraded by aquatic micro-organisms. (Note that a spray volume of 100 l/ha gives the same control as 500 l/ha). Half-life in soil is normally less than 60 days.
Toxicity Data	LC50 (96 hrs) trout 86 mg/l eight-day dietary LC50 ducks >4640 mg/kg diet eight-day dietary LD50 (five-day treatment) mallard duck > 5620 mg/kg diet (Roundup Pro Biactive) LC50 (96 hrs) common carp: > 895 mg/l (Roundup Pro Biactive) LC50 (96 hrs) rainbow trout: > 989 mg/l (Roundup Pro Biactive) EC50 (48 hrs) water flea: 676 mg/l (Roundup Pro Biactive)

Trade name/ manufacturer /MAFF number	
	Roundup – Monsanto plc – No 01828
	Roundup Pro – Monsanto plc – No 04146
	Roundup Biactive – Monsanto plc – 06941
	Roundup Biactive Dry – Monsanto plc – 06942
	Roundup Pro Biactive – Monsanto plc – 06954
	Barclay Gallup Amenity – Barclay Plant Protection – No 06753
	Helosate – Helm – No 06499
	Spasor – Rhône Poulenc – No 06499
	Spasor Biactive – Rhône Poulenc – No 07651
	Glyfos Proactive – Nomix Chipman – No 07800
	Glyper – pbi Ltd – No 07968

7) Maleic hydrazide (liquid)

Type	Translocated growth regulator which inhibits cell division and retards growth of grasses. Inhibits certain broad-leaved weeds' growth.
Suitable for	Control of grass on watercourse banks after cutting to maintain a short grass sward, sometimes combined with 2,4-D amine to control broad-leaved weeds. Can also be used to kill grass (see below)
Unsuitable for	
Apply	Spraying should be carried out in calm weather when the vegetation is dry. A period of eight hours' dry weather is required for effective results. Use when active growth starts (March – May) to retard growth for 12 – 14 weeks. If applied in autumn it will give control for five – seven weeks in the following spring. Employing this technique, an application rate of Regulox K at 16 l/ha in 900-1100 litres of water must not be exceeded. Do not allow spray to enter water. A minimum of eight weeks must be observed between repeated applications to areas near water.
Permitted concentration	2 mg/l active ingredient
Safety interval before irrigation	Three weeks or less than 0.02 mg/l active ingredient residue.
Restrictions	Can affect a range of crops; care is needed to avoid spray drift and contamination of irrigation water. If used too frequently or in too high a concentration, maleic hydrazide can turn grass yellow and may encourage a tough wiry growth that is difficult to cut. Do not treat fine turf or grass seeded less than eight months previously. Only apply to grass not to be used for grazing.
Special instructions to operators	Wash any contamination from skin or eyes immediately. Normal hygiene precautions when handling or using herbicide. Wear rubber boots, gloves and clothing which covers as much of the body as possible.
Comments	Half life in soil approximately two – eight weeks. Rapid photochemical degradation in water.
Toxicity data	LC50 (96 hrs) rainbow trout 1435 mg/l LC50 (96 hrs) bluegill sunfish 1608 mg/l Acute LD50 mallard duck > 5000 mg/kg
Trade name/ manufacturer/ MAFF number	Regulox K – Rhône Poulenc – No 05405

8) **Terbutryn (granules)**

Type	Translocated herbicide absorbed by foliage and roots. Photosynthesis inhibitor. Not persistent but slow-release formulation controls regrowth.
Suitable for	Wide range of submerged and floating weeds and algae: 4, (11), 12, 23, 35, 36, (38), (41), (41a), 42, 43, 45, 45b, 47, 48, 52, 53, 54, 55, 55b, 61, 63, 67, 68, 72, 73, (75), (77), 78.
Unsuitable for	Reeds, rushes, emergent weeds, water lilies (moderately suppressed or damaged) or certain other plants with floating leaves. 40 is resistant.
Apply	Early in the year (April – May) to avoid deoxygenation problems arising from plant decay. Can be used in sluggish flows of up to 20 m/hour but best effects are obtained if flow is stopped for seven days. Apply granules evenly over water surface. Effectiveness reduced in waters with a peaty bottom. If dense weed growth needs controlling, it is suggested sections of 400 m of water course or not more than a quarter of the total area of a lake be treated with an interval of 14 days between applications.
Permitted Concentration	Not more than 0.1 mg/l active ingredient.
Safety interval before irrigation	At least one week.
Restrictions	The potentially severe problems arising from oxygen depletion with this herbicide mean that it cannot be recommended where a valuable fishery is at risk, or where suitable alternative herbicides may be used. Experience has shown that partial treatment is not possible. Terbutryn appears to become ineffective at or below temperatures around 5 – 8°C. Threshold odour concentrations: 5.7 mg/l (soft water) 4.8 mg/l (hard water) 16.8 mg/l after dechlorination
Special instructions to operators	Normal precautions when handling concentrate and during application.
Comments	Large safety margin in its acute toxicity to mammals and birds. Weed growth ceases after application but obvious signs of death may not occur for two – four weeks. Residual activity in soil is three – 10 weeks.
Toxicity data	LC50 (96hrs) rainbow trout 3 mg/l. Eight-day dietary LC50 mallard ducks >4640 mg/kg.
Trade name/ manufacturer/ MAFF number	Clarosan – Novartis Crop Protection – No 08396 (old No 03859)

4.4.2) Common aquatic plants and suitable herbicides

Herbicides given in brackets give only partial control

EMERGENT SPECIES			
1.	*Alisma plantago-aquatica*	Water-plantain	2,4-D, (dichlobenil)
2.	*Apium nodiflorum*	Fool's water-cress	Glyphosate
3.	*Berula erecta*	Narrow-leaved water warsnip	(Dichlobenil)
4.	*Callitriche spp*	Water-starwort	Dichlobenil, terbutryn
5.	*Carex riparia*	Great pond sedge	Glyphosate
6.	*Carex spp*	Sedge	Glyphosate
7.	*Crassula helmsii*	Swamp stonecrop	(Diquat), (glyphosate)
8.	*Epilobium hirsutum*	Great willow herb	(2,4-D)
9.	*Equisetum spp*	Horsetail	(2,4-D), dichlobenil
10.	*Glyceria maxima*	Reed sweet-grass	Glyphosate
11.	*Hippuris vulgaris*	Mare's-tail	Dichlobenil, (Terbutryn – only when fully submerged for at least three weeks after treatment)
12.	*Hottonia palustris*	Water-violet	Dichlobenil, terbutryn
13.	*Hydrocharis morsus-ranae*	Frog-bit	Dichlobenil
14.	*Iris pseudacorus*	Yellow flag	Glyphosate
15.	*Juncus effusus*	Soft rush	2,4-D, glyphosate
16.	*Lythrum salicaria*	Purple-loosestrife	(2,4-D)
17.	*Mentha aquatica*	Water mint	Glyphosate, (2,4-D)
18.	*Nasturtium officinale*	Water-cress	2 4-D, glyphosate, (dichlobenil)
19.	*Phalaris arundinacea*	Reed canary grass	Glyphosate
20.	*Phragmites australis*	Common reed	Glyphosate
21.	*Polygonum amphibium*	Amphibious bistort	(2,4-D) (dichlobenil)
22.	*Pteridium aquilinum*	Bracken	Asulam
23.	*Ranunculus spp*	Water-crowfoot	Dichlobenil, diquat, terbutryn
24.	*Rumex hydrolapathum*	Water dock	Asulam, dichlobenil
25.	*Sagittaria sagittifolia*	Arrowhead	Dichlobenil, (2,4-D)
26.	*Scirpus lacustris*	Common bulrush, clubrush	Glyphosate
27.	*Sparganium emersum*	Unbranched bur-reed	Diquat
28.	*Sparganium erectum*	Branched bur-reed	(Dichlobenil), (2,4-D)
*29.	*Stratiotes aloides*	Water-soldier	Dichlobenil
30.	*Typha angustifolia*	Narrow-leaved reedmace	Glyphosate
31.	*Typha latifolia*	Reedmace	Glyphosate
31a	*Berula erecta*	Lesser water parsnip	(Dichlobenil)

FLOATING SPECIES			
32.	*Azolla filiculoides*	Water fern	Glyphosate, diquat
33.	*Glyceria fluitans*	Floating sweet-grass	Dichlobenil, glyphosate
34.	*Hydrocharis morsus-ranae*	Frog-bit	(Dichlobenil), (diquat)
35.	*Lemna spp*	Duckweed	Diquat, glyphosate, terbutryn
36.	*Lemna minor*	Lesser duckweed	Diquat, glyphosate, terbutryn
37.	*Nuphar lutea*	Yellow water-lily	(Dichlobenil), glyphosate, (2,4-D)
38.	*Nymphaea alba*	White water-lily	(Dichlobenil), (2,4-D) glyphosate, (terbutryn)
39.	*Nymphoides peltata*	Fringed water-lily	Dichlobenil, (glyphosate)
40.	*Polygonum amphibium*	Amphibious bistort	(2,4-D)
41.	*Potamogeton natans*	Broad-leaved pondweed	Diquat, (dichlobenil)
41a.	*Nuphar spp*	Water-lilies	Glyphosate, (terbutryn)
SUBMERGED SPECIES			
42.	*Callitriche spp*	Water starwort	Dichlobenil, terbutryn, diquat
43.	*Ceratophyllum demersum*	Hornwort (rigid)	Dichlobenil, diquat, terbutryn
44.	*Chara spp*	Stonewort	Dichlobenil
45.	*Cladophora glomerata*	Blanketweed	(Diquat), terbutryn
45b.	*Cladophora spp*	Blanketweed	(Diquat), terbutryn
46.	*Crassula helmsii*	Swamp stonecrop	(Diquat), glyphosate
47.	*Elodea canadensis*	Canadian pondweed	Dichlobenil, diquat, terbutryn
48.	*Entermorpha intestinalis*	Bladderweed	Terbutryn (diquat)
49.	*Fontinalis spp*	Willow moss	Dichlobenil, diquat
50.	*Glyceria fluitans*	Floating sweet-grass	Dichlobenil, glyphosate
51.	*Hippuris vulgaris*	Mares-tail	Dichlobenil
52.	*Hottonia palustris*	Water-violet	Dichlobenil, glyphosate, terbutryn
53.	*Lemna Spp*	Duckweed	Diquat, glyphosate, terbutryn
54.	*Lemna trisulca*	Ivy-leaved duckweed	Dichlobenil, diquat, terbutryn
55.	*Myriophyllum spp*	Water-milfoil	Dichlobenil, terbutryn
55b.	*Myriophyllum spicatum*	Spiked Water-milfoil	Dichlobenil, terbutryn
56.	*Nitella spp*	Stonewort	(Dichlobenil)
57.	*Oenanthe aquatica*	Fine-leaved water-dropwort	(2,4-D), dichlobenil
58.	*Oenanthe crocata* (*poisonous)	Hemlock water-dropwort	(2,4-D), (dichlobenil)
59.	*Potamogeton berchtoldii*	Small pondweed	Diquat
60.	*Potamogeton compressus*	Grass/wrack pondweed	Diquat

61.	*Potamogeton crispus*	Curled pondweed	Dichlobenil, diquat, terbutryn
62.	*Potamogeton lucens*	Shining pondweed	(Diquat) (Dichlobenil)
63.	*Potamogeton pectinatus*	Fennel-leaved pondweed	Dichlobenil, (diquat) terbutryn
64.	*Potamogeton perfoliatus*	Perfoliate pondweed	Diquat
65.	*Potamogeton praelongus*	Long-stalked pondweed	Diquat
66	*Potamogeton pusillus*	Small pondweed	Diquat
67.	*Rhizoclonium hieroglyphicum*	Filamentous alga	(Diquat), terbutryn
68.	*Ranunculus spp*	Water-crowfoot	Dichlobenil, diquat, terbutryn
69.	*Sagittaria sagittifolia*	Arrowhead	Dichlobenil, diquat
70.	*Scirpus lacustris*	Common bulrush, clubrush	Diquat, glyphosate
71.	*Sparganium emersum*	Unbranched bur-reed	(Diquat)
72.	*Spirodela polyrrhiza*	Great duckweed	Terbutryn
73.	*Spirogyra spp*	Filamentous alga (blanketweed or cott)	Terbutryn, (diquat)
74.	*Vaucheria sessilis*	Filamentous alga	(Diquat), (terbutryn)
75.	*Zannichellia palustris*	Horned pondweed	Dichlobenil, diquat
76.	*Vaucheria spp*	Cott	(Diquat), terbutryn
77.	*Rhizoclonium spp*	Blanketweed or cott	Terbutryn

* In certain areas this plant is of botanical interest and importance because of its rarity. Where it is present local naturalists should be consulted before treatment.

4.4.3) Potentially poisonous plants

Although livestock usually avoid eating poisonous plants, some species become palatable when wilted following cutting or spraying. They are then attractive to livestock while retaining their toxicity. Other poisonous species may be eaten as a result of being made more accessible to the livestock or when mixed with other vegetation following dredging/cutting.

Species	Notes
Atropa belladona (Deadly nightshade)	
Caltha palustris (Marsh marigold)	
Cicuta virosa (Cowbane)	Remains toxic after death
Conium maculatum (Hemlock)	
Digitalis purpurea (Foxglove)	Remains toxic after death
Equisetum spp (Horsetails)	Remains toxic after death
Iris pseudacorus (Yellow flag)	Remains toxic after death
Juncus inflexus (Hard rush)	
Oenanthe crocata (Hemlock water-dropwort)	Remains toxic after death
Polygonum hydropiper (Water-pepper) & other *Polygonum spp*	
Pteridium aquilinum (Bracken)	Remains toxic after death
Ranunculus spp (Most-yellow flowering buttercup species)	
Rhododendron ponticum (Rhododendron)	
Scrophularia aquatica (Water figwort)	
Senecio jacobaea (Common ragwort)	Remains toxic after death
Sium latifolium (Great water-parsnip)	
Solanum dulcamara (Bittersweet)	

5

Notification and consultation procedures

5) Notification and consultation procedures

5.1) General

Notification and consultation apply to the use of aquatic herbicides by the Agency, companies under subcontract to the Agency and external users.

The Agency uses herbicides in or near water and also deals with proposed herbicide applications from outside persons. MAFF guidelines (1995)[23] state that the appropriate water authority must be consulted before a herbicide is applied in or near water. It is accepted that this now applies to the Agency. This is reinforced in Conservation Guidelines for Drainage Authorities (1991)[16] and DETR booklet Guidance for Control of Weeds on Non-Agricultural Land (1992)[19]. The latter states that the Agency must be consulted if the intention is to use any herbicide in or near water, and its agreement is needed before herbicides or growth regulators can be used to control aquatic weeds. The provision of such information is reasonably required by the Agency to carry out its functions under parts of the Water Resources Act 1991 dealing with pollution control. As herbicides are potentially poisonous, noxious or polluting matter, anybody refusing or failing to provide the information reasonably requested could be served a notice under S202 of the Water Resources Act 1991. The user of the herbicide is responsible for providing this information. The Agency can then give advice to the user about abstraction licence holders and other interested parties which may be affected such as fisheries and conservation.

Notification procedures are necessary to ensure that consultation takes place between the herbicide user, relevant Agency sections and other organisations so decisions can take account of all environmental aspects. Notification should be made for all proposals to apply herbicides in or near water, including land adjacent to watercourses that are susceptible to flooding.

Agency managers responsible for specifying contracts should note the responsibilities under the COSHH regulations, that is, the COSHH assessment safety policy and certificates of competence of potential contractors should be checked. Contracts should specify the herbicides which may be used and the standards to which the contractor must operate. For both Agency staff and contractors working practices should be checked and the effectiveness of treatment monitored.

A forms system has been devised to provide a formal framework to help ensure that consultations are carried out in a consistent manner across the regions. Notification of intent to use a herbicide is often received very close to the proposed treatment date. Thus, the internal consultation mechanism must be rapid and easy to execute. Where applications have been approved at the same location previously, a quicker response time should be possible. It is recommended that consultation with large users,for example, internal drainage boards, commences early in the year. The system involves a notification form for:

1) herbicide use in or near water;

2) aerial application.

These forms should be used by the Agency and its subcontractors and also by external users.

5.2) Designated officers

Each area should appoint a designated officer to deal with herbicide applications. It is expected that the designated officer will have the BASIS Certificate in Aquatics and be a member of the BASIS Professional Register.

It is recommended that the appointed designated officer contacts local contractors and informs them that any correspondence should come through them at the appropriate address.

5.3) Notification forms

5.3.1) Notification of proposal for the use of herbicides in or near water (excluding aerial application of herbicides)

Standard application form and notes can be found in Appendix 5.9.1.

The notification form should provide information about the proposed herbicide use. The information should then assist in the decision-making process.

The applicant should complete form H1 (Appendix 5.9.3) and receive a copy of the notes attached. A standard letter accompanies Form H1. Where notification comprises a long list of watercourse stretches to be treated, a coded map should be submitted with the form, clearly indicating treatment stretches and dates. The form should help to ensure that the intended user approaches the use of herbicides in a serious manner and is a reminder that Agency agreement is required. This should be widely publicised to help stop herbicide applications being made without Agency knowledge. The existence of the Agency's policy and procedures should be advertised through regional advisory committees and public relations sections, for example, direct to fishing clubs, in Agency fishing literature and angling magazines, in the ADA gazette and at exhibitions. The form also provides a means of imparting key information to users and documenting the Agency's response. Environmental protection officers are used as the central contact point for the return of forms and should be responsible for maintaining a database.

5.3.1.1) Internal consultation procedures
A flow diagram for internal consultation in response to an external or internal proposal to use a herbicide in or near water is shown in Appendix 5.9.3. Form H2 is used to communicate the receipt of an enquiry and obtain a response from other Agency departments. Finally a letter of agreement/objection is sent to the applicant. For some applications it may not be necessary to consult all those listed; this should be at the discretion of the co-ordinating officer.

5.3.2) Notification of proposal for the aerial application of herbicides
The form H3 (Figure 5.9.4) in the aerial spraying guidance document will assist the user to comply with the Control of Pesticide Regulations, provide a record that the regulations have been followed and give the Agency information required to carry out its pollution control functions. This includes the protection of public water supply sources.

The only herbicide which is cleared for both aerial application and for use near water is asulam (Asulox), which is used to control bracken. As there is a danger of spray entering a watercourse during treatment the consent of the Agency must be obtained before herbicides are applied.

Agreement for aerial spraying to control weeds near water should only be given where there is minimal or no risk of contaminating drinking water sources. To protect water supplies the following buffer zones have been agreed internally and with the product manufacturers:

Aerial spraying conventional nozzles)	160 metres
Aerial spraying (RD raindrop nozzles)	50 metres
Tractor and knapsack (conventional system)	20 metres
Tractor and knapsack (low drift system)	5metres
Hand held ULVA	50 metres

Appendix IV gives more detailed guidance on application systems.

While there will be no blanket ban of aerial spraying, some particularly vulnerable areas for example private wells, will be identified in which aerial spraying will not be appropriate. In many of these instances, after consultation, the use of tractor or knapsack sprayers would be acceptable. Spring and well sources should also be identified by the applicant with advice from the local Environmental Health Officer (EHO) and care should be taken to provide adequate protection.

5.3.2.1) Internal consultation procedures
The procedure should be similar to that in Appendix 5.9.3 except that the response time must be 72 hours. Form H3 should be completed by the applicant and returned to the designated officer. After consultation with the relevant Agency departments the designated officer will send a letter of agreement/objection (aerial spraying guidance document) as necessary.

5.4) Consultee responsibilities

It is the responsibility of the:

- **Ecologist (conservation)** to ensure protection and enhancement of nature conservation, landscape, amenity and recreation interest. In particular he/she may need to ensure that the applicant has liaised with English Nature and the Countryside Commission for Wales and the National Parks

where necessary. It is essential for the applicant to contact the former for sites designated as Sites of Special Scientific Interest (SSSIs). (Wildlife and Countryside Act 1981). Herbicides should not be applied within *any* nature reserve without consultation of the organisation responsible for its management. EN must be consulted by the owner/occupier at least four months prior to herbicide applications within SSSIs;

- **Ecologist (biology)** to ensure that plant and invertebrate life is protected and verify the identity of weeds submitted;
- **Water resources officer** to ensure that licensed abstractions and any designated aquifer protection zones are unaffected, and where necessary provide information about abstractions;
- **Fisheries officer** to provide input in relation to the protection of fish life and management of the fishery;
- **Environment protection officer** to advise on any concerns related to protection of controlled waters against pollution;
- **Flood defence officer** to ensure that proposals do not interfere with flood defence activities.

5.5) Approval decision

If approval is given, certain conditions may be imposed, for example, an alternative application method. A standard letter of agreement for applications to water is illustrated in Appendix 5.9.3 and for aerial applications in Appendix 1 of the aerial spraying guidance document. If the proposed application is refused, this should be communicated using the standard letters (Appendix 5.9.3 for water and Appendix 5.9.4 for aerial spraying) and the reason(s) for the objection should be clearly stated. Any disagreement with the final decision may be referred to the regional general manager.

The Agency reserves the right to take chemical and biological samples in order to monitor the environmental impact of the application. A protocol for investigating pollution incidents associated with pesticides is given in the Guidelines for Monitoring and Reporting Pesticide Pollution Incidents in the Aquatic Environment (1992)[21].

Approvals are given on the assumption that:

a) the details provided to the Agency are correct;

b) the statutory procedures are adhered to;

c) spraying is carried out in the correct conditions.

Agency permission to use a herbicide is required for each application made. Repeat applications therefore require separate notification using forms H1 or H3 (Appendix 5.9.3 and Appendix 5.9.4) as appropriate. Treatments must not take place until permission is granted.

5.6) User responsibilities

Herbicide users have a responsibility to ensure that the interests of other water users are not adversely affected. This applies in particular to water abstractors for public supply, livestock and crop irrigation.

The user should notify all riparian owners and occupiers of the site and downstream of it of the intention to apply a herbicide. Public rights of way, including roads, footpaths and bridleways, should not be oversprayed. If the product label indicates that people and animals should keep out of the treated area, a warning notice should be put up (for example, "THIS AREA HAS BEEN TREATED WITH A WEED KILLER, KEEP TO FOOTPATH"). These notices should be removed as soon as it is safe to do so. For aerial applications, signs adequate to warn pedestrians and drivers of vehicles of the time and place of the intended application must be erected within 200 feet of the land which is to be treated. Enquiries should also be made to ensure that nature reserves or SSSIs are not likely to be adversely affected by the proposed treatment (Wildlife and Countryside Act 1981).

In all cases the safety interval for irrigation stated on the product label must be observed. An upper limit for the active ingredient concentration is also stated on the product label. The length of river over which the irrigation safety interval applies will be that length of river in which the upper limit for the active ingredient is exceeded. No herbicide should be used where there is a risk of contamination of potable water supplies or groundwater.

Where poisonous plants are present in or near the weeds to be controlled, the area should be fenced off from livestock until the weeds have decomposed or been removed and burnt. Appendix 4.4.3 lists poisonous plants growing in or near water.

All herbicide users should follow guidelines on the safe storage, use and disposal of pesticides.

5.7) Record keeping

5.7.1) Applications of herbicides

Paper or electronic records of applications must be kept.

5.7.2) Individual users

COSHH regulations require that for health and safety reasons, records of individual users must be kept for risk assessment for up to 30 years.

5.8) Procedure for dealing with unauthorised herbicide applications

Any contravention of FEPA including the use of a herbicide to water without Agency approval should be referred to the Health and Safety Executive (HSE) according to the HSE/Environment Agency Memorandum of Understanding. It is the responsibility of HSE to administer FEPA and to prosecute where appropriate.

5.9 Appendices

5.9.1 Notification of proposals for the use of herbicides in or near water – notes

Herbicides should only be used once all other methods of weed control have been considered.

The information sought in form H1 is required in order to:

a) protect the environment;

b) determine whether the proposed treatment will be effective for the purpose outlined;

c) determine whether the proposed treatment will interfere with downstream water uses (for example, crop irrigation, stock watering etc).

Approvals are given subject to:

i) the details given to the Agency being correct;

ii) the statutory procedures being adhered to;

iii) applications only being made in the correct weather conditions.

It is the responsibility of the user to ensure that other water uses, such as water abstraction for public supply and livestock, crop irrigation and fisheries, are not adversely affected. A list of licensed abstractors on the relevant watercourse can be provided by the Agency if requested. The user should also notify all riparian owners and occupiers of the site and downstream of it of the intention to apply a herbicide. Enquiries should also be made to ensure that nature reserves or SSSIs are not likely to be adversely affected by the proposed treatment (Wildlife and Countryside Act 1981).

Statutory controls under the Food and Environment Protection Act 1985 (Control of Pesticides Regulations 1986) also place a number of responsibilities on herbicide users:

1) Users must take all reasonable precautions to protect the health of human beings, creatures and plants and to safeguard the environment. They must in particular take precautions to avoid the pollution of water.

2) Users must comply with the instructions on the product label or in the published approval for the pesticide.

3) All users must be competent in their duties and have received adequate instruction and guidance in the safe, efficient and humane use of pesticides.

4) Certificates of competence are required from:

(a) Anyone born after 31 December 1964, who is using pesticides approved for use in agriculture, horticulture and forestry, unless they are working under the direct and personal supervision (within eyesight and vocal contact) of a certificate holder.

(b) Contractors, unless they are working under the direct supervision of a certificate holder. A "contractor" is defined as anyone applying pesticides to property or premises which are not owned or occupied by themselves or their employer.

Training courses are organised by the Agricultural Training Board (ATB) and testing leading to certification by the National Proficiency Tests Council (NPTC).

Before using aquatic herbicides it is advisable to read the MAFF Guidelines for the Use of Herbicides on Weeds In or Near Watercourses and Lakes (Revised 1995), obtainable from MAFF Publications, London SE99 7TP (tel 0645 556000).

The book Aquatic Plants – A Guide to Recognition, D Spencer-Jones and M Wade 1986, ICI Professional Products ISBN 0 901747 03 3, is a useful guide to help weed identification.

If the proposed application is refused, the reason(s) for the objection will be put in writing. Any disagreements with the final decision may be referred to the regional general manager.

5.9.2 Guidance notes on filling in the application form

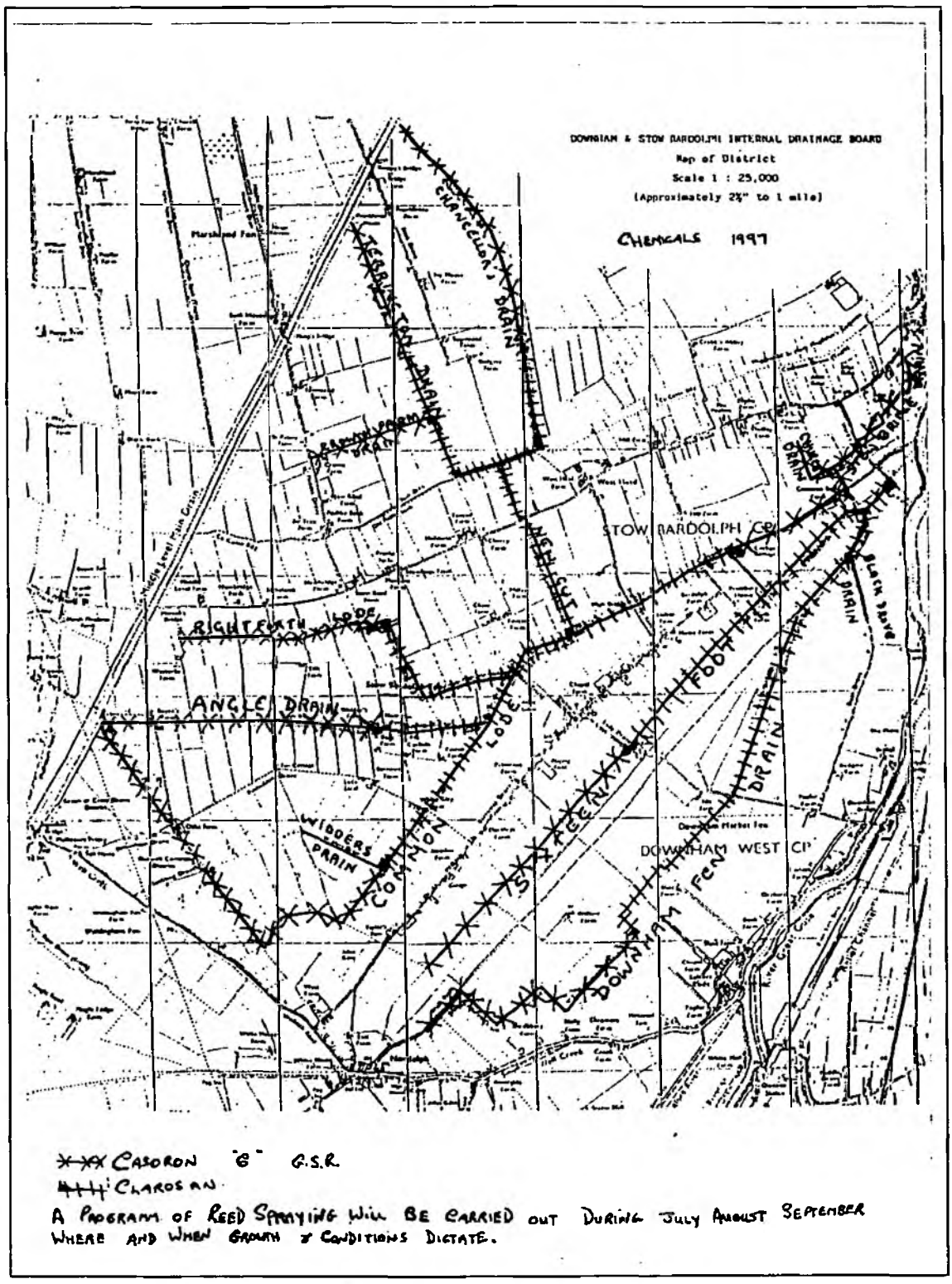
Please provide as much as possible of the information asked for on the form. This will enable the Agency to make a decision more quickly. These notes give some further information on exactly what information is required. It is suggested that you read these notes while filling in the appropriate sections of the application form.

Dates	The date of application is the date when you are filling in this form and sending it to the Agency. The proposed date of treatment is the date when you want to apply the aquatic herbicides.
Names and addresses	There are three boxes for details of the applicant, owner and a manager or site contact. Please fill in as many of these as are appropriate to the application. The provision of fax numbers and e-mail addresses will speed up the reply. You may also send your application by fax or e-mail.
Location/site name	Enter the names of the site, the general area and the nearest village or town as necessary to identify the site. If it is the first application for treatment on that site the location should be shown on an extract of an Ordnance Survey map. If the water body is small a sketch map should be drawn on page four of the application form showing detail of the area to be sprayed. Figures 5.1 and 5.2 are examples of acceptable site plans and drawings, showing the desired detail. Neighbouring land use should be shown.

Figure 5.1

Example map

The areas to be treated have been indicated on an Ordnance Survey map. The map is not at the scale indicated, but has been reduced. Maps should be submitted at the original scale of the Ordnance Survey map



Reproduced from the Ordnance Survey mapping with the permission of the Controller of Her Majesty's Stationery Office

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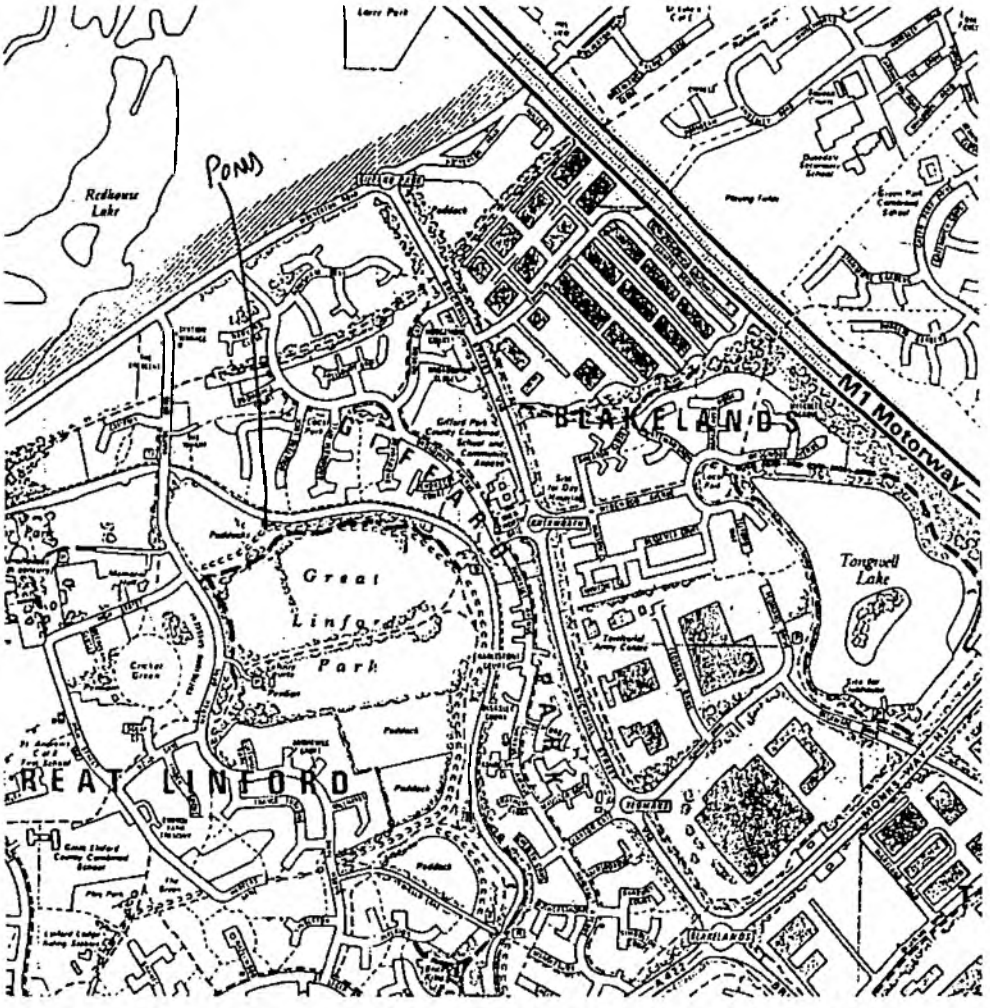
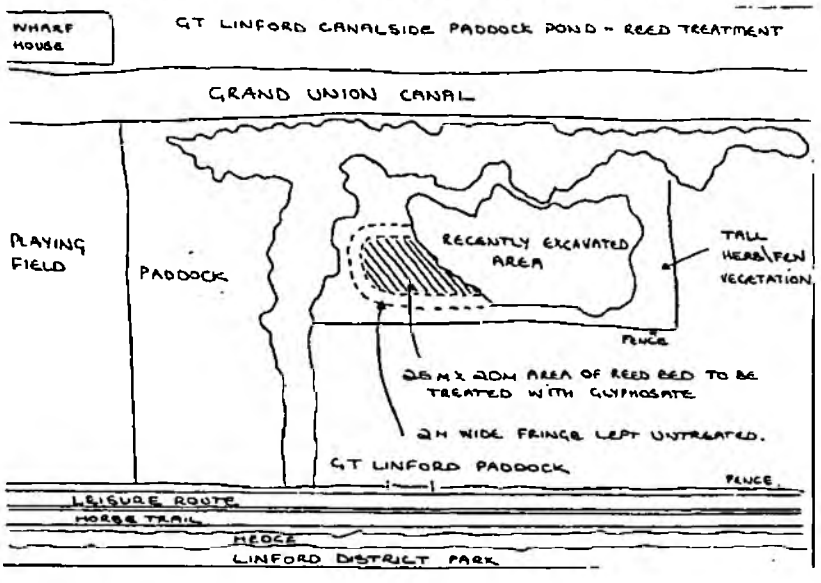
Figure 5.2

Ordnance Survey map showing the location of a pond which is to be treated, and sketch map showing details of the pond and land use around the pond





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OS map reference

Two OS map references are needed, one for each end of the area to be treated. For example, two points on a river between which treatment is intended. If the area is very small such as a pond, one grid reference will be sufficient and should be entered in both boxes.

To obtain a grid reference you need a map showing the waterbody where treatment is intended. Figure 5.3 shows the National Grid. The UK is divided into 100 km squares, each of which is identified by two letters. The two letters of the 100 km square in which the site is located form the first two characters of the grid reference. The rest of the grid reference is composed of eight numbers which identify the exact point.

Figure 5.4 shows a photographically enlarged extract from a map. The letters of the National Grid in which this map is located is shown in the top right hand corner, that is, TL. Each gridline is labelled with two numbers and the distance between two gridlines represents 1 km. A grid in the centre has been further subdivided into 100 squares, each square having a length of 100m. Points A and B on the River Ouse are contained within this grid. To obtain a grid reference for point A, first the position in the west-east direction is read. Point A is between gridlines 30 and 31. Therefore the grid reference begins TL 30... The next number is obtained by locating point A between the 100 m subdivisions. It is located between the 8th and 9th subdivision, hence the next number is 8: TL 308.... If the distance between 308 and 309 is further subdivided into 10 equal distances, point A is approximately 4/10 away from line 308, and the west-east component of the grid reference becomes TL 3084... The other four numbers in the grid reference are concerned with the south-north direction and can be obtained in exactly the same way using the south-north divisions: Point A is located between grid lines 71 and 72 (TL 308471...), between the 5th and 6th of the 100 m subdivisions (TL3084715...) and about 3/10 above the 5th 100m subdivision, giving the grid reference TL 30847153.

Similarly, point B has the grid reference TL 30177163. If the section of the river between points A and B is to be treated, then those two grid references would be entered in the application form.

Figure 5.3
National Grid

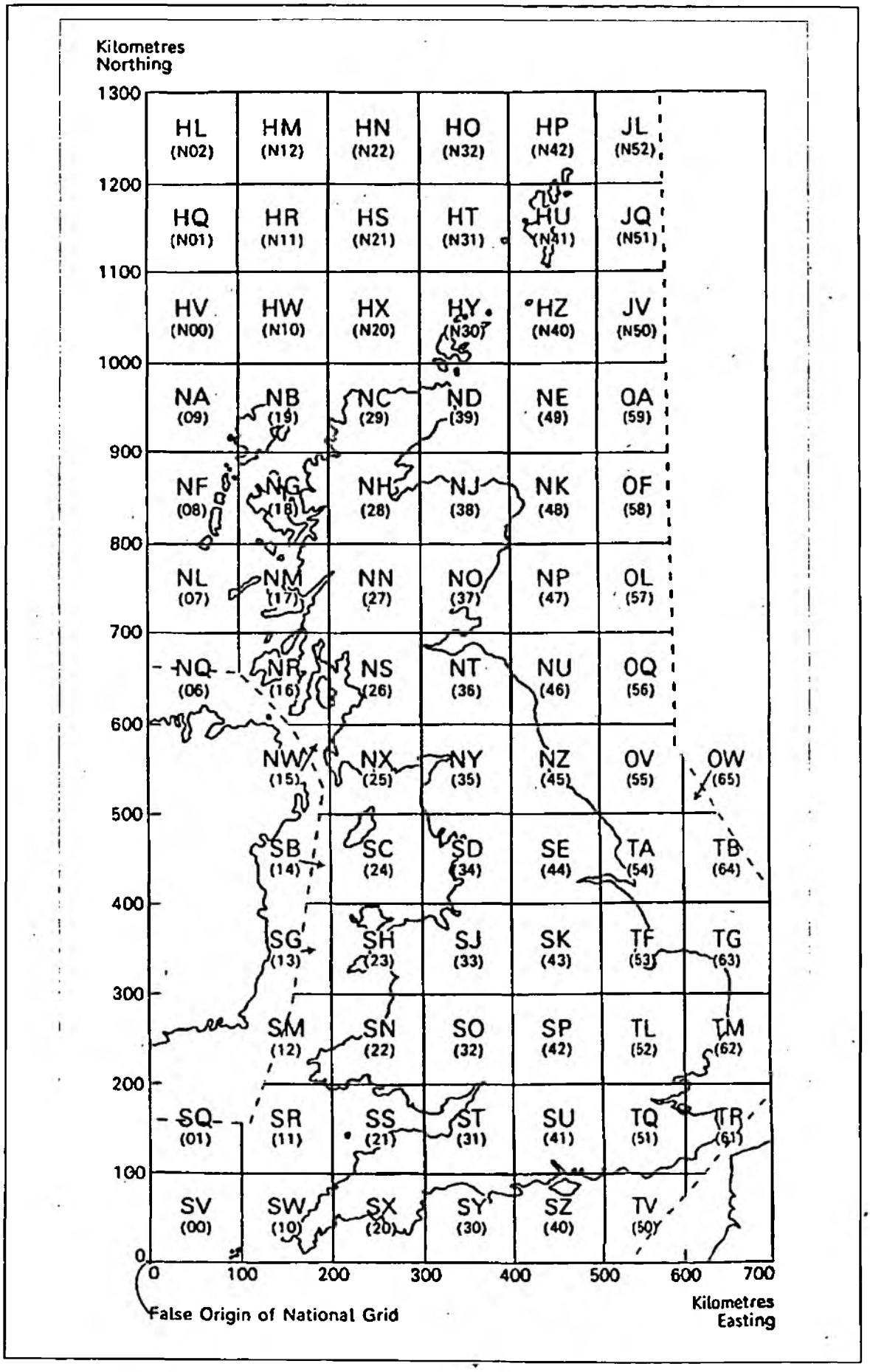
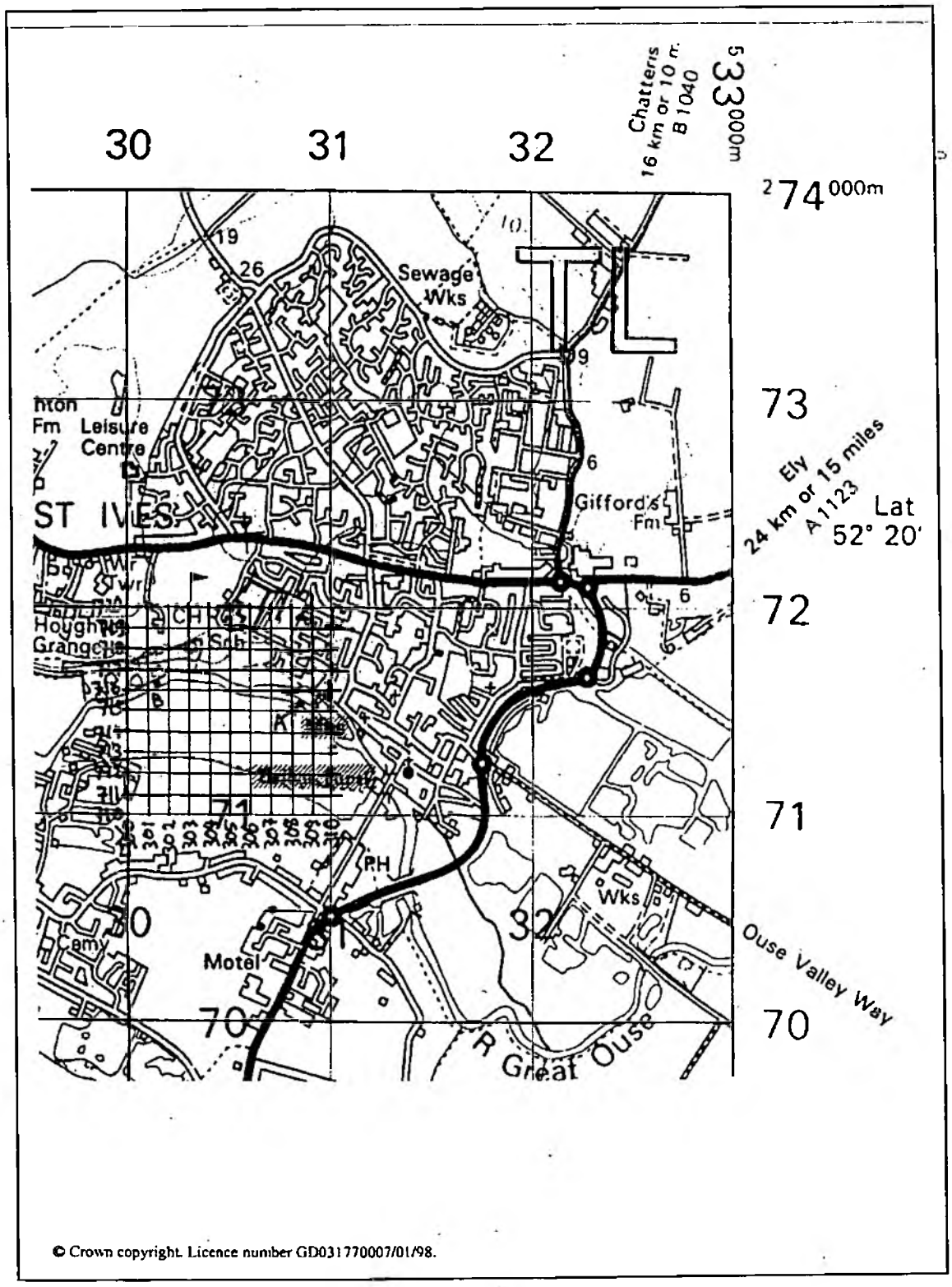


Figure 5.4

Part of a 1:50,000 Ordnance Survey map showing how to subdivide a square to obtain a grid reference for points A and B (see guidance notes)



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Previous herbicide use	Answer yes or no to this question. If the site was approved for herbicide use previously, state the date.
Reason for weed control	Please tick the appropriate boxes. If there are any other reasons than those listed above the boxes, write them into the other box. Please provide information on alternative methods that have been considered and why they are not being used.
Weeds to be controlled	Please list submerged, floating, emergent and bankside species and their percent cover in the appropriate boxes. If any other plants are present (which are not to be controlled), list them in the other box. If you are not sure what the plants are, please send a specimen in a dry plastic bag. Only a small specimen is needed for identification. Do not post specimens on a Friday as they may not keep over the weekend.
Are fish present?	Answer yes or no and list the species.
Conservation status	Answer yes or no and specify the conservation status.
Downstream water bodies	List any downstream water bodies and their uses.
Proposed herbicide	List the product name and the active ingredient. The name of the active ingredient can be found on the product label. List the amount of product (kg or litres) which is to be used and the corresponding amount of active ingredient (g). The methodology for calculating these is given below for both liquid and solid herbicide formulations. Name the proposed method of application.

The information needed to calculate the amount of product needed and the corresponding amount of active ingredient can be found on the product label. Instructions for dilution can also be found on the product label.

For example, the active ingredient in Roundup Pro Biactive is glyphosate. It is a liquid formulation containing glyphosate at a concentration of 360 g/litre. It is recommended to use

5 litres/ha for emergent weeds and 6 litres/ha for floating weeds. Given that 1ha = 10000m^2, the calculations are shown in the following two tables for different-sized areas:

Emergent weeds: 5 litres/ha

Area (m2)	Amount of Product	Amount of Active Ingredient
10000 (1ha)	5 l	360g/l x 5 l = 1800 g
6000	5 l x (6000/10000) = 3 l	360g/l x 3 l = 1080 g
1000	5 l x (1000/10000) = 0.5 l	360g/l x 0.5 l = 180 g
50	5 l x (50/10000) = 0.025 l	360g/l x 0.025 l = 9 g
35000 (3.5ha)	5l x (35000/10000)=17.5 l	360 g/l x 17.5 l = 7560 g

Floating weeds: 6 litres/ha

Area (m2)	Amount of Product	Amount of Active Ingredient
10000 (1ha)	6 l	360g/l x 6 l = 2160 g
6000	6 l x (6000/10000) = 3.6 l	360g/l x 3.6 l = 1296 g
1000	6 l x (1000/10000) = 0.6 l	360g/l x 0.6 l = 216 g
50	6 l x (50/10000) = 0.03 l	360g/l x 0.03 l = 10.8 g
35000 (3.5ha)	6l x (35000/10000) = 21 l	360 g/l x 21 l = 7560 g

Roundup Biactive Dry is a solid and it is recommended to use 5 kg/ha for aquatic weeds. The concentration of the active ingredient glyphosate in the formulation is 41.5% w/w. The calculations are shown in the following table:

Solid formulation: Roundup Biactive Dry: 5 kg/ha

Area (m2)	Amount of Product	Amount of Active Ingredient
10000 (1ha)	5 kg	5 kg x (41.5%/100) = 2.075 kg = 2075 g
6000	5 kg x (6000/10000) = 3 kg	3kg x (41.5%/100) = 1.245 kg = 1245 g
1000	5 kg x (1000/10000) = 0.5 kg	0.5 kg x (41.5%/100) = 0.2075 kg = 207.5 g
50	5 kg x (50/10000) = 0.025 kg	0.025 kg x (41.5%/100) = 0.0104 kg = 10.4 g
35000 (3.5ha)	5kg x (35000/10000)=17.5 kg	17.5 kg x (41.5%/100) = 7.264 kg = 7264 g

Nature of water body

Tick the appropriate box for the nature of the water body, give the total area of the water body in hectares (1ha = 10,000m^2) and the average depth in metres. If the area to be treated is different from the area of the whole water body, give the area and depth of the section to be treated in the next two boxes.

Water speed

Tick the appropriate box on how fast the water is flowing. Give information on how many inflows and outflows are present and whether the outflows can be controlled in such a way that water containing herbicide cannot enter the outflow.

Details of spray operator	Enter the name of the spray operator, NPTC certificate number and category in the spaces provided. Please provide a photocopy of the NPTC certificate for the first notification. It will not be necessary to send a further photocopy for subsequent applications unless the details change.

Please provide a photocopy of the COSSH assessment with this application and sign the application in the appropriate place. The completed form should be returned to the address shown

at the bottom. Make sure that you have enclosed the following as needed:

- site plan showing water body and neighbouring land use
- cross-section of the water body
- photocopy of the NPTC certificate
- photocopy of the COSSH assessment

5.9.3 Standard form and letters for aquatic herbicide notifications

The following pages include:

- Form H1 – Notification of proposals for the use of herbicides in or near water;
- Standard letter for application of herbicides in or near water (excluding aerial applications);
- Form H2 – Circulation list for applications
- Internal consultation procedure
- Standard letter of agreement for use of herbicides in or near water (excluding aerial applications)
- Standard letter of objection for the use of herbicides in or near water (excluding aerial applications).

FORM: H1

ENVIRONMENT AGENCY

Region	

NOTIFICATION OF PROPOSALS FOR THE USE OF HERBICIDES IN OR NEAR WATER
(excluding aerial application of herbicides)

IMPORTANT - Please read the attached notes before completing this form.

Date of Application:		Proposed date of treatment:	

Name of Applicant:		
Address of Applicant:		
Telephone:	Fax:	E-mail:

Name of Owner:		
Address of Owner:		
Telephone:	Fax:	E-mail

Name of Manager/Site Contact:		
Address of Manager/Site Contact:		
Telephone:	Fax:	E-mail:

Location/Name of Site (please attach a map or site plan on pp. 4 - show inlet(s) / outlet(s))			
OS Map ref. from:		OS Map ref. to:	
Was the site approved for herbicide use previously?		**If yes, please specify date:**	

Reason for weed control				
Flood Defence	Angling	Leisure	Bracken Control	Other - please specify

What alternative methods of weed control have been considered (e.g. manual methods, barley straw)? Why was the alternative method not used?

Weeds to be controlled - species and % cover (*see footnote)			
Submerged	Floating	Emergent	Bankside
Identity of other plants present			

Are fish present?	YES / NO	**Species if known:**	

Does the site have conservation status?	YES / NO	**If yes, please specify**	

Downstream water bodies and their uses if known:	

Proposed herbicide			
Product		Active Ingredient:	
Amount of product (kg or litres)		Amount of active ingredient (g)	
Proposed method of application:			

Nature of the waterbody					
River	Canal	Pond	Lake	Enclosed Lake	Reservoir
Total area of waterbody / watercourse / bankside (hectares)				Average depth of waterbody (metres)	
Area of section to be treated if different to above				Average depth of waterbody (metres)	

How fast is the water flowing?					
Standing	Minimal	Slow	Moderate	Fast	Rapid
Number of inflow(s) present		Number of outflow(s) present		Can the outflow(s) be controlled?	

Name of spray operator	
NPTC Certificate number (please provide a photocopy for the first notification - not necessary for subsequent applications unless details change)	
NPTC category	

Any other information that you consider relevant	

Please enclose a photocopy of the COSSH assessment with this application.

Signature of Applicant	

Please return completed form to:
Title:
Address:

Tel no:
Fax no:
E-mail:

* if identity is unknown specimens may be submitted to the Environment Agency for identification. Please send specimens in a dry plastic bag and do **not** post on Friday. Only small specimens are needed.

Office Use

1) Are the proposals considered effective YES/NO
2) Are the proposals likely to prejudice any Environment Agency operations YES/NO
3) Any objections to use YES/NO
4) If yes to (3), reason
5) Informant notified of (3) above:_____Date:_/ /_

Please use this page to draw an outline plan of the area to be treated. The plan should show the waterbody and/or area near water which is to be treated as well as the surrounding land use. It does not need to be to scale and needs only to be a sketch, but should show the main features including inlets and outlets (an example is given in the notes). If a site plan has been provided in a previous application, this page does not need to be filled in.

ENVIRONMENT AGENCY

Our Ref:

Your Ref:

Dear

PROPOSED HERBICIDE APPLICATION IN OR NEAR WATER

Thank you for your enquiry dated , about the use of a herbicide in or near water.

The Agency's agreement is needed before a herbicide is used for this purpose. To help us protect the environment and judge your proposed usage, I would be grateful if you would complete the enclosed notification form, H1, and return it to the Senior Biologist (or designated officer) at the address below.

We will subsequently inform you of our decision in writing.

I would like to take this opportunity to draw your attention to your responsibilities under the Food and Environment Protection Act 1985 (Control of Pesticides Regulations 1986). The main ones are summarised in the notes attached to the notification form.

Yours sincerely

For telephone enquiries please contact –

The Environment Agency

Form H2 – Circulation list for applications

CIRCULATION LIST:		
FROM	Designated officer	DATE
		LOCATION
TO:	Environmental Protection Officer	
	Water Resources Officer	
	Fisheries Officer	
	Ecologist (Conservation)	
	Ecologist (Biology)	
	Flood Defence Officer	
For comment		
Please enter your comments and return by:		

RETURN SLIP

RESPONSE TO NOTIFICATION FORM H1 - Number:

From: Designated Officer

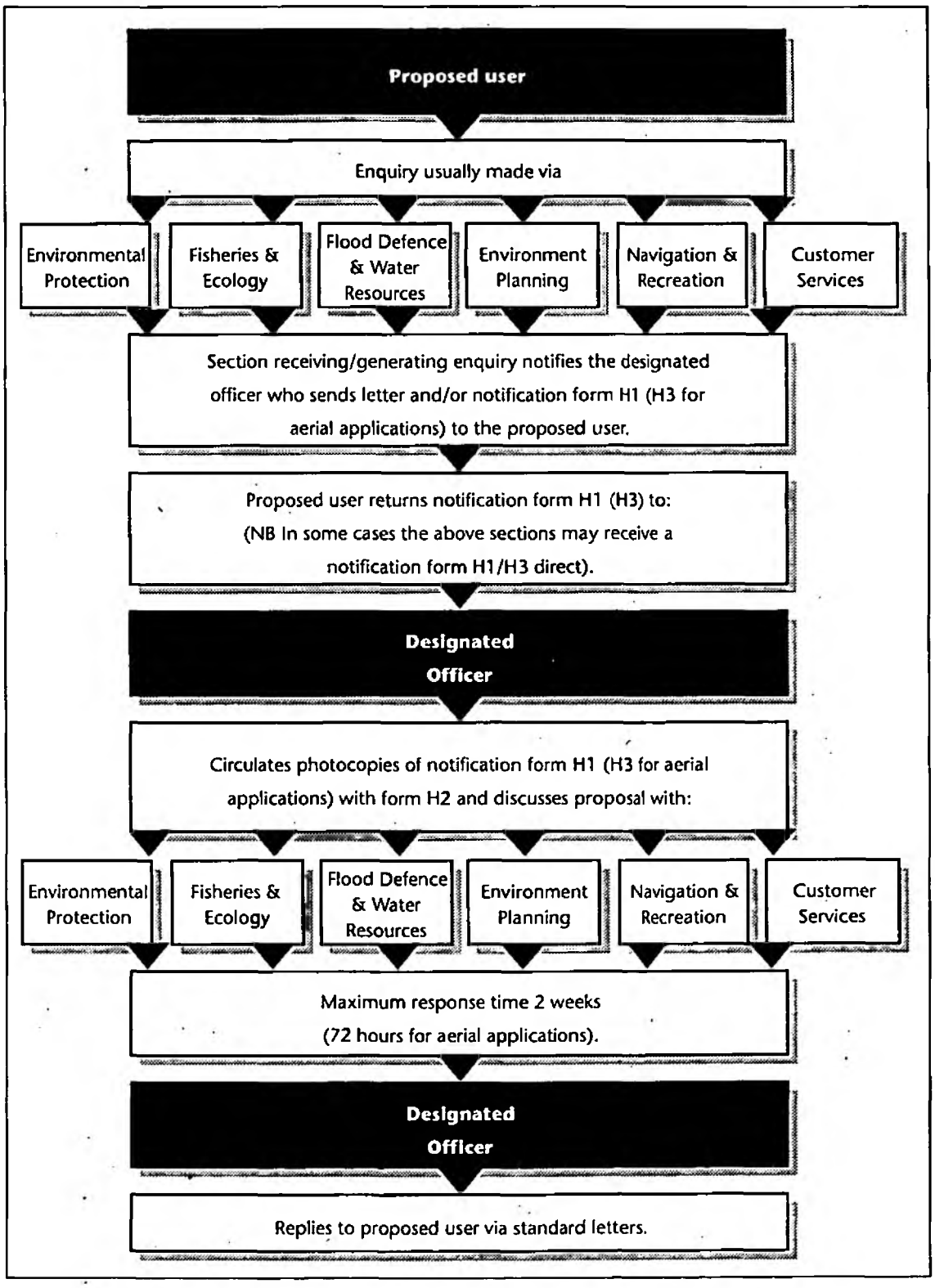
To:

Proposed herbicide application site:

Comments:

External/internal enquiries from outside bodies regarding the use of herbicides in or near water

Internal consultation procedure



ENVIRONMENT AGENCY

Our Ref:

Your Ref:

Dear

PROPOSED USE OF THE HERBICIDE AT

Thank you for your notification form H1 dated concerning your proposal to use the herbicide " " to treat in

The Agency has no objection to you proceeding with the application provided that:

1) the application proceeds as notified on form H1;

2) the manufacturer's instructions and the Control of Pesticide Regulations 1986 are complied with;

3) spraying is carried out in the correct conditions.

It is the responsibility of the user to inform the Environment Agency when the operation has been completed.

Thank you for your co-operation with this matter.

Yours sincerely

For telephone enquiries please contact –

The Environment Agency

ENVIRONMENT AGENCY

Our Ref:

Your Ref:

Dear

PROPOSED USE OF THE HERBICIDE AT

Thank you for your notification form H1 dated concerning your proposal to use the herbicide " " to treat in . I regret to inform you that the Agency is unable to give approval for this herbicide application for the following reason(s):

Yours sincerely

For telephone enquiries please contact –

The Environment Agency

5.9.4) Guidance notes for aerial spraying with asulam (Asulox) to control bracken for Agency staff

The purpose of this section is to provide *internal guidance* to Agency staff on the control of bracken with asulam and ensure that waters are of sustainable quality for potable supply. It provides information on the need for control, the legal responsibilities of the Agency and users, the use of buffer zones, and the use of Asulox to control bankside vegetation. This document may also be provided to an external audience upon request.

5.9.4.1) Background

Bracken *Pteridium aquilinum* is a native plant found in most areas of Britain. It provides a rich habitat for many native species including butterflies, birds, plants and other insects. However, due to its invasive nature it has become problematic in some areas and needs to be controlled. It has an economic impact on the value of grazing land or heather moorland that it has overgrown and is potentially harmful to man, carrying ticks which may result in infections such as Lyme Disease. Bracken plants are also known to contain carcinogens and their spores have been shown to be tumour inducing.

A common method of controlling bracken is to apply Asulox* by aerial spraying. However, this practice has potential water pollution and conservation implications. These notes provide guidance to Agency staff on their responsibilities in this area.

5.9.4.2) Legal responsibilities of the Agency and users

The Control of Pesticides (Amendments) Regulations COP(A)R 1997 require **consultation** with the appropriate area office of the Agency not less than 72 hours before undertaking aerial application of pesticides if the land to be treated is adjacent to or within 250 metres of water.

In considering applications the Agency has the following legal responsibilities:

i) **The Water Supply (Water Quality) Regulations 1989 (and EU Drinking Water Directive).** The Agency has a responsibility to protect water abstracted for drinking supply from contamination. The regulatory limit for pesticides in drinking water set by the Water Supply (Water Quality) Regulations 1989 (and EU Drinking Water Directive) is 0.1µg/litre (1 part in 10 billion). Although for asulam this limit is very much lower than levels which could have health implications, the regulations require that this limit is not exceeded in any sample of water supplied to customers' taps. Pesticides are not removed by conventional water treatment processes and if they are found in supplies, specialised treatment with high capital and running costs has to be installed to remove them.

ii) **The Environment Act 1995 s. 7-(1)(b).** It is the duty of the Agency to consider – "any proposals relating to pollution control functions of the Agency, to have regard to the desirability of conserving and enhancement of natural beauty and conserving flora, fauna and geological or physiological features of special interest;". Consideration should be given to the environmental benefit of the area being sprayed and whether there are any conservation implications.

iii) **Water Resources Act 1991 s. 85 -(1)** A person contravenes this section if he causes or knowingly permits any poisonous, noxious or polluting matter or any solid waste matter to enter any controlled waters.

**the product Asulox contains the active ingredient asulam.*

iv) **Salmon and Freshwater Fisheries Act 1975 s. 4-(1).** This provides for the offence of causing or knowingly permitting – "to be put into any waters containing fish or into any tributaries of water containing fish, any liquid or solid matter to such an extent as to cause the waters to be poisonous or injurious to fish or the spawning grounds, spawn or food of fish, shall be guilty of an offence". In this case, consideration should be given to soil erosion problems that may result from the control of bracken and its potential for pollution of sensitive spawning grounds, particularly those for salmonids.

Agreement with aerial spraying should only be given where it is believed there is minimal or no risk of contamination by asulam to public or private water supplies at greater than 0.1μg/l or if conservation implications are not an issue. It should be expected that some areas in drinking water reservoir catchments, where agreement would previously have been given, will no longer receive agreement. The above legislation applies irrespective of whether the user is applying for a MAFF grant or not.

If spraying is carried out without consulting the Agency, the Health and Safety Executive will be informed and a prosecution could follow under the Food and Environment Protection Act 1985. The Agency can also prosecute under the Water Resources Act 1991 if pollution has occurred, for example, if a public water supply is polluted by asulam, or under the Environment Act 1995 if there has been a conservation impact, for example, damage to rare or protected species.

Users of Asulox should be reminded of their obligation to comply with all relevant legislation. Although the legal requirement for consultation with the Agency is a minimum of 72 hours, it would be very helpful if initial application could be made much earlier as part of a long-term bracken control programme. This early application could indicate general areas where spraying might be considered, with a more precise location given nearer the date. This would enable proper consideration of any application, with adequate time for consultation where necessary with water abstractors/Plc's and other interested parties. Where possible long-term bracken control plans (for example, five to 10 years) should be discussed in advance with land owners to identify potential pollution risk areas.

In addition to Agency consultation it is necessary for any applicant to consult the appropriate nature conservation agency (English Nature or the Countryside Council for Wales) where a local nature reserve, a Marine Nature Reserve, a National Nature Reserve or an SSSI, lies within 1500 metres of the land that is being treated. Agency staff should also liaise with the appropriate conservation body where there are conservation implications other than designated areas. For instance, asulam can harm other vegetation such as ferns, and bracken supports insects which may be rare and protected under the Wildlife and Countryside Act 1981, such as the high brown fritillary butterfly.

There are other legal notification requirements that aerial spray operators must follow and this information can be obtained from the advisory leaflet on the Aerial Spraying of Pesticides – Consultation and Notification available from the Pesticides Safety Directorate (PSD).

5.9.4.3) Use of buffer zones to protect the environment

In practice, aerial spraying on moorlands, uplands and heathlands is likely to result in the spray entering a watercourse from drift. Many small streams and rivulets run across these areas and hence feed drinking water catchments. The risk of contamination of drinking water sources can therefore be high. In the case of bracken, spraying must be done in accordance with the best practice laid out in the Bracken Management Handbook, produced by Rhône Poulenc who manufacture Asulox, with the exception of the buffer zones given on page 35. Agency buffer zones will be used in their place. These buffer zones have been agreed by the Agency and with the product manufacturer to protect water supplies, and are illustrated in Section 5.3.2. Buffer zones should be applied where there are concerns over water supply contamination. In practice this will generally mean recommending the use of buffer zones adjacent to water supply sources or *significant* feeder streams i.e. where there may be insufficient dilution to meet the 0.1μg/l drinking water standard. However, recognising the genuine need to control bracken, agreement may be given to spraying within normal buffer widths if the proportion of the total catchment is small and

available dilution would provide adequate protection for the water source.

In areas where buffer zones are applied, non-chemical and traditional mechanical methods may provide a viable alternative to pesticides, provided that these can be carried out in such a way as to ensure protection of drinking water supplies and the environment.

Bracken can form dense stands with no underlying turf. In such cases bare soil would be left after spraying and it is important that consideration is given to an aftercare management plan to restore ground cover and so prevent erosion. In some cases spraying may not be appropriate. Erosion has consequences for both the environment and drinking water treatment.

5.9.4.4) Use of Asulox to control weeds near water

Asulox is approved for both aerial application and for use near water to control bracken. Under COP(A)R 1997 the consent of the Agency must be obtained before a pesticide is to be applied for the purpose of controlling aquatic weeds or weeds on the banks of watercourses or lakes. This statement is now included in the statutory box on product labels. Requests for Agency consent to control weeds near water enable Agency staff to make an environmental assessment of the proposed treatment, including the potential of spray entering a watercourse.

Because of the nature of the terrain in upland, moorland and heathland areas with steep slopes adjacent to watercourses, as a default, the "banks" would be considered to be the area within the buffer zones distances specified in section 5.3.2. For aerial application with conventional nozzles the bank is the area within 160 metres from the watercourse. **In practice, the aerial spraying of Asulox to control bracken "near water" should not be permitted unless water supplies are not at risk, rare ferns or other sensitive plants are absent and soil erosion is not an issue.**

Further guidance on Agency staff's responsibility for consenting to the control of weeds in or near water is provided in the Agency document, The Use of Herbicides to Control Weeds in or Near Water.

5.9.4.5) Conclusion

These guidance notes have provided advice to Agency staff on their responsibilities in respect to the aerial spraying of Asulox to control bracken. The notification form H3 (Figure 5.11) for the aerial application of herbicides including Asulox is included for information along with the standard letters for application, agreement and objection (Figures 5.12, 5.13 and 5.14). Further advice on this issue may be obtained from the Pesticides Section, EHS National Centre

5.9.5) Standard notification form and letters for aerial application of herbicides

The following pages include:

- Form H3 – Standard notification form and letter for aerial applications of herbicides in or near water
- Standard letter for aerial applications of herbicides
- Standard letter of agreement for aerial applications of herbicides
- Standard letter objection for aerial application of herbicides

FORM: H3

ENVIRONMENT AGENCY

Region		
Address		
Tel:	Fax:	E-mail:

CONTROL OF PESTICIDES REGULATIONS 1986 (as amended)
(Schedule 4, Paragraphs 2(b) & (c))

AERIAL APPLICATION OF HERBICIDES

In the event of aerial application if land to be treated is adjacent to or within 250 metres of water, Environment Agency consent is required. Under the above legislation you are required to notify the Agency not less than 72 hours before commencement of aerial application.

This form is to assist you in complying with the above requirements and to provide a record that the regulations have been followed.

Name and address of company		
Tel:	Fax:	E-mail:

Name and address of company		
Tel:	Fax:	E-mail:

Name and address of land owner	

Location to be treated (OS map grid ref(s) and sufficient information for the area to be identified). Submit a marked site plan.	

Approx date(s) of treatment	

Is it for the control of : a) bracken b) other (give details)	

Name of pesticide to be applied	

State dose rate and total amount to be used	

Have the following been contacted: Local EHO for private abstractions/well supplies	
English Nature or Countryside Council for Wales, contacted for conservation implications	

ENVIRONMENT AGENCY

Our Ref:

Your Ref:

Dear

AERIAL APPLICATION OF

With reference to your letter of the Environment Agency has the following general comments and requirements to make on the aerial application of any pesticides:

a) The user should abide by the conditions of Schedule 4 of the Control of Pesticides Regulations 1986 and the conditions in the Civil Aviation Authority's booklet CAP 414 *Information on Requirements to be met by Applicants and Holders of the Aerial Application Certificate.*

b) The Agency should be notified in writing as early as possible, ideally at least three weeks, and legally not less than 72 hours before the commencement of the aerial spraying programme. This notification should include the submission of a map which clearly identifies the proposed areas of spraying and possible helicopter landing sites, plus a completed form, H3 (enclosed).

c) It is the responsibility of the user to ensure that interests such as water abstraction for public supply and livestock, crop irrigation and fisheries are not adversely affected. Because of the large number of reservoirs and abstractions within the area, full details of the former cannot be given at this time. However once you have provided us with the details required in a) above, we will be able to send you details of any water abstractions registered with the

Agency within and close to the affected areas. An early notification helps the Agency to provide you with information in time to take measures to safeguard the environment.

Please note that many small private drinking water supplies are not licensed by us, but are regulated by the local environmental health officer, who can provide you with details of these in order that you can avoid contaminating any such sources.

d) The Agency's consent is required if it is intended to apply the pesticide to control aquatic weeds or weeds on the banks of watercourses and lakes. The only herbicide which is cleared for both aerial application and use near water is asulam. Clearance for the aerial application of asulam is given for the control of bracken in grassland. During the application the spray may enter a watercourse and thus the prior agreement of the Agency must be obtained before application.

For telephone enquiries please contact –

The Environment Agency

/Contd.....

e) As a general rule, helicopter landing sites should *not* be located at:

It is expected that there will be liaison between landowners/agents/contractors regarding the fulfilment of the above requirements.

We will subsequently inform you of our decision regarding your application in writing.

Yours sincerely

For telephone enquiries please contact –

The Environment Agency

ENVIRONMENT AGENCY

Our Ref:

Your Ref:

Dear

AERIAL APPLICATION OF ON

Thank you for your letter dated and enclosed map and form.

The Agency has no objection to aerial spraying in the areas proposed provided the following conditions are adhered to.

The manufacturer's recommendations should be strictly followed. In order to minimise the risks, spraying should be avoided when rain is expected, during windy periods (ref. Schedule 4, Control of Pesticides Regulations 1986) and when the soil is saturated. If these conditions are avoided much greater absorption by the bracken and soil will occur. Watercourses, lie within the proposed treatment areas. These watercourses contain sensitive invertebrate animal life, and great care should be taken to avoid spray drift/run off into these waters.

In the case of bracken, spraying must be done in accordance with the best practice laid out in the BRACKEN MANAGEMENT HANDBOOK (copy enclosed / previously supplied[†]), produced by Rhône Poulenc who manufacture Asulox, with the exception of the buffer zones given on page 35. Agency buffer zones will be used in their place. *Particular attention must be given to the aftercare of treated areas where the cover of bracken is dense with little or no underlying vegetation to replace it.* Failure to do this will lead to bare areas of land being exposed to erosion once the bracken litter has disappeared from the treated areas, allowing soil and associated debris to be washed into nearby watercourses. Any person allowing such circumstances to occur through bad management practices may well be contravening Section 85 of the Water Resources Act 1991 and as such be subjected to prosecution by the Agency.

It is the responsibility of the person spraying to notify and consult with any downstream water user and to avoid contaminating water abstraction sources.

*The following abstractions are registered with the Agency in this area:/There are no licensed abstractions within 500 m of the proposed treatment area. There are almost certainly unlicensed spring abstractions within the affected areas, of which we have no record. Your local environmental health office <name and number> should have details of these.

For telephone enquiries please contact –

The Environment Agency

contd/...

† In order to protect public water supplies the Agency considers it necessary to impose a buffer zone of < m> around . (Other restrictions may be added if necessary.)

Helicopters should be washed off on waste ground at least 10 metres from a watercourse. The spray tanks should be filled with clean water and the contents sprayed within the treated area; they should not be emptied onto land.

Follow the conditions in the Civil Aviation Authority booklet CAP 414 *Information on requirements to be met by Applicants and Holders of the Aerial Application Certificate* at all times.

The Agency must be notified, immediately in the event of any accidental spillage of chemical, by means of the telephone number given below (24-hour emergency number).

Subject to these conditions being met, the Agency has no objection to bracken spraying being carried out this year in the areas proposed. The Agency maintains the right to take water samples before, during and after spraying, and may take proceedings under the relevant legislation if a pollution occurs as a result of spraying.

It is the responsibility of the user to inform the Agency when the operation has been completed.

Yours sincerely

For telephone enquiries please contact –

* use whichever is appropriate

† delete as appropriate

For telephone enquiries please contact –

The Environment Agency

ENVIRONMENT AGENCY

Our Ref:

Your Ref:

Dear

AERIAL APPLICATION OF AT

Thank you for your notification form H3 dated concerning your proposal to aerially apply the herbicide at . I regret to inform you that the Agency is unable to give approval for this herbicide application for the following reason(s):

Yours sincerely

For telephone enquiries please contact –

For telephone enquiries please contact –

The Environment Agency

6

Users code of practice

6) Users code of practice

6.1) Introduction

The application of herbicides is one method of weed control used in the water environment. Herbicides must always be used with care and according to the guidelines.

It is essential that all employees who may use or come into contact with herbicides are given sufficient training and instruction to ensure that they do not endanger themselves, other employees, the public or the environment.

All supervisory staff must be aware of the legislation governing pesticides and must comply with and implement this code of practice. Any safe working procedures and local safe systems of work should be read in association with this code of practice.

If there are any difficulties or queries about implementing the code, the Agency Safety Adviser should be contacted to resolve the problem and give appropriate advice.

6.2) Potential hazards associated with pesticides

The herbicides the Agency uses are of low toxicity to humans and aquatic life, and provided precautions are taken will not harm operators or persons nearby. However, the following are some of the hazards associated with pesticides and care should be taken at all times.

a) Poisoning of humans by inhalation, ingestion or absorbtion of chemical.

b) Damage to eyes.

c) Poisoning of domestic animals or wildlife.

d) Production of toxic fumes and compounds if involved in fire.

e) Contamination of water supplies and environmental pollution.

6.3) Storage and transportation of pesticides

6.3.1) Main stores

Stocks of pesticides should be kept to the minimum needed to meet foreseeable operational requirements for the season. The store must be under the direct control of a nominated person. Certificates of Competence for storekeepers are issued by BASIS (the independent registration scheme for the pesticide industry recognised under the Control of Pesticide Regulations 1986) and are required by all Agency personnel responsible for pesticide stores. The storekeeper should also be issued with a copy of this guide and other relevant documents.

Appropriate security precautions must be taken and access to the store must be restricted to authorised personnel only.

All Agency pesticide stores must be inspected by pollution control staff to ensure adequate pollution prevention measures are in place. The stores should comply with CS19 – Storage of Approved Pesticides by farmers and other users. Further specialist advice may be obtained from the fire, crime and pollution control officers of the appropriate authorities.

The location and structure of main stores should be chosen to provide maximum safety in the event of spillage or fire. It should be a frost-proof building with ample working space, headroom, lighting, ventilation and access, with level and dry floors. There should be no water pipes or drains in the storage area and any spillage must not be able to escape from the building.

The doors giving access to stores must be marked with warning signs (black exclamation mark in yellow triangle) at a height of about 1.7 metres from the ground and bins or cabinets used for herbicide/pesticide storage should carry similar signs.

Washing facilities should be available near, but not in, each store for the use of store personnel and proper arrangements must be made for accommodation of protective and personal clothing.

Smoking and eating or drinking in the storage area or its vicinity is forbidden.

Pesticides should be stored in their original containers or clearly marked suitable substitutes, which carry the manufacturer's full safety warnings.

Detailed information on storage of pesticides is provided in HSE Guidance Note CS19: Storage of Approved Pesticides – Guidance for Farmers and other Professional Users[30].

6.3.2) Product Segregation

Within the store, products should be grouped by type, for example, herbicides, insecticides, fungicides, rodenticides, etc. with separate stocks for liquids and solids. Granules and powders should not be stored below liquids. Readily combustible chemical materials should be kept segregated in a safe place.

6.3.3) Stacking

Stacks should be arranged, with labels visible, to allow easy access for:

i) issuing on a "first in – first out" basis;

ii) stack inspection;

iii) fire fighting;

iv) cleaning and spillage removal.

All containers and packages should be stored off the floor. Careful attention should be given to the pattern and height of stacking so as to achieve stability and avoid damage to containers.

A high standard of housekeeping must be maintained in the store at all times.

All issues and receipts of herbicides are the responsibility of the storekeeper and must be recorded in a storage stock register maintained and held separate to the store building.

6.3.4) Local sub-stores

Quantities of approved products may be issued to a sub-store for local use. Such issues should be restricted to a single container of each chemical whenever possible.

Local storage conditions must comply as far as reasonably practicable with conditions set out for Main Stores. Proprietary storage bins form useful local stores.

Several types of small self-contained prefabricated steel stores with integral spill-tank are available, such as "Chem Safe" from Cleveland Sitesafe Ltd and the "Chemvault" from Portasilo Ltd.

6.3.5) Fire precautions in stores

The advice of the local fire prevention officer must be sought about all main stores and the fire brigade must be informed that the store contains pesticides.

A fire and spillage emergency procedure must be produced, displayed prominently and regularly practised. A list of materials stored should be kept off site.

Fire extinguishers of adequate capacity must be readily available. Use of water for fire fighting can cause a risk of pollution and therefore extinguishers containing water must not be used on fires involving pesticides. Ideally there should be an automatic fire alarm fitted in each main store if significant quantities of potentially hazardous chemicals are held.

Combustible material, for example, packing, paper, wood and empty sacks, must not be allowed to accumulate in the store and proper arrangements should be made for the safe storage and disposal of empty containers.

6.3.6) Safety equipment

The following items of equipment should be available at the store in case of any spillages:

- Rubber boots
- Rubber or PVC gloves
- PVC trousers, jackets or suits
- Goggles (gas resistant)
- Suitable respirators (full face or ori-nasal)
- Supply of dry sand, soil or oil absorbent
- Shovel
- Brush
- Plastic bags
- Eye irrigation facilities

Proper storage and maintenance facilities must be provided for protective clothing and equipment.

6.3.7) Transportation

Bulk quantities of herbicides should not be carried in Agency vehicles unless special ar-

rangements are made. When transporting herbicides, they should always be carried in a locked, water-tight container and must be physically separated from the driver compartment.

Transport should be limited to the transfer of quantities required by local sub-stores or for use in the working day. The drivers must be aware of the nature of the materials, relevant safety procedures and how to obtain assistance in an emergency. Written emergency information on the material being transported must be carried in a prominent, readily accessible place in the vehicle.

6.4) Personnel training and instruction requirements

All persons involved in the storage, handling and application of herbicides should be instructed and trained in how to carry out their duties safely and correctly.

Training requirements must meet the Control of Pesticides Regulations 1986 (COPR) and the Control of Substances Hazardous to Health 1988 (COSHH) Regulations.

To comply with these obligations people will need training that provides information on legislation, hazards and risks posed by pesticides, safe working practices, emergency action, health surveillance and record keeping.

First line supervisors must be fully familiar with the manufacturers' instructions and safe operating procedures for all herbicides and application equipment used by their staff.

Only responsible, competent and certificated employees who have been given adequate instruction in the handling, mixing and application of such materials are permitted to work with herbicides.

6.5) Application equipment and methods

a) Hand application is normally used for spreading granular chemicals over small areas.

b) Mechanical spreading is used for applying granular materials over medium-sized areas,

Application machines can be either hand-powered or engine-driven and safety precautions appropriate to the method of drive must be taken.

With all granular herbicides the inhalation of dust from the chemical must be avoided.

c) Hand-held air-pressurised sprayers are normally used for applying diluted liquid chemicals to very small areas with good accuracy.

d) Back-pack pump sprayers are used for applications of diluted liquid chemicals to fairly small areas. The weight of the tank can cause difficulty to operators on uneven ground.

e) Vehicle-mounted sprayers are normally used for the application of diluted liquid chemicals to large areas.

These machines require specialised training and considerable experience for safe operation. Maintenance requirements are far more complex than other methods.

f) Specialised droplet applicators using undiluted liquids are available from some manufacturers for use with specially formulated materials. These reduce the potential loss or wastage and permit better dose control.

6.6) Personal protective clothing, safety equipment and hygiene requirements

6.6.1) Protective clothing and equipment

This may include:

a) eye protection (full face shield);

b) unlined gloves (gauntlet type – chemical–resistant);

c) disposable coveralls;

d) waterproof jacket and over-trousers;

e) wellington/safety boots;

f) respirator (ori-nasal filter-type with appropriate cartridge);

g) PVC aprons;

h) first aid facilities including eye washing;

i) 5-litre container of fresh tap water for emergency washing;

j) soap;

k) paper towels.

Operators should use protective clothing and equipment issued to them and comply with safe working procedures and instructions that are applicable to the task, taking reasonable practicable steps to ensure their own safety and that of others. Items of personal protection should not be used for purposes other than those for which they are designed and issued.

Items of equipment which are personally issued should be maintained in clean and hygienic conditions.

Breakages or damage to items of protective clothing/equipment which affect their efficiency should be reported immediately to supervisors so that exchanges can be arranged.

6.6.2) Personal hygiene

People handling herbicides should:

a) Always wash hands thoroughly before eating, drinking, smoking and using the toilet.

b) Never smoke whilst handling or applying herbicides or visiting any area where herbicides are being stored or used.

c) Be aware that contamination by herbicides may still occur through protective clothing. If so, operators should stop work, wash and change from the contaminated clothing into clean clothing. Contaminated clothing should be disposed of via a reputable waste contractor.

6.7) Preparation and calibration

a) Check spray equipment

Operators must check that spray equipment is in good working order.

It is a legal requirement to **READ THE PRODUCT LABEL** before use.

b) Dilution

An area should be designated/constructed for filling and washing, so that in the case of a spillage the contaminated area will be isolated. Criteria for the selection of a site must consider possible contamination of groundwater or run-off into surface waters.

Mixing and diluting should be carried out according to the manufacturer's instructions and preferably out of doors. Avoid breathing fumes or dust. If the concentrate is spilled on the skin, wash it off immediately.

Pesticides should not be mixed together unless it is recommended on the product label.

Herbicide sprays which are already in fluid form and need no pre-mixing or diluting are recommended (currently none is available for aquatic use).

The container should be rinsed when empty and the washings added to the spray tank. The empty containers should be made unusable, that is, punctured. See Chapter 7, Disposal.

c) Assessment/estimate of requirements

Only mix the quantity of pesticide required, taking into consideration the area to be sprayed and the weather conditions. If in doubt, it is better to underestimate and to leave a small area untreated. This can be sprayed at the end, when it will be easier to calculate exactly how much more is needed.

d) Select nozzle and calibrate sprayer

In order to apply the correct dose rate the exact output of the equipment must be known. Check the recommended nozzle size with the manufacturer's instructions. The sprayer should be calibrated using water at the beginning of the season and again every two or three months or whenever settings, equipment or personnel are changed.

Output is dependent on:

(i) speed of operator;

(ii) operating pressure;

(ii) size of nozzles.

It is important that the sprayer is calibrated in accordance with manufacturers' instructions.

e) Wear protective clothing

The protective clothing specified for the job should be worn and this should be checked to ensure that all items are in good condition.

6.8) Application

6.8.1) General

The application rate can be found in the manufacturer's instructions. This and any other instructions in the manual or from your supervisor must be strictly followed.

The material should be applied at a steady and continuous rate of application. This requires walking at the speed which achieves the correct application. Frequent checking of equipment to ensure that it is working correctly is necessary.

A steady pumping action should be used to ensure that the calibrated pressure is maintained. The nozzle should be kept at a height which will ensure the correct band width coverage.

It is important to:

i) turn off the spray before carrying out any work on the nozzle;

ii) never blow through the nozzle to try to clear blockages;

iii) keep gloves on when removing nozzles.

6.8.2) Spray drift

To avoid herbicide drifting onto non-target species, application must only be made:

i) When the wind speed is between Force 1 and 3 – check with your supervisor if in doubt. (When there is no wind, thermals cause the spray to drift).

ii) Through suitable and undamaged nozzles.

Do not allow spray to be accidentally directed onto adjacent crops. Equipment, and particularly the spray nozzles, should be selected to give a spray pattern to fit the target. When a herbicide is applied as a granular formulation, an even distribution over the area of water surface to be treated is required.

6.8.3) Checks before operating

Depressurise the sprayer before carrying out maintenance.

6.8.4) Spraying machines

i) Clean the spray tank and lines to ensure there is no contamination from the previous application.

ii) Ensure spray nozzles are clean and not cracked or chipped so that the correct spray pattern is being formed.

iii) Set pressure control to that required. Low pressure is desirable for aquatic situations.

iv) Ensure pump is in good working order.

v) Ensure all nuts are tight.

vi) Ensure all joints are leak-proof.

vii) Clear filter and air vent.

viii) Clean trigger filter and clear nozzle aperture.

6.8.5) Spreaders

i) The hopper should be clean and not contaminated with material from the last application.

ii) Rollers and grids etc., responsible for metering out the correct dosage rate, should be working properly.

iii) If the rate of application is altered by adjustable levers, these should be securely fastened so that they cannot alter their setting due to vibration when the machine is in operation.

6.9) After spraying

i) Ensure any surplus material is placed in a clearly labelled container.

ii) Return all empty containers to the store for safe disposal.

iii) Equipment and containers should be wiped down if necessary with a clean rag or paper towels and placed in correct storage. Used rags or towels should be put in plastic bags, etc. for disposal.

iv) Complete spray records and log sheets.

6.10) Disposal of surplus material and empty containers

It is very important that surplus dilute herbicides and empty containers are correctly disposed of. If this is not done correctly and safely it could cause hazards to people and the environment.

The following should be followed:

a) Good estimation

The best way of avoiding disposal of surplus mix is to accurately estimate the quantity needed to do the job. Underestimate rather than overestimate.

b) Excess

If surplus mix remains it should be disposed of appropriately. It is NOT acceptable to reapply to the treated area in aquatic situations because of the risk of causing a pollution. The Code of Practice for the Safe Use of Pesticides on Farms and Holdings permits disposal of dilute pesticide waste onto an area of non-cropped land of minimal wildlife value. However, this is only acceptable if the land is the property of the applicant or if **written permission** from the landowner has been given. Therefore, in most instances the most appropriate method of disposal is via a reputable waste disposal contractor. Herbicides should NEVER be emptied down drains.

c) Container rinsing

It is essential that containers are emptied and not left with small amounts of material in them. They should be rinsed three times at the time of application and the washings added to the spray tank. Before disposing of any container it must be thoroughly emptied.

d) Empty containers

Empty containers must be kept in a specially designated area of the pesticide store for safety; any part-used containers should be tightly closed and placed back into the store for use at a later date.

e) Container disposal

The Agency policy is to dispose of containers via a reputable waste disposal contractor.

Other methods of disposal of containers, such as burial and incineration, suggested by the Code of Practice for the Safe Use of Pesticides on Farms and Holdings[28], produced by MAFF/HSE are NOT to be used by the Agency.

For further information, see Chapter 7, Disposal.

6.11) Spillages and emergencies

If a spillage occurs, every effort must be made to prevent the material escaping into sewers, watercourses, ponds or land drains. *All personnel must wear appropriate protective clothing and equipment for the circumstances to ensure their safety.*

Spillages of granular or powdered materials must be removed in such a way that dust is not spread or inhaled. If the material has become wet it must be placed in waterproof containers and kept in a well-ventilated place pending safe disposal.

Minor liquid chemical spillages, well away from watercourses, drains, etc., may be dealt with locally by absorbing the material into dry sand, earth, etc. The contaminated absorbent material must then be put into waterproof containers pending appropriate disposal.

Major spillages, or where the chemical has already entered a watercourse or drain, require prompt action and senior supervisory staff must be informed *at once*. These officers will alert the pollution control section and other specialist officers, including the safety officer.

In the event of a major incident the assistance of the emergency services may be necessary. It may also be necessary to inform the Health and Safety Executive.

Some chemicals are non-hazardous alone but, if mixed with other materials, become extremely dangerous. Any spillage involving several types of chemical must therefore be treated as a major spillage and appropriate action must be taken.

In the event of herbicides becoming involved in fire, toxic smoke will be given off and, if immediate use of a fire extinguisher is unsuccessful, the area affected by smoke must be evacuated.

Fire Brigade assistance must always be obtained if a fire of any significant size involves chemicals. *Clear information* on the *location* of the incident and the fact that *herbicides* are involved must be given.

6.12) Appendices

6.12.1) Operators' safety rules if you have to use herbicides:

- Record personal details to satisfy COSHH regulations in record book.
- Always read instructions and handling precautions on labels and in appropriate leaflets; if you do not understand them ask your supervisor.
- Make sure you have the correct protective clothing.
- Keep protective clothing clean (both inside and out) and in good condition.
- Store protective clothing separately from personal clothing so that the latter does not become contaminated.
- Dispose of contaminated protective clothing via a waste disposal contractor.
- Ensure that food, drink and tobacco are not in the vicinity of pesticides.
- Keep all pesticide containers closed when not in use.
- Keep undiluted pesticides in their original labelled container.
- Keep pesticides locked in a safe place, out of reach of children and animals.
- Make sure all equipment including measuring vessels, is kept clean.
- Take care to avoid spillages, particularly of concentrated pesticides. If spillages do occur dispose of safely as instructed. Do not contaminate waterways or ponds.
- If eyes are contaminated with chemical, wash out with plenty of water and seek medical attention.
- Wash all contaminated skin immediately with plenty of soap and water.
- Wash hands and exposed skin thoroughly before eating, drinking, smoking, using the toilet and after work.
- Always dispose of surplus chemicals and containers safely. Do not leave them so that children or animals can be affected by their contents.
- If you become unwell when using or after using herbicides report immediately to your supervisor, rest, and if the symptoms continue go to the doctor, taking the product label or leaflet with you. If a herbicide is swallowed, get medical assistance immediately.
- Never blow or suck nozzles or other parts of equipment to clear obstructions.
- Never eat, drink or smoke whilst handling or applying herbicides or cleaning application equipment or containers.
- Never repair or send for repair any equipment which has not been thoroughly cleaned.
- Never allow untrained persons to handle herbicides unsupervised.
- Never work in spray mist and stop spraying if the wind starts blowing the spray out of the target area.
- Never put herbicides, concentrated or diluted, into containers which normally contain food or drink, for example, beer bottles, cups, jugs, etc. This is probably the most common cause of poisoning with herbicides.
- The precautions which are printed on the herbicide container or on the leaflet which is supplied with the product must always be followed.

If there are no instructions as to use and the precautions to be taken by the operators, the herbicide is *NOT TO BE USED.*

If the instruction leaflet specifies clothing or equipment, this must be obtained before the herbicide is used.

6.12.2) First aid measures

If an incident occurs, check the product label and the COSHH data sheet for emergency information. If in a remote area, it may be necessary to take the casualty for medical assistance immediately rather than waiting for an ambulance.

a) Eyes

If pesticides get into the eyes the operator should wash them immediately with copious amounts of tap water for at least 20 minutes and seek medical advice urgently.

b) Skin

If pesticides get on the skin, contaminated clothing should be removed and the area washed thoroughly for 20 minutes. If contamination is extensive, medical advice should be sought without delay. Skin contamination should not be cleaned using organic solvents.

c) Swallowing

If pesticides have been swallowed, the patient should rest and get medical advice immediately. Nothing should be taken by mouth, and the patient should not be made sick. The data sheet, label or leaflet for the product should be taken to the medical services with the patient, so the appropriate treatment can be given. If the patient is sick, a sample of vomit should be taken to the hospital with data sheets, etc.

d) Inhalation

If pesticides have been inhaled, the patient should be removed to fresh air, kept at rest and medical advice obtained. Check breathing; any difficulties may require artificial respiration and hospital care. Hospital help should be sought especially if the patient begins to feel unwell.

7

Disposal of waste herbicides, containers and equipment

7) Disposal of waste herbicides, containers and equipment

7.1) Regulations

Regulations governing the disposal of pesticides and their containers are contained within the Food and Environment Protection Act 1985 (FEPA), Health and Safety at Work Act 1974, Control of Pollution Act 1974 (COPA), Environmental Protection Act 1990 and Water Resources Act 1991. These regulations must be strictly adhered to by all users.

Under COPA it is an offence to abandon or dispose of waste which is poisonous, noxious, or polluting on any land where the environment may be at risk. Agency waste section officers can:

a) provide advice on general disposal matters which may include details of specialist disposal contractors;

b) issue disposal licences under COPA, for waste disposal activity on land in the area.

Under the Water Resources Act 1991 it is an offence to cause or knowingly permit any poisonous, noxious or polluting matter, or any solid waste matter to enter any controlled waters.

The Environment Agency Policy and Practice for Protection of Groundwater (1992) seeks to ensure that use and disposal of pesticides/herbicides is restricted in water supply protection zones.

7.2) Preparation prior to application

To satisfy the COSHH Regulations 1988 it is necessary to consider whether it is absolutely necessary to use a herbicide to achieve the required effect. Assuming that a herbicide is justified, it is essential to carefully plan and prepare the application to minimise the quantity of waste herbicide produced. Estimate as accurately as possible the quantity required and only buy what is needed.

Methods of disposing of waste should be considered and solved prior to purchase and application. All methods of reducing waste herbicide must be considered.

7.3) Disposal of container washings

Containers should be rinsed three times at the time of mixing, by following the conditions on the product label or by successive rinsing. The rinse should be added to the spray tank.

7.4) Disposal of spray tank washings

If surplus mix remains it should be disposed of appropriately. It is NOT acceptable to reapply to the treated area in aquatic situations because of the risk of causing a pollution. The Code of Practice for the Safe Use of Pesticides on Farms and Holdings[28] permits disposal of dilute pesticide waste onto an area of non-cropped land of minimal wildlife value. However, this is only acceptable if the land is the property of the applicant or if written permission from the landowner has been given. Therefore, in most instances the most appropriate method of disposal is via a reputable waste disposal contractor. Herbicides should NEVER be emptied down drains.

After application all equipment used should be cleaned, washed and rinsed thoroughly in an area where contaminated water cannot enter drains or watercourses.

When washing great care must be taken to ensure that back-siphoning of pesticides into the water supply cannot occur.

7.5) Disposal of waste concentrates

Disposal of concentrates should be minimal if correct purchase and storage procedures are adhered to. However, in the following circumstances, concentrates may need disposing:

a) date of shelf life expired;

b) un-approved or approval revoked;

c) container damaged (possible hazard).

Disposal of concentrates should always be via a reputable waste contractor. Duty of care applies – see Waste Management, The Duty of Care: A Code of Practice (1996)[35].

If unopened pesticides are surplus to requirements they should be returned to the supplier

if possible, or used at another time. If neither of these options is available, they must be disposed of via a reputable waste contractor.

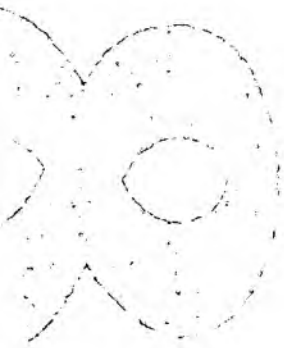
The Agency now regulates waste. The waste sections in local Agency offices should be contacted for any queries or if permission for the transport or disposal of waste needs to be obtained. Further information can be found in the publications listed in section 10.

7.6) Disposal of containers

Rinsed containers (see 7.3) should be punctured so that they cannot be re-used. If possible, the label should be kept intact.

Agency policy is to dispose of containers via a reputable waste disposal contractor. Other methods of disposal of containers, such as burial and incineration, suggested by the Code of Practice for the Safe Use of Pesticides on Farms and Holdings[28], produced by MAFF/HSE, are NOT to be used by the Agency.

Training



8) Training

8.1) Introduction

In order to comply with the Control of Pesticides Regulations 1986 and the Control of Substances Hazardous to Health 1988, all people involved with pesticides must be properly trained.

Schedules 2 and 3 of the Control of Pesticides Regulations 1986 specify a number of conditions covering the storage and use of pesticides. The relevant conditions are:

a) No person should use a pesticide in the course of business unless he/she has received adequate instruction and guidance in the safe, efficient and humane use of pesticides and is competent for the duties which he/she is called upon to perform.

b) No person who was born later than 31 December 1964 shall use a pesticide approved for agricultural use unless he/she has obtained a certificate of competence or he/she uses the pesticide under the direct and personal supervision, that is, within eyesight and visual contact, of a person who holds such a certificate. The certificates of competence for pesticide applications are shown in Table 8.1.

c) No person shall use a pesticide approved for agricultural use on land not in his or her employers ownership or occupation, unless he/she has obtained a certificate of competence or uses the pesticide under the direct and personal supervision of a person who holds such a certificate. (This condition would apply to any work undertaken by the Agency under contract, for example, for internal drainage boards or angling clubs.)

d) It is the duty of every employer to ensure that any person in his/her employment who may be required to use or store a pesticide during the course of that employment is provided with such instruction and guidance to achieve the required standard of competence.

e) Any person who uses a pesticide shall take all reasonable precautions to protect the health of human beings, creatures and plants, to safeguard the environment and in particular to avoid pollution of water.

Under the Control of Substances Hazardous to Health Regulations 1988 information must be given to employees about any risks to health which may arise from using a pesticide; and they must be trained in the precautions necessary to prevent or adequately control exposure and in emergency measures.

All persons involved with storing, using and advising on herbicides MUST receive adequate training and instruction to fulfil the above. Only responsible competent employees who have been given adequate instruction in the handling, mixing and application of such materials are allowed to work with herbicides.

8.2) Users

Users of pesticides are required to have knowledge of relevant legislation, hazards and risks posed by pesticides, safe working practices, emergency action, health surveillance and record keeping.

The certificates of competence recognised by the Ministry for pesticide users are the pesticide application module certificates issued by the National Proficiency Testing Council (NPTC). Test candidates are required to pass the appropriate proficiency tests, that is, the foundation module and subsequently at least one other practical test module on the application equipment appropriate to their job.

Possession of a recognised certificate of competence is sufficient basic training for COSHH.

8.3) Store keepers

Certificates of competence for storekeepers are issued by BASIS and should be held by all Agency storekeepers.

8.4) Advisors and regulators

A BASIS certificate of competence is needed by all Agency staff giving internal and external advice on herbicides, since they may be liable to prosecution if they give incorrect advice which results in an offence under Section 16 (12) of FEPA (a person who causes or permits another person to contravene the regulations).

A training course on aquatic weed control for advisers has been tailored to meet the Agency's needs. (For further information contact National Training, The Environment Agency, Block 1, Government Buildings, Burghill Road, Westbury-on-Trym, Bristol BS10 6BF, Tel 0117 9142659, Fax 0117 9142663.)

BASIS also operates a register of practitioners for pesticide advice, which is open to all who hold the appropriate certificate of competence and are prepared to update their training on an annual basis.

8.5) Scope of training

Matters which need understanding include:

- legislation applied to pesticides;
- decisions on whether a pesticide has to be used;
- selection of appropriate pesticide for the job;
- interpretation of labels and codes of practice;
- hazards and risks to human health and to the environment;
- protective clothing requirements;
- calibration and safe operation of equipment;
- safe storage and disposal of pesticides;
- emergency action in case of poisoning or contamination;
- how to contain and deal with accidental spillage;
- constraints imposed by weather and other factors;
- appropriate record keeping;
- need for exposure monitoring or health surveillance;
- particular requirements relating to use in or near water.

8.6) Providers of training

Training requirements can be met by recognised training courses, by in-house training or both. MAFF produces a list of recognised providers of pesticide training for users and suitable courses are provided by agricultural colleges, the Agricultural Training Board and other bodies.

"In house" courses using certificated instructors and input from regional safety advisers are also recommended for refresher purposes and to reinforce ATB courses. It is important that "in house" training is given by someone who is competent to do so and to an equivalent standard. It should also be adequately recorded by training sections.

8.7) Who should be trained?

All Agency staff involved with the application of pesticides should attend ATB courses of basic training for the module on the "Safe Use of Pesticides" plus other relevant modules, for example, "Hand Held Applicators" and "Safe Use of Pesticides in or Near Water" and undertake the NPTC tests to gain a certificate of competence. All Agency users of pesticides, irrespective of age, must hold the NPTC certificate.

The above training and testing should also apply to first line supervisors of pesticide users, who must be fully familiar with the manufacturer's instructions and safe operating procedures for all pesticides and application equipment used by their staff.

All persons working in or having access to the store must have been given adequate training to ensure that they can carry out their routine duties safely and can deal with any emergency in an effective manner. The storekeeper should attend a BASIS storekeeper training course and obtain a BASIS storekeeper's certificate of competence.

Staff acting in an advisory or regulatory capacity should undertake the aquatic BASIS course and obtain BASIS certification. They should then update their training annually and become BASIS registered.

Training requirements should be co-ordinated by then national training officer and implemented by regional training officers in liaison with line managers. These should be subject to annual review. The organisations involved in training are listed in Section 11.2.

Table 8.1
NPTC certificates of competence

Certificate	Qualification structure		
1	**Foundation Module** The successful completion of this module will be a condition of entry to any other module identified in this schedule with the exception of Group 7A and Group 11A and 11B.		
Certificate	**Test module**	**Qualification**	**Equipment**
		in addition to the module identified in column 1, the certificate holder is also qualified in respect of:	in this test module
2A	GROUND CROP SPRAYER- boom type hydraulic nozzle	PA 2F, 2AR, 8 and any other mounted or trailed method not specified in this schedule.	Any mounted or trailed ground crop sprayer of the type specified in column 1.
2B	GROUND CROP SPRAYER- boom type rotary atomizer	PA 2F, 2BR, 8 and any other mounted or trailed method not specified in this schedule.	Any mounted or trailed ground crop sprayer of the type specified in column 1.
2C	GROUND CROP SPRAYER- boom type twin fluid nozzle	PA 2F, 8 and any other mounted or trailed method not specified in this schedule.	Any mounted or trailed ground crop sprayer of the type specified in column 1.
2D	GROUND CROP SPRAYER- electrostatically charged	PA 2F, 8 and any other mounted or trailed method not specified in this schedule	Any mounted or trailed ground crop sprayer of the type specified in column 1.
2E	GROUND CROP SPRAYER- boom type fitted with downward air assistance	PA 2A, 2F, 8 and any other mounted or trailed method not specified in this schedule.	Any mounted or trailed ground crop sprayer of the type specified in column 1, where the boom geometry is in the horizontal mode.
2F	WICK APPLICATOR- boom of frame type	Test module only	Any mounted or trailed wick applicator of the type specified in column 1. Direct contact applicators.
2AR	VEHICLE MOUNTED KERB SPRAYER- hydraulic nozzle type	Test module only	Any vehicle-mounted kerb sprayer of the type specified in column 1.
2BR	VEHICLE MOUNTED KERB SPRAYER- rotary atomizer type	Test module only	Any vehicle-mounted kerb sprayer of the type specified in column 1.
2ST	SPRAY TRAINS- hydraulic nozzle and rotary atomiser types	Test module only	Any vehicle running on permanent way (railway track) of the type specified in column 1.
3A	BROADCAST AIR	PA 8 or any other mounte	Any mounted or trailed broad-

	BLAST SPRAYER-mounted or trailed	or trailed method not specified in this schedule.	cast air blast sprayer of the type specified in column 1.
3B	VARIABLE GEOMETRY BOOM AIR-ASSISTED SPRAYER-Mounted or trailed	PA 2A, 2E, 2F, 3A, 8 or other mounted or trailed method not specified in this schedule.	Any mounted or trailed variable geometry sprayer of the type specified in column 1, where the boom geometry may be varied between a horizontal and vertical plane.
4	GRANULE APPLICATOR Mounted or trailed	PA 6C	Any full width (eg. spinning disc, pendulum, pneumatic) or placement type mounted or trailed pesticide granule applicator. Any mounted or trailed direct injection equipment.
5A	BOAT-MOUNTED APPLICATOR Hydraulic nozzle boom	PA 5B, 5C, and any other boat mounte applicator not specified in this schedule.	Any boat-mounted sprayer of the type specified in column 1.
5B	BOAT-MOUNTED APPLICATOR Granule applicator.	PA 6C, 6CW	Any boat-mounted pesticide granule applicator of the type specified in column 1.
5C	BOAT-MOUNTED APPLICATOR Viscous gel applicator	Test module only	Any boat-mounted viscous gel applicator of the type specified in column 1.
6A	HAND-HELD APPLICATORS Hydraulic nozzle and/or rotary atomizer types.	PA 6C, 6D, and any other hand held applicator of similar type not specified in this schedule.	Any hand-held and/or pedestrian-controlled sprayer of the type specified in column 1.
6AW	HAND-HELD APPLICATORS Application to water using hydraulic nozzle or rotary atomizer type sprayers.	PA 6A, 6C, 6CW, 6D, any other hand-held applicator of similar type not specified in this schedule.	Any hand-held and/or pedestrian-controlled sprayer of the type specified in column 1.
6B	HAND-HELD APPLICATORS Application to water using viscous oil applicators.	PA 6A, 6AW, 6C, 6CW, 6D, and any other hand held applicator not specified in this schedule.	Any hand-held and/or pedestrian-controlled viscous gel applicator of the type specified in column 1.
6C	HAND-HELD APPLICATORS Granule applicator.	PA 6D and any other hand held applicators of similar type not specified in this schedule.	Any hand-held and/or pedestrian-controlled pesticide granule applicator of the type specified in column 1.
6CW	HAND-HELD APPLICATORS Application to water using granule applicators.	PA 6C, 6D and any other hand held applicators of similar type not specified in this schedule.	Any hand-held and/or pedestrian-controlled pesticide granule applicator of the type specified in column 1.
6D	HAND-HELD	Test module only, and	Any other hand-held and/or pe-

	APPLICATORS Hand-held applicators requiring minimal calibration.	any other hand held applicators of similar type.	destrian-controlled pesticide application equipment including wick applicators, drench guns, rollers, watering cans, aerosols, direct injection equipment, pepper pots and brushes.
7A	AERIAL APPLICATION Pilot.	Test module only	Pilots and any fixed wing aircraft and/or helicopter.
7B	AERIAL APPLICATION Fieldsmen, ground marker.	Test module only	Any individual acting as a fieldsman/marker.
8	MIXER / LOADER	Test module only	Any individual acting as a mixer/loader.
9	FOGGING, MISTING AND SMOKES	Test module only	Any hand-held and/or pedestrian-controlled pesticide application equipment designed to produce a fog, mist or smoke.
10	DIPPING BULBS, CORMS, PLANT MATERIAL OR CONTAINERS	Test module only	Any equipment designed for the purpose of applying pesticide by immersion.
11A	SEED TREATING EQUIPMENT Mobile equipment	PA 11B	Any equipment designed to apply pesticides to cereal grains, pulses and other seeds, and which is mounted on a mobile vehicle.
11B	SEED TREATING EQUIPMENT Static equipment.	Test module only	Any equipment designed to apply pesticides to cereal grains, pulses and other seeds, and which is in a static position.
12	APPLICATION OF PESTICIDES TO MATERIAL AS A CONTINUOUS OR BATCH PROCESS Via conveyors, roller tables and other moving equipment.	Test module only	Any equipment designed to apply pesticides as a continuous or batch process to materials being transported on a moving conveyor, roller table or other moving equipment.

9

Glossary

9) Glossary

Active ingredient	The component of a pesticide with the pesticidal activity.
Adjuvant	Substance other than water without significant pesticidal properties used in conjunction with a pesticide to enhance its effectiveness.
Aerial application	The application of a pesticide from an aircraft in flight.
Algae	Relatively simple but diverse major group of plants including: – microscopic algae, whose individual structure cannot be seen, but can make the water look discoloured; – filamentous algae which can form large visible, sometimes floating masses, sometimes called blanket weed or cott; – stoneworts, which are highly developed forms of algae, sometimes mistaken for submerged rooted plants.
Alginate	Viscous sodium alginate solution used in conjunction with diquat to form diquat alginate gel solution which can stick to plants.
Amine	Derivative of ammonia (NH_3) in which one or more hydrogen atoms are replaced by an alkyl radicle, for example, methylamine CH_3NH_3. Soluble in water.
Contact herbicide	A weedkiller which kills weeds on contact with the foliage of the plant (leaves and stem) usually with no residue effect (also known as a foliar-acting herbicide).
Contractor	Anyone applying herbicides to property or premises which are not in the ownership or occupancy of themselves or their employer.
Controlled waters	Waters subject to the Water Resources Act 1991. Includes all rivers, lakes, groundwaters, estuaries and coastal waters.
Dicotyledon	Plants with a pair of seed leaves. Typically with leaves relatively wide and shoots bushy.
Efficacy	Effectiveness.
EHS Centre	National Centre for Ecotoxicology and Hazardous Substances.
Emergent weed	Plant which grows through the water with leaves extending above the water.
Epiphytic	Plant living attached to another plant, usually algae living on large plants.
Ester	A molecule derived from an acid and an alcohol by the elimination of water. They are usually only sparingly soluble.
Filamentous	Thread-like.

Foliar	Pertaining to or consisting of leaves.
Herbicide	A pesticide which acts on plants.
LC50	Lethal concentration 50, concentration which has caused the death of 50 percent of a defined test population.
LD50	Lethal dose 50, a calculated dose affecting 50 percent of exposed test population.
Macrophyte	Plant visible to the naked eye including flowering plants, horsetails, ferns, mosses and large algae, for example *Chara, Cladophora.*
Meristem	Growth area of a plant tissue where new cells are produced.
Monocotyledon	Plant with one seed leaf. Typically with narrow leaves, grasses etc.
Near water	Areas immediately adjacent to drainage channels, streams, rivers, ponds, reservoirs, canals, boreholes, dry ditches, estuaries and the sea. Also areas designated for water storage and areas liable to flooding such as areas within flood banks, beaches and sea defence embankments.
NOEL	No Observed Effect Level.
Pesticide	Any substance, preparation or organism prepared or used for destroying any pest. This includes herbicides, fungicides, insecticides, growth regulators, masonry and timber preservatives.
Photosynthesis	Process by which plants manufacture carbohydrates using energy from light.
Planktonic algae	Algae in suspension in the water liable to movement by wind and currents.
Potable	Drinkable.
Riparian	Riverside, bankside.
Rhizomes	Perennial underground horizontal stem often thickened and tuber-shaped.
SSSI	Site of Special Scientific Interest.
Stolons	Creeping horizontal stems.
Submerged weed	Plant which permanently grows under the surface of the water.
Sward	Turf or grass.
Translocation	Movement of substances within the plant.
Vascular plant	Plant with channels/vessels for transportation of fluids through the plant.

10

Useful publications

10)
Useful publications

1 *Amenity Handbook*, BAA, published annually

2 *Approved Code of Practice for the Safe Use of Pesticides for Non-Agricultural Purposes*, 1991, HSC, ISBN 0-7176-0542-6, obtainable from HSE Books

3 *Aquatic Plants, A Guide to Recognition*: D.H. Spencer-Jones and P.M. Wade, ICI Professional Products, 1986, ISBN 0901747033

4 *Aquatic Weed Control Operation – Phase 1 Report – Existing Practice*, 1993, Environment Agency R&D Note 189

5 *Aquatic Weed Control Operation – Best Practice Guidelines – Phase 2 Report*, 1995, Environment Agency R&D Note 395

6 *Aquatic Weed Control Operation – Phase 3 Report*, in preparation

7 *Aquatic Weed Control Operation: Best Practice Guidelines*, Environment Agency Information Leaflet

8 *Bracken Management Handbook – Integrated Bracken Management – A Guide to Best Practice*, Rhône-Poulenc

9 *British Poisonous Plants – Their Effects on Animals and Man*, 1995, 4th edition, ISBN 011 242 9815, The Stationery Office

10 *British Water Plants, Field Studies 4*, Haslam, Sinker and Wolseley, 1975

11 *Chemical Compounds Used In Agriculture and Food Storage: Recommendations for Safe Use In Great Britain*, MAFF (Pesticides branch)

12 *Code of Good Agricultural Practice for the Protection of Water*, MAFF, 1998

13 *Code of Good Agricultural Practice for the Protection of Soil*, MAFF, 1998

14 *Code of Practice for Supplies of Pesticides to Agriculture, Horticulture and Forestry*, MAFF, 1990 (booklet PB 0091)

15 *Code of Practice for the Use of Approved Pesticides in Amenity and Industrial Areas*, 1998, National Association of Agricultural Contractors/British Agrochemicals Association

16 *Conservation Guidelines for Drainage Authorities*, MAFF, 1991 (booklet PB0743)

17 *Investigations into the Use of Straw to Control Blue Green Algal Growth*, H.A. James, 1992, Foundation for Water Research, FRO285

18 *Grass Carp for Aquatic Weed Control. A User's Manual*, 1992, Environment Agency R&D Note 53

19 *Guidance for Control of Weeds on Non-Agricultural Land*, DETR, 1992, 92 EP 240

20 *Guidelines for the Disposal of Unwanted Pesticides and Containers on Farms and Holdings*, MAFF, 1985 (Booklet 2198), now distributed through ADAS

21 *Guidelines for Monitoring and Reporting Pesticide Pollution Incidents in the Aquatic Environment*, 1992

22 *Guidelines for the Safe Disposal of Unwanted Pesticides and Used Containers from Stores of Local Authorities, Agricultural Merchants and Agricultural Spraying Contractors,* British Crop Protection Council

23 *Guidelines for the Use of Herbicides on Weeds In or Near Watercourses and Lakes,* MAFF, 1995

24 *Information on Requirements to be Met by Applicants and Holders of the Aerial Application Certificate,* Civil Aviation Authority booklet CAP414

25 *Information Sheets on Aquatic Weed Control,* Centre for Aquatic Plant Management

26 *Keeping Pesticides out of Water,* MAFF, 1995 (booklet PB 2088)

27 *Pesticides 19XX; Pesticides Approved Under the Control of Pesticides Regulations 1986,* MAFF/HSE, revised annually, The Stationery Office

28 *Pesticides; Code of Practice for the Safe Use of Pesticides on Farms and Holdings,* MAFF/HSC, 1998, MAFF Publications

29 *Poisonous Chemicals On the Farm,* HSE (HS(G)2), The Stationery Office

30 *Storage of Approved Pesticides – Guidance for Farmers and Other Professional Users,* 1998, HSE Guidance Note CS19

31 *The Hand-Operated Sprayer's Handbook,* 1994, British Crop Protection Council

32 *The Safe Disposal of Non-Agricultural Professional Pesticides and Their Empty Containers,* 1993, BAA

33 *The UK Pesticide Guide 19XX,* CAB International/British Crop Protection Council, revised annually

34 *Think Water. Keep it Clean,* 1993, BAA

35 *Waste Management. The Duty of Care: A Code of Practice,* 1996, The Stationery Office

36 *Working With Pesticides Guide: The Regulations and Your Responsibilities,* Schering Agriculture, A Green Science Publication

11

Useful addresses

11)
Useful addresses

11.1) Advisory bodies

ADA **Association of Drainage Authorities**
The Mews
3 Royal Oak Passage
High Street
Huntingdon
Cambridge PE18 6EA
Tel 01480 411123
Fax 01480 431107

ADAS **ADAS Environmental**
Gleadthorpe Grange
Meden Vale
Mansfield
Notts. NG20 9PD
Tel 01623 846742
Fax 01623 847424

BAA **British Agrochemicals Association**
4 Lincoln Court
Lincoln Road
Peterborough PE1 2RP
Tel 01733 349225
Fax 01733 562523

BCPC **British Crop Protection Council**
BCPC Publications Sales
Bear Farm
Binfield
Bracknell
Berkshire RG12 5QE
Tel 0118 934 2727
Fax 0118 934 1998

CAPM **Centre for Aquatic Plant Management**
Broadmoor Lane
Sonning
Reading
Berks RG4 6TH
Tel 0118 9690072
Fax 0118 9441730
email IACR_CAPM@compuserve.com

DETR **Department of the Environment, Transport and Regions**
Ashdown House
123 Victoria Street
SWIE 6DE
Tel 0171 890 3000

EN **English Nature**
Northminster House
Peterborough PE1 1UA
Tel 01733 455000
Fax 01733 568834

FWR **Foundation for Water Research**
Allen House
The Listons
Liston Road
Marlow
Bucks SL7 1FD
Tel 01628 891589

HSE **Health and Safety Executive – Books**
PO Box 1999
Sudbury
Suffolk CO10 6FS
Tel 01787 881165
Fax 01787 313995

HSE **Health and Safety Executive**
Information Centre
Broad Lane
Sheffield
South Yorkshire S3 7HQ
Tel 0114 2892345/6
Fax 0114 2892333

MAFF **Pesticide Safety Directorate**
Mallard House
Kings Pool
3 Peasholme Green
York YO1 2PX
Tel 01904 640500
Fax 01904 455733

MAFF **Food & Veternary Science Division**
Nobel House
17 Smith Square
London SW1P 3JR
Tel 0171 238 5526
Fax 0171 238 6129

MAFF **MAFF Publications**
Admail 6000
London SW1A 2XX
Tel 0645 556000

NAAC **National Association of Agricultural Contractors**
Huts Corner
Tilford Road
Hindhead
Surrey
GU26 6SF

The Stationery Office
Publications Centre
PO Box 276
London SW8 5DT
Tel 0171 8739090 (orders)
0171 8730011 (enquiries)
Fax 0171 873 8200

Water UK
1 Queen Anne's Gate
London SW1H 9BT
Tel 0171 957 4567
Fax 0171 9574666

11.2) Training organisations

ATB **Agricultural Training Board**
Head Office
Stoneleigh Park Pavilion
National Agricultural Centre
Kenilworth
Warwickshire CV8 2UG
Tel 01203 696996
Fax 01203 696732

BASIS **BASIS (Registration) Limited**
34, St John Street
Ashbourne
Derbyshire DE6 1GH
Tel 01335 343945
Fax 01335 346488

NPTC **National Proficiency Tests Council**
Tenth Street
National Agricultural Centre
Stoneleigh
Kenilworth
Warwickshire CV8 2LG
Tel 01203 696553
Fax 01203 696900

National Training
Environment Agency
Block One
Government Buildings
Burghill Road
Westbury-on-Trym
Bristol BS10 6BF
Tel 0117 9142659
Fax 0117 9142663

11.3) Manufacturers/distributors

AgrEvo UK Crop Protection Ltd.
(previously Schering Agriculture)
East Winch Hall
East Winch
King's Lynn
Norfolk PE32 1HN
Tel 01553 841581
Fax 01553 841090

Atlas Crop Protection Ltd.
Moorend House
Moorend Lane
Dewsbury
West Yorkshire WF13 4QQ
Tel 01924 411138
Fax 01924 411139

Barclay Plant Protection
28 Howard Street
Glossop
Derbyshire SK13 9DD
Tel 01457 853386
Fax 01457 853557

DuPont (UK) Ltd
Agricultural Products Dept
Wedgwood Way
Stevenage
Herts SG1 4QN
Tel 01438 734000
Fax 01438 734452

Helm Great Britain Chemicals Ltd
Wimbledon Bridge House
1 Hartfield Road
London SW19 3RU
Tel: 0181 5449000
Fax: 0181 5441011

Hortichem Ltd.
1 Edison Road
Churchfields Industrial Estate
Salisbury
Wilts P2 7NU
Tel 01722 320133
Fax 01722 326799

Mirfield Sales Services Ltd
Moorend House
Moorend Lane
Dewsbury
West Yorkshire WF13 4QQ
Tel 01924 409782
Fax 01924 410792

Monsanto Crop Protection
P.O. Box 53
Lane End Road
High Wycombe
Bucks. HP12 4HL
Tel 01494 474918
Fax 01494 474872

Nomix-Chipman Ltd
Portland Building
Portland Street
Staple Hill
Bristol BS16 4PS
Tel: 0117 9574574
Fax: 0117 9563461

Novartis Crop Protection UK Ltd.
Whittlesford
Cambridge CB2 4QT.
Tel 01223 833621
Fax 01223 835211

pbi Agrochemicals Ltd
Britannica Works
Sewardstone Road
Waltham Abbey
Essex EN9 1NP
Tel 01992 712579
Fax 01992 659800

Rhône Poulenc Agriculture Ltd.
Fyfield Road
Ongar
Essex CM5 0HW
Tel 01277 301301
Fax 01277 362610

Rigby Taylor Ltd.
The Riverway Estate
Portsmouth Road
Peasmarsh
Guildford
Surrey GU3 1LZ
Tel 01483 35657
Fax 01483 34058

The Scotts Company (UK) Ltd
previously Miracle Professional
Salisbury House
Weyside Park
Catteshall Lane
Godalming
Surrey GU7 1XE
Tel 01483 410210
Fax 01483 410267

Uniroyal Chemicals Ltd
Kennet House
4 Langley Quay
Slough
Berks. SL3 6EH
Tel 01753 603000
Fax 01753 603077

Zeneca Crop Protection
Fernhurst
Haslemere
Surrey GU27 3JE
Tel 01428 656564
Fax 01428 657385

Zeneca Professional Products
see The Scotts Company (UK) Ltd

12

Appendix

Appendix I – general pollution prevention guidelines

Before applying a herbicide you should consider all alternative methods of weed control. If a herbicide is needed, the risk of pollution can be minimised by following these guidelines.

Storage

Even if only small quantities of herbicides are stored you should:

* keep them in a suitable store, protected against fire and theft;
* only store MAFF approved and numbered products;
* only store enough herbicide for your immediate need;
* always keep the store locked and clearly marked;
* keep records of the store contents in a separate place in case of an incident;
* site any stores well away from any watercourses, drains, boreholes and areas prone to flooding.

Mixing

When mixing herbicides always take extreme care. To minimise risks:

* mix herbicides in a designated area where any spillages will not get into drains, watercourses or groundwater;
* in case of an accident absorb spillages with an inert material such as fine sand and dispose of in a safe manner;
* use closed transfer and induction mixing systems whenever possible to avoid the need for manual mixing;
* avoid back siphoning by ensuring that there are no direct connections between a spray tank and the water supply.

Use

When herbicides are applied correctly there is minimal risk of water pollution. Follow these measures to reduce the risk further:

* only use herbicides when absolutely necessary;
* only use herbicides with approval for use in or near water;
* follow instructions on the manufacturer's label;
* only prepare the amount of chemical needed to avoid having to dispose of the surplus;

* don't mix up large quantities if there is a risk that the weather will prevent you from spraying;

* only apply herbicides when the weather conditions are suitable, that is, not if the wind will cause the spray to drift onto non-target plants or if heavy rain is forecast.

Disposal

Careless or incorrect disposal of even very small amounts of pesticide is a potential source of pollution. Disposal of all wastes must be carried out in a safe manner.

1) Dilute pesticides

There should be no need to dispose of dilute pesticides if the amount required is accurately estimated. Disposal of unavoidable waste should:

* be onto an area of non-cropped land of minimal wildlife value. This is **only** acceptable if the land is the property of the applicant or if **written permission** from the landowner has been given. If this is to be undertaken by non-Agency staff, then prior discussion with the Agency is recommended.

* preferably be via a reputable waste disposal contractor.

2) Concentrates

If the product still has MAFF approval, it should be used in an appropriate application. Otherwise, it must be disposed of via a specialist waste disposal contractor.

3) Containers

Agency policy is to dispose of containers via a reputable waste disposal contractor. Other methods of disposal of containers, such as burial and incineration, suggested by the Code of Practice for the Safe Use of Pesticides on Farms and Holdings, produced by MAFF/HSE, are NOT to be used by the Agency.

Further information can be found in:

Chapters 6 and 7 of this document.

Agricultural pesticides and water leaflet

Pollution prevention guidance note – pesticides

Appendix II – BASIS qualified Environment Agency staff

Anglian
Chris Adams
Richard Chadd
Terry Clough
Paul Espin
Chris Extence
Joanne Goodson
Sue Hogarth
Sue Loveridge
Lesley Saint
Julia Stansfield

North East
Richard Atkinson
Elaine Axford
Jonathan Brickland
Edmund Clegg
Paul Curry
Caroline Essery
David Fullwood
Leonora Gilligan
Jim Heslop
Vicky Hirst
Anne Lewis
Roger Martin
Alan Mullinger
Louise Waring
Vicki Warren

North West
Judith Bennett
Bernard Chappel
Elaine Fisher
Steve Garner
Neil Guthrie
David Holland
Lucy Morris
Ed Mycock
Pam Nolan
Ray Prigg

Midlands
Ayleen Clements
Martin Cooper
Belinda Falkner
Gary Fretwell
Alan George
Phil Harding
Valerie Holt
Shelley Howard
Lucy Morris
Anne Penney
Roy Sedgwick
Peter Sibley
Sarah Thomas
Jonathan Thompson
Philip Wormald

Southern
Steve Betts
Rebecca Dorman
Philip Griffiths
Nancy Haylor
David Horne
Robert Pilcher
Bob Slatcher
Cedric Stuart
Marc Thain
Nick Williams

Welsh
Kate Cameron
John Coombe
Chris Formaggia
Bryan Jones
Teg Jones
Moira Kitchen
Carrie Lane
Jo-Anne Nightingale
Iwan Thomas
Hannah Wilkinson
Stuart Craxford

South West
Colin Babb
Jeanette Collett
Samantha Dawe
James Flory
Allan Frake
Steve Griffiths
Andy Hicklin
Alison Howard
Paul King
David Lloyd
Lawrence Mathew
Malcolm Newton
Lee Portlock
Trevor Renals
Simon Smythe
Simon Toms
Geoff Way
Mike Williams

Thames
Steve Colclough
Sarah Davies
Chris Dutton
Ian Hall
Robert Jeffery
Ian Larkins
Alison Love
Anna MacQueen
Bruce McGlashan
Stewart Ower
Leslie Pearman
Jonathan Perkins
Helen Richardson
Peter Rudd
Ruth Shaw
Alan Tubb
John Waxman

Appendix III – conversion tables

To convert	To	Multiply by
Yards	Metres	0.9144
Yards^2	Metres^2	0.836
Acres	Metres^2	4047
Acres	Hectares	0.4047
Gallons (UK)	Litres	4.546
Yards^3	Metres^3	0.76
Metres	Yards	1.0936
Metres^2	Yards^2	1.196
Hectares	Acres	2.471
Litres	Gallons	0.22
Metres^3	Yards^3	1.308

Ratios

Solids in liquids	1 ppm = 1 mg/l = 1:1,000,000
	1000 ppm = 1 gm/l = 1:1,000
Solids in solids	1 ppm = 1g/1000 kg = 1 mg/kg
Liquids in liquids	1 ppm = 1 ml/1000 l = 0.001 ml/l

Useful reminders

1 m^3 = 1,000 l = 220 gallons
1 kg = 1000 g = the weight of 1 l water
1 Ml = 1,000,000 l =1,000 m^3
1 l = 1,000 ml = 1,000cm^3
1 g = 1,000 mg
1 ha = 10,000 m^2

Appendix IV – Bracken control – application systems and buffer zones to protect water supplies

The following buffer zones have been agreed by the Agency and with the product manufacturer to protect water supplies:

Aerial spraying (conventional nozzles)	160 metres
Aerial spraying (raindrop nozzles)	50 metres
Tractor and knapsack (conventional system)	20 metres
Tractor and knapsack (low drift system)	5 metres
Hand held ULVA drift sprayer	50 metres

1. Conventional systems

Aerial (160m) and tractor and knapsack (20m)

This category pf systems include spray gear fitted with conventional hydraulic nozzles *not* having a recognised drift-control capability.

2. Low drift systems

2.1 Tractor and knapsack (5m)

2.1.1 Large droplet (250μm) spinning-disc systems

This category includes spinning disc or controlled droplet applicators (CDA) set to produce droplets of 250 micron or more.

2.1.2 Ground based, low-drift boom and nozzle systems

This category includes spray gear fitted with conventional hydraulic nozzles having a recognised drift-control capability. Some examples of these include:-

Spraying Systems

- LP TEEJET fan nozzles
- DGTEEJET drift guard fan nozzles
- FLOODJET anvil nozzles (larger sizes or any sizes at low pressure)
- TURBO TEEJET anvil nozzles

Lurmark

- LO-DRIFT fan nozzles
- LOW PRESSURE FANTIP fan nozzles
- DEFLECTIP anvil nozzles (larger sizes or any sizes at low pressure)
- POLIJET anvil nozzles (larger sizes or any sizes at low pressure)

Sprays International

- ENVIROGUARD fan nozzles
- DEFLECTOR anvil nozzles (larger sizes or any sizes at low pressure)

2.2 Aerial spraying (RD raindrop nozzles) (50m)

This category specifically refers to helicopters with reduced-drift boom fitted with RD raindrop nozzles.

3.0 Drift systems

3.1 ULVA drift sprayer (50m)

Drift spraying requiring a steady breeze for application to bracken. The operator walks across the wind applying swaths at 3 metre intervals. This category covers both the older Micron 'ULVA-8' and the newer 'ULVA+' hand held spinning-disc applicators.

More detailed guidance on spray drift systems is provided on page 40 of 'The Bracken Management Handbook' produced by Rhône-Poulenc.

Appendix V – useful information sheets on the control of some aquatic weeds

Several information sheets compiled by the Centre for Aquatic Plant Management, at the Institute of Arable Crops Research, Long Ashton, have been included. Some of these sheets are out of date, particularly some of the chemical control options. They have been included for information only.

INFORMATION SHEET 1

Control of Algae with Barley Straw

Centre for Aquatic Plant Management
IACR Long Ashton Research Station
Integrated Approach to Crop Research

INTRODUCTION

Algae are a common nuisance in garden ponds. Some forms of algae turn the water green while others form hairy masses or blankets which stick to plants and the sides of the pond, or form floating mats on the surface. One way of controlling these algae without harming other plants or the pondlife is to treat the pond with straw.

The Centre for Aquatic Plant Management has developed this technique over a number of years and, although there are a number of aspects which we do not fully understand, we hope that the following information will be useful to gardeners.

WHAT TYPE OF STRAW?

Although many types of straw control algae, barley straw is the most active and remains active for a longer period than wheat, linseed, maize or oil-seed rape straw.

HOW MUCH STRAW?

The amount of straw needed to treat a pond is calculated on the area of the pond surface, and it is not necessary to measure the depth or volume of the pond. In ponds with surface area of less than 10 square metres you should use a minimum weight of 100 grammes of straw. In larger ponds the quantity of straw should be approximately 10 grammes of straw per square metre of water surface. Most garden ponds will have a surface area less than 10 square metres and so the minimum quantity should be used.

The values are approximate and it is not necessary to measure the area of the pond very accurately. One hundred grammes (4 oz) of straw is enough to make a pile of loose straw which measures about 30 x 30 x 10 cm (1 foot square by 3 inches deep).

HOW TO APPLY THE STRAW

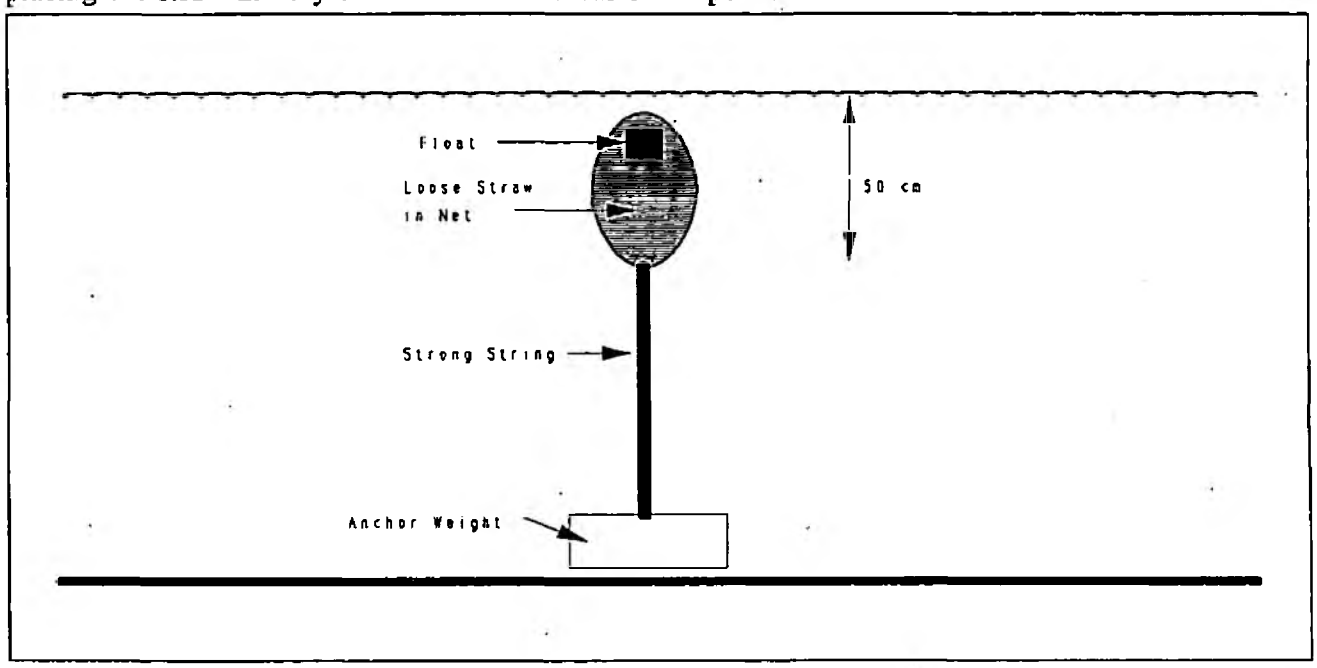
Loose straw will float when first put into water and can look unsightly. The decomposition process works better if the loose straw is packed into a netting sack, which can be anchored. The best position for the sack is floating at, or just below, the surface of the water. After a while, the straw will become waterlogged and sink. The anti-algal effect produced from the straw is reduced if the straw comes into contact with the mud at the bottom of the pond. We recommend that a float (tennis ball, plastic bottle, polystyrene etc.) is put into the net with the straw. The netting sack can be anchored in the water by attaching it to a stone or brick, as shown in the diagram. The sack can be arranged so that it floats at the surface or, if considered too unsightly, just below the surface. In any event, the straw should be kept in the top 50 cm (18 inches) of the water to maintain the best effects.

The sack can be made with plastic garden netting, onion sacks or, as a last resort, nylon tights. It is important to use a netting with a mesh size that allows water to flow freely through the straw. If nylon tights are used, they should be well laddered!

The CAPM is part of the Institute of Arable Crops Research-Long Ashton Research Station and is supported by the Environment Agency, British Waterways, Internal Drainage Boards and Regional Flood Defence Committees.
Centre for Aquatic Plant Management, Broadmoor Lane, Sonning-on-Thames, Reading, Berkshire, RG4 6TH, UK.

WHERE IS THE BEST POSITION IN THE POND?

If there is an inflowing stream or fountain in the pond, place the straw so that water flows through and over it. If the pond is large, say over 50 square metres, it is better to make two or more nets of straw and place them at regular intervals around the pond in addition to one near the inlet stream or fountain. Avoid placing the straw in very sheltered or still areas of the pond.



WHEN SHOULD THE STRAW BE APPLIED?

Straw is more effective at preventing algal growth than in killing algae which are already present in the pond. Therefore you should aim to apply the straw early in the spring before growth starts. The straw should continue to work for about six months under normal UK conditions, after which it loses its activity quite quickly. A second application of straw should be made in early autumn. It is important not to remove the old straw for at least one month after the new straw is added, and the following timetable will give a good guide to application times:-

Feb - April	1st application
Sept - Nov	2nd application
Feb - April	3rd application - remove 1st application
Sept - Nov	4th application - remove 2nd application
etc.	

If the straw rots away before the next planned application, add more straw as soon as possible, as algal growth starts very quickly once the straw has rotted away.

HOW QUICKLY DOES IT WORK?

It usually takes about 2-3 weeks after the straw is applied before it starts to become active and have an effect on the algae. Once it has become active, algal growth stops or slows down but the algae do not die immediately. Single celled algae will usually start to disappear after 5-6 weeks, but filamentous algae (blanket weeds) can survive for months, If the straw is applied before algal growth has started, then algal problems should not occur. However, if straw is applied to a pond which already has a problem with blanket weed, rake out as much as possible before the straw is put in and again after about 6 weeks.

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Dr Jonathan Newman

The CAPM is part of the Institute of Arable Crops Research-Long Ashton Research Station and is supported by the Environment Agency, British Waterways, Internal Drainage Boards and Regional Flood Defence Committees.
Centre for Aquatic Plant Management, Broadmoor Lane, Sonning-on-Thames, Reading, Berkshire, RG4 6TH, UK.

Table 1. *Method for estimating amount of straw required.*

Decision Step		Calculated example
1	Estimate the surface area of the lake	1.5ha (15,000 m^2)
2	Decide on the dose rate of straw required. This will range from 10g/m^2 in a clear lake with little algae or mud to 50 g/m^2 in a heavily infested lake with muddy water	25 g/m^2
3	Multiply the area of the lake (in m^2) by the quantity of straw required per m^2 to obtain the total quantity required	15,000 x 25 = 375,000 g 375,000÷1000 = 375kg
4	To obtain the number of bales to be purchased, divide the total weight of straw by the weight of bales (small rectangular bales normally weigh about 20kg). Weights should be checked on other sizes and shapes of bales.	375÷20 = 19 bales
5	Decide on the weight of straw to be placed in each net. (Bear in mind that the smaller the quantity in each net, the more nets there are and so the better the distribution of the chemical. Against this, the time and labour to construct the nets and the interference that they may cause to the lake functions will limit the numbers). Nets should normally contain between 1kg (in small lakes) to 40kg (in very large lakes).	25 kg
6	Calculate the number of nets which will have to be constructed. Divide the total quantity of straw required (3) by the weight in each net (5).	375 ÷25 = 15 nets
7	Calculate the area of water which will be treated by each net at the dose rate decided in 2 (above).	25kg÷25g/m^2 = 1,000 m^2
8	Calculate the radius of a circle with an area of the size calculated in 6 (above) using πr^2.	πr^2 = 1,000 r = √1,000÷3.142 r = 17.85m
9	The diameter of a circle of 1,000 m^2 is $.r \times 2$	diameter = 35.7 m
10	Decide on the most appropriate placement of the nets of straw in the lake so that each one is approximately 35m from its neighbour and 17m from the bank.	Usually a regular square grid pattern with centres at 35 m

The spacing of nets does not need to be exact. Practical considerations may influence the number of nets and their local placement. For example, it may be necessary to leave a wider corridor between some sets of nets to allow for adequate boat passage or angling purposes.

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In flowing waters such as streams and rivers. We do not yet have sufficient information on the properties of straw to express a quantity of straw required in relation to the surface area or volume of water flowing down the stream. However, straw has been used effectively in these situations by placing quantities of straw at intervals along either bank of the river. The distance between straw masses has usually been between 30-50m and the size of each straw mass was chosen, for convenience, as about one bale (20kg).

The risk of causing deoxygenation in flowing waters is very small as the continuous supply of fresh oxygenated water will prevent any local deoxygenation around the straw.

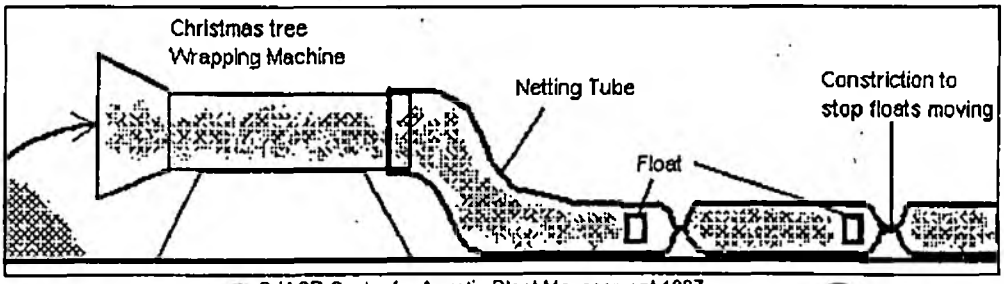
HOW TO APPLY STRAW -

The best way of applying straw varies with the size and type of water body. Suggestions as to the most appropriate methods for different types of water body are given below.

Fast flowing rivers and streams. Straw can be applied in the form of bales because the flow of water will keep oxygen levels high enough to prevent the straw from becoming anaerobic. Only small bales (approximately 20kg) should be used. Bales can break up under the forces produced by fast flowing water and they should normally be wrapped with netting or chicken wire and securely anchored to the bank or posts driven into the river bed. Another way of applying straw which has worked effectively in flowing water is to place the straw in gabions. These are wire mesh boxes (usually filled with stone for bank protection) but they work equally effectively as cages for straw. They have the additional advantage that they can be refilled as the straw rots away. Nets and loose woven sacks (e.g. Onion sacks) filled with straw can also be used. In all instances, it is essential to ensure that the straw container is well anchored to the bank or to stakes in the bottom which will hold it in place during periods of high flow.

Slow flowing rivers. Straw should be applied in a loose form, either in gabions or as straw sausages. This increases the diffusion of oxygen to the site of decomposition and speeds up the process in this type of environment.

Ponds, lakes and reservoirs. In still or very slow flowing water, bales should not normally be used as they are too tightly packed and do not allow adequate water movement through the straw. It is preferable to apply the straw in a loose form retained in some form of netting or cage.



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In small garden ponds where only a few grams of straw are needed, the straw can be put into a net bag, nylon stocking or simply tied into a bundle with string. This can be attached to an anchor made of a stone or brick and dropped into the pond. However, as the straw becomes waterlogged, the net will gradually sink to the bottom. In this position, it will not work as effectively as it does near the surface and it is advisable to include some form of float in the net. Floats can be made of corks, polystyrene or small plastic bottles with well-fitting screw tops. Once the straw has rotted, the net, complete with float and anchor can be removed and used again.

Some garden centres supply small packets of straw for use in ponds. They will work best if anchored and attached to a float as described above.

In larger ponds, lakes and reservoirs, where larger quantities of straw are needed, bales should be broken up on the bank and the loose straw wrapped in some form of netting or wire. One of the simpler ways of wrapping large quantities of loose straw is to use one of the various forms of tubular netting normally sold for wrapping Christmas trees, constructing onion sacks and for other agricultural purposes.

When used in conjunction with a tree wrapping machine they can be used to construct straw sausages which can be made up to about 20m long and contain some 50kg of straw. The length and size of each sausage is determined by the size and shape of the water body (described later). It is advisable to incorporate some floats within the netting to keep the straw near the surface when it becomes waterlogged. When first constructed, these sausages float well and can be towed behind a boat to the required position and anchored by rope to concrete blocks or sacks of gravel. It is preferable to anchor these straw sausages at only one end so that they can swing round to offer minimum resistance to wind or currents. Straw sausages can interfere with angling and boat traffic and their positioning needs to be carefully considered so as to have the minimum adverse effect on water users. Floats or buoys can be attached as markers to warn boat traffic or anglers of the position of the straw.

WHERE TO APPLY STRAW

It is always preferable to apply several small quantities of straw to a water body rather than one large one. This improves the distribution of the active factors throughout the water body. Straw works best if it is held near to the surface where water movement is greatest. This keeps the straw well oxygenated and helps to distribute the anti-algal chemical. In addition this ensures that the chemical is produced close to where the majority of the algae are growing and away from the bottom mud which will inactivate the chemical. The following aspects should be considered when deciding where to place the straw within a water body.

Small ponds In small ponds where only a single net of straw is required, this should be

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placed in the centre of the pond. However, if there is an incoming flow of water, either as a stream or fountain, the straw net should be placed where there is a continuous flow of water over and through the straw. This will help to keep the straw oxygenated and spread the chemical throughout the pond.

Lakes and Reservoirs In any body of still water, it can be assumed that the anti-algal chemical will diffuse outwards in all directions from each net of straw gradually being absorbed by algae and inactivated by mud until the concentration becomes too low to be effective. Beyond this distance, algal growth will continue unchecked and these algae will gradually drift back into the treated areas giving the impression that the straw is not working. In order to ensure that there are no areas within the water body unaffected by the straw, it is necessary to calculate how much straw is needed, how many nets should be employed and how far apart each net should be. Nets or sausages of straw should then be placed so that each net is roughly equidistant from its neighbours and from the bank. The steps involved in this calculation are explained overleaf with an example:

In rivers and streams From the point of view of getting maximum benefit from straw, it would be preferable to place the straw as a barrier across the flow of water. However, this is seldom possible because the force of the water would tend to wash the straw away and the straw would impede water movement and boat traffic. Therefore, bales, straw nets or gabions should either be placed opposite each other in pairs or alternately along both banks. In fast flowing streams where there is little mud to absorb the chemical, the space between straw nets can be as much as 100 m (50 m if placed alternately) but in slow-flowing muddy watercourses, this space should be reduced to no more than 30 m. In very narrow streams, it may be necessary to place the straw close to the bank so as not to impede flow but in larger watercourses the straw should be as far out from the bank as possible. This makes it less subject to vandalism and damage from livestock and ensures that there is a good flow of water around and through the straw.

Always ensure that the straw is well secured to the bank or to stakes in the bottom so that it does not get washed away during floods. It is usually necessary to consult the local water authority before applying straw to flowing water because they have the responsibility of ensuring that there is no danger to water supplies or other riparian users caused by partial obstruction to the flow.

Marine situations There has been very little research with straw in seawater and any treatments in these conditions should be regarded as experimental. Results from a very limited number of trials in salt water lagoons and artificial pools suggest that straw can work in salt as well as fresh water. However, it is very unlikely that it would have any effect on the large marine algae normally found on rocky shores or on kelp beds in the seas because of the problems of short persistence time and exposure. It is also unlikely that sufficient straw could be placed and held for long periods in the open sea.

wait until all the straw has rotted before making a second application as there will then be an interval when no chemical is being produced and rapid algal growth can take place. For the same reason, the old straw should not be removed for at least one month after the addition of the new straw. This allows time for the new straw to become active.

THE USE OF STRAW IN COMBINATION WITH OTHER CONTROL METHODS

Filamentous algae are not easily controlled by straw once they have formed floating mats. However, they can be controlled by other methods. In some situations, filamentous algae can be raked out. However, many fragments will remain in the water and rapid regrowth is likely. To prevent this straw should be added about one month before the alga is raked out.

In other situations, herbicides (diquat or terbutryn) have been used in combination with straw. The herbicides control the algae but their effects may not persist for long once the herbicide has decayed or been otherwise dissipated from the water. By adding straw at the same time, or soon after the herbicide has been applied and maintaining a straw treatment regime as outlined above, the straw helps to prevent the return of the algae.

OTHER EFFECTS OF STRAW

During the numerous field trials in which straw has been applied in a number of forms and in a range of water bodies, various effects in additional to the control of algae have been noted. While these have not been investigated in any detail, they have occurred sufficiently frequently to be worth noting as possible consequences of using straw.

1 **Effects on other aquatic plants.** No direct effect of straw on aquatic vascular plants has been found in either laboratory or field experiments. However, in several trials where straw has successfully controlled algae, there has been a noticeable increase in the growth of submerged vascular plants. It is likely that this is a result of the loss of competition from the algae which has allowed the vascular plants to recolonise water in which previously they were unable to compete with the algae. In some instances, the recovery of the vascular plants has been so marked that they, in turn, caused problems to water users and also required some form of management. However, they are generally easier to control and less troublesome than the algae and so are more acceptable in most waters. In some instances the recovery of the vascular plants has been so strong that they replaced the algal growth as the dominant plant form so that subsequent treatment with straw was no longer needed.

2 **Effects on invertebrates** It has been observed frequently that loose masses of well oxygenated straw provide a good habitat for some of the aquatic invertebrate animals such as the Water Shrimp (*Gammarus spp.*). These invertebrates, mostly detritus eaters, breed and grow rapidly in the safe environment created by the straw and their numbers can

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2: The anti-algal chemical

The chemical released by the straw does not kill algal cells already present but it prevents the growth of new algal cells. Thus algae which die will not be replaced when the straw is present and so the algal problem is controlled.

3: Speed of effect

Once the straw has become active, the time taken for control to become effective varies with the type of alga. Small, unicellular species which make the water appear green and turbid, usually disappear within 6-8 weeks of straw application. The larger filamentous algae, often known as blanket weeds, can survive for longer periods and may not be controlled adequately in the first season if the straw is added too late in the growing season when algal growth is dense. It is, therefore, preferable to add the straw very early in the spring before algal growth starts.

4: Production of the anti-algal activity

Activity is only produced if the straw is rotting under well oxygenated conditions. Usually, there is adequate dissolved oxygen in water to ensure that the chemical is produced by the straw. However, if the straw is applied in large compact masses such as bales, or to very sheltered and isolated areas of water, there will be insufficient water movement through the straw, which will progressively become anaerobic (without oxygen). Under these conditions, only the surface layers of the straw will produce the chemical and so the majority of the straw will have no useful effect.

5: Absorption and inactivation of the chemical

The chemical is very quickly absorbed by algae and is inactivated by mud. Therefore, in waters which have high algal populations and are turbid with suspended mud, it is necessary to add more straw than in clear waters.

6: Selective effect on algae

The chemical does not appear to have any effect on higher plants. In our experiments, we have seen that the suppression of dense algal growth has allowed flowering plants (macrophytes) to recolonise waters which were previously dominated by algae. In several shallow lakes where straw was used, algae were replaced by higher plants which suppressed the subsequent growth of algae, so eliminating the need for further straw treatments.

7: Effects on invertebrate animals and fish

There are no reports of harmful effects on invertebrates or fish except in a few instances

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where excessive amounts of straw were applied to small ponds and the water became deoxygenated. These excessive doses were at least 100 times the doses recommended in this leaflet. In most instances, invertebrate populations increase substantially around the straw so providing a useful food source for fish. There is anecdotal evidence that, in fish farms and fisheries, straw treatments may be associated with improved gill function and fish health and vigour.

HOW MUCH STRAW TO APPLY?

In ponds, lakes and other still water bodies. We have found that the most important measurement in calculating the quantity of straw required is the surface area of the water. Surprisingly, the volume of the water does not appear to affect the performance of the straw as might be expected. This may be because the majority of algal growth takes place in the surface layers of the water and so it is not necessary to measure the depth of the water or volume of the lake when calculating the quantity of straw required.

In still waters such as lakes, ponds and reservoirs, the minimum quantity of straw needed to control algae is about 10g straw m^{-2} of water surface. However, when a water body with a history of severe algal problems is first treated, a higher dose is preferable (25 g m^{-2}) and quantities up to 100 g m^{-2} have been used. Once the algal problem has been controlled, and further additions of straw are being made to prevent a recurrence of the problem, the dose can be reduced.

In turbid or muddy waters, it will always be necessary to add more straw than in clear, mud-free waters. It is clear from numerous trials in different types of water body that the quantity of straw needed can vary considerably and it is better to apply too much initially and then to reduce the quantity gradually each time straw is added until the dose has been reduced to 10g m^{-2} or until algal growth starts to increase again when the dose should be increased to a previously effective level.

There is a theoretical level at which straw could cause problems by deoxygenating the water. This is caused by the microorganisms which colonise the straw and absorb oxygen from the water and by chemical oxygen demand of the rotting process. However, straw decomposes slowly and the oxygen demand of these microorganisms is unlikely to cause any problems unless excessive amounts of straw (more than 100g m^{-2}) are applied. Deoxygenation can occur as the result of natural processes especially in prolonged hot weather when the solubility of oxygen in water is reduced and biological oxygen demand increased. This deoxygenation is often caused by algal blooms and so the presence of straw, which prevents the formation of these blooms, can reduce the risk of deoxygenation. However, straw should not be applied during prolonged periods of hot weather to waters containing dense algal blooms as the combined oxygen demand from the algal bloom and the straw could temporarily increase the risk of deoxygenation.

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Where possible any enlarged gaps between straw nets should be compensated for by decreasing the gaps between adjacent nets. If there are any inflowing streams, it is advisable to increase the number of nets near the inlet so that water flows through the straw and distributes the chemical into the lake. It is possible to compensate for this local concentration of straw nets near the inlet by reducing the numbers of nets near any outlet as the chemical released from these may be washed out of the lake.

In an irregularly shaped water body, the preferred place for some of the nets is opposite any promontories or points where the nets will be exposed to maximum wind and wave action. The remainder should be spaced between these, using the method of calculating the gaps shown above.

WHEN TO APPLY STRAW

Although straw can be applied at any time of year, it is much more effective if applied before algal growth takes place. This is because the anti-algal agents released by the straw are more effective in preventing algal growth than in killing algae already present. Therefore, straw is best applied in the autumn, winter or very early spring when the water temperature is low. The straw will usually become active within one month and will continue to inhibit algal growth for about 6 months. However, rapid algal growth can take place once the straw has rotted away and so further applications should be made each 6 months.

It is important to note that the rate at which straw rots varies considerably and regular observations should be kept on the straw so that fresh straw can be added before the end of the 6 month period if necessary. It is not always possible to predict that an algal problem will occur and so it is sometimes necessary to treat an algal problem which has already developed. Some algae, mainly the small unicellular species and the cyanobacteria (blue-green algae), can be controlled by adding straw to existing blooms.

The time taken for the algae to be controlled depends on a number of factors, of which water temperature is probably the most important. At water temperatures above 20°C straw has been effective in controlling algal blooms within 4-5 weeks, sometimes even faster. Avoid applying straw during prolonged periods of hot weather as the combined effect of the dying algae and the rotting straw may increase the risk of deoxygenation. At lower temperatures, the process is slower and it may take 8 - 10 weeks to control the algae but the risk of deoxygenation is then minimal.

When filamentous algae are the main problem, straw applied to dense floating mats will have very little useful effect unless combined with other treatments which will be described later. After the initial straw treatment, further additions will be required to prevent the return of the algae. Although a period of 6 months is suggested as the likely interval between straw applications, more frequent treatments may be necessary. It is inadvisable to

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SUMMARY

1 When algal problems occur in water bodies ranging from garden ponds to large reservoirs, lakes and rivers, barley straw offers an environmentally acceptable and cost-effective form of control.

2 It should be applied twice each year, preferably in early spring before algal growth starts and in autumn.

3 Particularly in static waters, the straw should be in a loose form through which water can pass easily and should be held in nets, cages or bags.

4 The minimum effective quantity of barley straw in still or very slow flowing water is about 2.5 g m^{-2} but higher doses of up to 50 g m^{-2} should be used in densely infested waters and muddy waters.

5 In rivers, masses of straw (bales or nets) should be spaced along the sides at intervals not more than 100m apart.

6 Straw should be supported by floats so that it does not sink to more than one metre below the surface, even when waterlogged.

7 If the straw starts to smell then it is not working and should be removed. This is caused by too much straw in too little water.

The CAPM is part of IACR-Long Ashton Research Station and is funded by subscription from the Environment Agency,
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IACR-CENTRE FOR AQUATIC PLANT MANAGEMENT

INFORMATION SHEET 3: *CONTROL OF ALGAE WITH STRAW*

INTRODUCTION

Algae cause a number of problems in water. They impede flow in drainage systems, block pumps and sluices, interfere with navigation, fishing and other forms of recreation, cause taint and odour problems in potable waters, block filters and, in some instances, create a health hazard to humans, livestock and wildlife. These problems seem to be increasing, probably because nutrient levels in water are rising as a result of human activity and natural processes. At the same time there is a growing worldwide demand for improvement in water quality. Thus, the need to control algae is increasing for environmental, recreational and public health reasons.

Because of their small size and rapid growth rates, algae are difficult to control by methods used for other aquatic plants. Cutting and other forms of mechanical control can help to reduce problems with filamentous algae but are of very limited use. Many algae are susceptible to appropriate herbicides but this approach is unpopular in some waters on environmental and public health grounds. Furthermore, herbicides which control algae also kill higher plants so that, although the water is cleared temporarily of all plants, once the herbicide has gone from the water, the regrowth of algae is not restricted by competition from the higher plants and the problem can get worse in subsequent years.

A new method of controlling algae has been developed by the Centre for Aquatic Plant Management which overcomes many of these problems. This involves the application of barley straw to water and has been tested in a wide range of situations and in many countries throughout the world and has proved to be very successful in most situations with no known undesirable side-effects. It offers a cheap and environmentally acceptable way of controlling algae in water bodies ranging from garden ponds to large reservoirs, streams, rivers and lakes.

Despite the simplicity of the idea, experience has shown that there are a number of basic rules which must be followed to ensure that the straw works successfully. The purpose of this leaflet is to provide practical advice on the optimum ways of using straw.

HOW STRAW WORKS

In order to use straw effectively, it is necessary to understand something of how the process works. When barley straw is put into water, it starts to rot and during this process a chemical is released which inhibits the growth of algae. Rotting is a microbial process and

is temperature dependent, being faster in summer than in winter. As a rough guide, it may take 6-8 weeks for straw to become active when water temperatures are below 10°C but only 1-2 weeks when the water is above 20°C. During this period, algal growth will continue unchecked. Once the straw has started to release the chemical it will remain active until it has almost completely decomposed. The duration of this period varies with the temperature and the form in which the straw is applied and this will be discussed in more detail later. However, as a generalisation, straw is likely to remain active for approximately six months, after which its activity gradually decreases.

Although the exact mechanism by which straw controls algae has not been fully proven we believe that the process may occur as follows. When straw rots, chemicals in the cell walls decompose at different rates. Lignins are very persistent and are likely to remain and be released into the water as the other components decay. If there is plenty of oxygen available in the water, lignins can be oxidised to humic acids and other humic substances. These humic substances occur naturally in many waters and it has been shown that, when sunlight shines onto water which contains dissolved oxygen, in the presence of humic substances, hydrogen peroxide is formed. Low levels of peroxide are known to inhibit the growth of algae and experiments have shown that sustained low concentrations of hydrogen peroxide can have a very similar effect on algae to that of straw. Peroxides are very reactive molecules and will only last in water for a short time. However, when humic substances are present, peroxides will be continuously generated whenever there is sufficient sunlight. The slow decomposition of the straw ensures that humic substances are always present to catalyse this reaction.

There are various factors which affect the performance of straw and which support this hypothesis. It is important to take these factors into account to ensure successful treatment of algal problems with straw.

1: Type of Straw

Barley straw works more effectively and for longer periods than wheat or other straws and should always be used in preference to other straws. If barley is unavailable, other straws, including wheat, linseed, oil seed rape, lavender stalks and maize can be used as a substitute. The information in this leaflet describes the use of barley straw. If other straws are used, it is likely that the quantities applied and frequency of application may have to be increased.

We have tested a range of barley straw varieties, including some grown organically; all these were active at the same level. Hay and green plant materials should not be used because they can release nutrients which may increase algal growth. Also they rot very rapidly and may cause deoxygenation of the water.

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increase by several orders of magnitude within a few months. As the straw gradually rots away and the numbers of invertebrates increases, individuals leave the safety of the straw and become prey to fish and waterfowl. Invertebrate animals are generally beneficial to water bodies as they help to decompose organic matter in the bottom; some of them graze on algae and aquatic plants and they form an important part of the food chain.

3 **Effects on fish and waterfowl** There have been a number of observations of improved growth, vigour and health of fish in waters treated by straw. One reason for this is likely to be the increased food supply in the form of invertebrate animals. Fish may also find it easier to find food in water which is not densely colonised by unicellular or filamentous algae. However, another possible explanation is that, by controlling the algae, the straw allows better light penetration to occur to deeper levels in the water so that photosynthesis can occur in a greater volume of the water body and so provide an improved environment for the fish. It has also been noted by the Game Conservancy that young ducklings require a diet which consists mainly of invertebrate animals. They found that adding straw to gravel pits significantly increased the survival of young ducklings.

In a number of water bodies, ducks and other waterfowl have been observed to nest and roost on floating masses of straw. This has been particularly beneficial to these birds in waters subject to high levels of human interference and terrestrial predators as the floating straw masses are usually inaccessible from the bank.

There have been a number of anecdotal reports that incidents of some fish diseases and parasites appear to have been reduced in fisheries and fish farms in which straw has been used.

4 **Effects of straw in flowing waters** When straw has been applied in flowing waters, either in the form of bales or in gabions, it has been noted that water is deflected around the straw and the accelerated flow caused silt and fine gravel to be washed away from the vicinity of the straw. In a small stream which had a very uniform depth, pairs of gabions containing straw were placed opposite each other and angled downstream so as to create a rapid flow between them. This caused the gravelly bed of the stream to wash out and so scour holes were formed. These were immediately colonised by trout which were the dominant fish species. The overall effect created by three pairs of gabions placed at approximately 100 m intervals was to create a pool and riffle environment which is usually considered to be preferable to a uniform channel for fish and aquatic life generally. In small streams, it is likely that careful placement of straw bales or gabions could be used to manipulate the location of silt deposits ensuring that an open channel is maintained and that silt beds are allowed to develop only in acceptable locations.

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ENVIRONMENTAL CONTROL

Because most emergent weeds are limited to water less than about 1m deep, it is sometimes possible to control them either by raising the water level or by dredging. When dredging becomes necessary in areas where emergent weeds cause problems, the creation of a steep bank descending immediately into water of more than 1m deep will limit the growth of these plants to a narrow fringe along the bank.

A narrow fringe of marginal vegetation is desirable because it acts to stabilise the toe of the bank from wave damage and often traps silt and other runoff from adjacent land. They are often used as the final stage in buffer strips.

BEST OPTION

In most instances, the use of glyphosate will provide the most cost-effective control with little environmental damage. The effects are longer-lasting than cutting and the herbicide can be applied easily in most situations where access to machinery may be limited. Control can be localised by careful direction of the spray so that predetermined areas of emergent weed can be preserved.

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Note: *Herbicides should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of Herbicides on Weeds in or near Watercourses and Lakes. It is necessary to consult the local Environment Agency, SEPA or other Regulatory Water Authority before applying herbicides.*

The CAPM is part of the Institute of Arable Crops Research Long Ashton Research Station and is supported by the Environment Agency, British Waterways, Internal Drainage Boards and Regional Flood Defence Committees.

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INFORMATION SHEET 4

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research

Control of Emergent Rushes, Reeds, Sedges and Grasses

(*Bulboschoenus, Glyceria, Phragmites, Sparganium and Typha*)

INTRODUCTION

Phragmites australis

Rushes, reeds and sedges are perennial plants which grow in or near static or flowing water and on marshy ground. When growing in water, they are usually found in water of less than 1m depth. Most of these species have rhizomes from which aerial shoots emerge in the spring, growing to a height of up to 3m (depending on the species) and dying back in the autumn. Although some species can also reproduce by seed the main method of spread is by vegetative growth from the rhizomes. Once the plants are established in shallow water, they trap silt around the roots and shoots. This can impede or divert water flow and allow further spread of the plants into water previously too deep areas to sustain them.

MECHANICAL CONTROL

These plants can be cut by hand, using a scythe, or by machine, using weed cutting buckets or boats. The choice of technique depends on the area involved and on factors such as water depth, ease of access and availability of suitable equipment. Cutting only removes the emergent shoots and does not affect the buried rhizomes from which new shoots will emerge. If cutting is carried out early in the season in May or June, a second cut may be necessary before the end of the season. Also May to early July is the period when birds use the plants for nesting and reproduction. Therefore, cutting then is severely environmentally damaging. **Delaying the cut until later in July and August is** recommended. This also reduces the time for the shoots to regrow to a troublesome extent before the end of the growing season. After cutting, the weed must be removed from the water and deposited well [illegible] from the bank where it cannot fall or be washed by [illegible]s back

Typha latifolia

Glyceria maxima

into the water. Alternatively, it may be necessary to remove the weed and dispose of it in an authorised tip.

Some emergent weeds, particularly *Phragmites australis* (the Common Reed), do not readily decompose in the autumn and, in some situations, it may be necessary to cut and remove the dead shoots in autumn to clean the channel and prevent impedance of winter flows.

Dredging often removes the rhizomes as well as the emergent shoots and so produces longer lasting control but is generally too expensive to be used purely as a method of weed control. When it is anticipated that a water body infested with rushes, reeds and sedges will require dredging, it may be beneficial to spray the emergent weeds with glyphosate (as described below) at least three weeks before dredging to kill the rhizomes and prevent their spread from the dumped spoil into adjacent agricultural land.

CHEMICAL CONTROL

Rushes, reeds and sedges are all susceptible to the herbicide glyphosate, sold under a number of product names which are approved for use in or near water. This herbicide is applied as a spray directly onto exposed foliage, usually in mid to late summer, and is then translocated to the rhizomes. Thus, it kills the whole plant and control can last for several seasons (normally 3). Only those plants which are treated with the spray are controlled so that localised control of selected areas or individual weed beds can be achieved. Plants which are to be controlled with glyphosate should have well-developed, undamaged foliage exposed above the water surface at the time of spraying. Plants which have been damaged by cutting or grazing, or which have been bent over or broken by flooding or other forms of mechanical damage are less likely to be controlled.

Carex acutiformis

Glyphosate is a slow acting herbicide and plants which are sprayed late in the season appear to die back naturally in the autumn at the same time as unsprayed plants. However, treated plants do not regrow in the following spring.

Although glyphosate is normally applied in mid to late summer, the evidence that

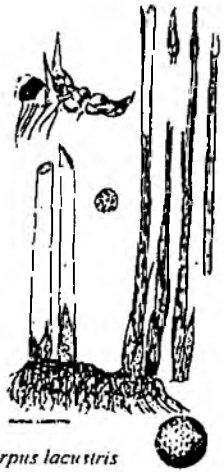
effective control of some emergent species can be achieved by spraying as early as May or June. Early season control has the advantages that the risk of summer flooding and other problems caused by the weeds during the growing season are reduced. Also, the weeds die back and decompose more rapidly if sprayed when still young and tender. If the plants are sprayed early in the season, there is also less likelihood of the plants being damaged before the spray is applied.

In slow flowing rivers which have become overgrown with emergent plant across the whole width of the river, a clear channel can be created by spraying a swath through the middle of he channel to restore adequate flow. This is a good method of restoring acceptable flows to rivers which have been artificially widened (and so become shallower). Clearance of a 2 metre wide channel will allow preferential flow and create a deeper channel which will prevent recolonisation by emergent plants but allow recolonisation by submerged aquatic plants. This is a form of bioengineering. Clearance of straight channels should be avoided and a meandering channel is preferred in most cases. The river can then be allowed to maintain a clear central channel and a wide marginal fringe.

BIOLOGICAL CONTROL

Cattle and, to a lesser extent, sheep graze on some types of rushes and reeds. Livestock are used for biological control particularly on large embankments where they provide a cost-effective form of management of grasses and other terrestrial plants as well as bankside rushes and reeds. However, livestock cause damage to banks and require fencing and regular husbandry and these disadvantages can outweigh the benefit of the weed control.

Phalaris arundinacea



Scirpus lacustris

INFORMATION SHEET 5

Centre for Aquatic Plant Management
Long Ashton Research Station
Institute of Arable Crops Research

CONTROL OF HIMALAYAN BALSAM

(Impatiens glandulifera)

INTRODUCTION

Himalayan Balsam (*Impatiens glandulifera*) is an introduced plant which has escaped from gardens and is rapidly colonising river banks and other areas of damp ground. It is an annual plant which grows to about 2 m with purplish-pink slipper shaped flowers in June - August. When the seed pods are mature, they explode when touched, scattering the seed. It is likely that the seeds are further spread by water movements. Himalayan Balsam forms dense stands which suppress the growth of grasses and native British plants leaving the banks bare of vegetation in autumn and winter and liable to erosion. Because Himalayan Balsam regrows annually from seed, any form of control carried out after the seed pods have formed will have no long-term benefit.

MECHANICAL CONTROL

The plant is easy to cut, either by hand or machine, provided there is adequate access. However, it often grows amongst bushes and brambles and in inaccessible locations on river banks. Unless the plant is cut below the lowest node, it will regrow and flower later in the season. Thus, a single cut is only

effective if made very close to the soil level. Regular mowing will also control this plant even if the cutting level is above the lowest node, provided the frequency is sufficient to prevent the formation of flowers and seeds.

Small infestations can be controlled by hand pulling as the plant is shallow rooted.

Mechanical control is likely to be effective only in those locations where good access is available to ground smooth enough for close mowing and free of shrubs or bushes.

CHEMICAL CONTROL

Himalayan Balsam can be controlled by spraying the foliage with glyphosate. The plants should be sprayed in the spring before flowering but late enough to ensure that germinating seedlings have grown up sufficiently to be adequately covered by the spray. Glyphosphate is sold under a number of product names including Roundup, Spasor and Sonic.

Small infestations and individual plants can be controlled by using glyphosate in a weed wiper. This has the advantage of preserving native plants and grasses which would otherwise be killed by the glyphosate.

The herbicide 2,4-D amine controls many broadleaves annual weeds and, although not fully tested on Himalayan balsam, may also control this species. This selective herbicide will not kill grasses which help to stabilise banks and so may be preferable to glyphosate in those situations where the weed has not produced complete cover of the grasses. 2,4-D amine is available under the product names of Atlas 2,4-D and Dormone.

A long-lance sprayer, available from Cooper Peglar Ltd, may assist in the spraying of less accessible areas out of the reach of conventional knapsack sprayers.

BIOLOGICAL CONTROL

Although no specific biological control agents are known to control this species, regular grazing of infested areas by cattle and sheep are likely to prevent the spread of Himalayan Balsam either by grazing on young seedlings or by trampling.

ENVIRONMENTAL CONTROL

The only environmental control likely to suppress the invasion of banks by this weed is the maintenance of a dense grass sward. This helps to prevent the germination of seedlings. However, once established, the shading effect of Himalayan Balsam suppresses grasses, thus encouraging further seed germination.

BEST OPTION

Control existing infestations of Himalayan Balsam by spraying with glyphosate, 2,4-D amine or by regular cutting. Carry out regular inspections of the banks in spring and hand pull or spot treat any germinating seedlings with a weed wiper or knapsack sprayer.

NOTE: *Herbicide should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of herbicides on weeds in or near watercourses and lakes. In most situations it is necessary to consult the local Water Authority before applying the herbicide.*

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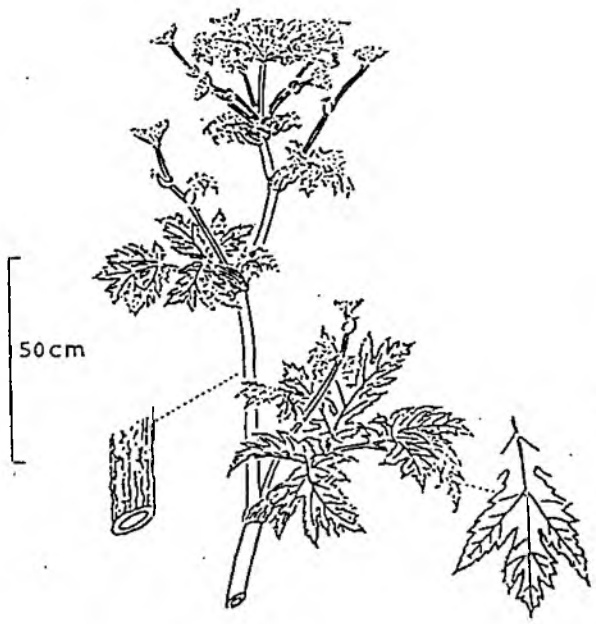
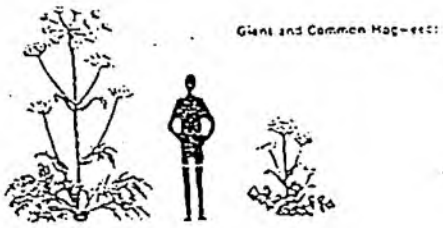
INFORMATION SHEET 6

CONTROL OF GIANT HOGWEED

Centre for Aquatic Plant Management
Long Ashton Research Station
Institute of Arable Crops Research





INTRODUCTION

Giant Hogweed (*Heracleum mantegazzianum*) was introduced into Britain in the 1893 as an ornamental plant. Recently, it has escaped and is now colonising many areas of waste land and river banks. It can grow to some 4m high and has an umbel of white flowers from which it produces large numbers of viable seeds. When these seeds fall into water they can be dispersed by currents and washed up along the bank, causing the plant to spread along watercourses. In a natural state, the plant is biennial, growing from seed in the first year and flowering in the second season. However, if the plant is cut down before it produces seed, it will survive into a third or subsequent season, attempting to flower each year. It can form dense colonies which suppress the growth of native plants and grasses and leave the banks bare of vegetation in the winter. These are then liable to erosion or to recolonisation by seeds of Giant Hogweed washed downstream onto the bare ground.

Warning: The sap of Giant Hogweed contains a toxic chemical which sensitises the skin and leads to severe blistering when exposed to sunlight. This reaction can recur for many years.

MECHANICAL CONTROL

Hand cutting should never be undertaken unless the operator is wearing full protective clothing to prevent skin contamination by the sap. Machine operators should take similar precautions because the sap can be spread onto machinery and subsequently come into contact with skin. Cutting before flowering will, at best, produce only temporary control and ensures that the plant regrows in the following season. Cutting after flowering has no benefit once the seeds have been formed, except to clear away the dying vegetation. Small infestations can be controlled by digging out the whole plant. It is possible that large infestations may be controlled by deep cultivation (ploughing) although this has not been tested and is generally impractical on river banks.

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impractical on river banks.

CHEMICAL CONTROL

The only herbicide which is known to control Giant Hogweed and which is approved for use in or near water, is glyphosate. The plants can be sprayed with glyphosate (available under various product names such as - Roundup, Spasor and Sonic) at a rate of 5l per ha when the plants are growing actively but still less than about 1m high. This is usually in April and May. Long-lance sprayers (available from Cooper-Peglar Ltd) may assist in accurate application of glyphosate to plants growing in inaccessible sites along river banks. Glyphosate can be applied as a spot treatment to individual plants, using hand-held equipment, or as an overall spray using machine-mounted spray booms. In the latter instance, total weed control of all vegetation will occur and it may be necessary to reseed the treated area with grass and other native plants. Establishing a good sward of grasses soon after treatment of the weed will help to reduce the rate of recolonisation of the area by seeds of Giant Hogweed. Before using glyphosate in or near water, the approval of the local water authority should be sought.

BIOLOGICAL CONTROL

None known.

ENVIRONMENTAL CONTROL

None known, although maintaining a dense grass sward may help to reduce germination of seedlings.

ADDITIONAL NOTES

The seeds of this plant are thought to remain viable for up to 7 years. Once a plant has produced seed, it should be assumed that the seeds will be present in the surrounding area for at least this length of time. Control measures will only affect those plants which have already germinated and viable seed may continue to germinate each year until the seed bank is exhausted. Therefore, eradication, as opposed to temporary control for one season only, requires regular annual checks to ensure that any germinating plants are controlled before they can seed.
On river banks, seeds may be washed downstream from colonies along the river bank. Any attempt to eradicate this plant is unlikely to succeed unless control is exercised along the whole river system.

BEST OPTION

Spray individual plants or whole colonies with glyphosate in April or May. Reseed the area once the plants have died off. Spot treat new plants as they appear.

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NOTE: *Herbicide should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of herbicides on weeds in or near watercourses and lakes. In most situations it is necessary to consult the local Water Authority before applying the herbicide.*

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INFORMATION SHEET 7

Control of Japanese Knotweed

Centre for Aquatic Plant Management
IACR Long Ashton Research Station
Integrated Approach to Crop Research

INTRODUCTION

Japanese Knotweed (known by three Latin names - *Reynoutria japonica, Fallopia japonica* or *Polygonum cuspidatum*) is an introduced weed which has escaped and is rapidly colonising river banks and areas of waste land. It is a perennial plant which grows from rhizomes in the spring to a height of about 3 m in mid summer with stiff, bamboo-like stems. In the autumn, the leaves and stems die but remain stiff and erect. The plant produces large masses of white flowers in summer but it is not thought to produce viable seeds. The plant overwinters in the form of rhizomes which grow rapidly and have been known to grow through rock, concrete and tarmac. Cut or broken stems lying on damp soil can root and form new plants. The spread of this plant to new sites may be caused by the transport of contaminated topsoil because fragments of rhizome as small as 1 gram can produce new plants. Spread along river banks may also occur when the shoots are cut and allowed to float downstream and are washed onto damp soil beside the river. Japanese Knotweed forms dense stands which severely impede access to river banks and shade out native species leaving the banks bare and liable to erosion in winter. The rhizomes can penetrate, damage and displace stone and concrete embankments and structures.

MECHANICAL CONTROL

Cutting the shoots in spring or summer has no long-term control and may encourage the spread of this weed unless the shoots are collected and burnt. The rhizomes appear to be able to survive for many years, even if shoots are cut regularly. Digging, ploughing and dredging are unlikely to have any long-term benefit because of the extensive nature of the rhizome system and because of the ability of even small fragments to regrow.

Transport of soil contaminated with this plant should be avoided and green shoots should not be cut and allowed to float away from any infected area where engineering works are being undertaken but should be collected, dried and burnt.

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CHEMICAL CONTROL

The only herbicide approved for use in or near water which controls this plant is glyphosate. The green shoots should be sprayed with glyphosate at 1.8 kg/ha when the plant is about 1 m high, usually in May. Total eradication is unlikely following a single application and to achieve this, shoots should be cut at least 3 weeks after the initial spraying so that any regrowth can be sprayed later in the season, usually in July or August. If the initial treatment in May is not made, later applications of glyphosate can be effective in July or August when the plant is fully grown. However, by this stage, the height of the plant will make application difficult. A long-lance sprayer (available from Cooper Peglar) may be useful when applying glyphosate to Japanese Knotweed because of the height of the plant and because it forms dense stands, often in inaccessible sites along river banks.

Regular inspections, preferably in May and August, of treated sites are recommended for at least two years with spot treatments of glyphosate on any surviving plants.

BIOLOGICAL CONTROL

None known, although considerable research effort is being made to identify appropriate control agents.

ENVIRONMENTAL CONTROL

Once the plant has become established, there is no environmental method of controlling it. However, the plant appears to be spread in two ways. First by the importation of contaminated soil which contains fragments of rhizome and it is advisable to ensure that any soil imported to a site is free of contamination. Secondly, the plant is spread by cut or broken stems floating downstream and washing onto bare muddy banks. These fragments are less likely to be able to establish on banks protected by a fringe of reed, covered by a dense grass sward which will hold the stems above the soil surface and allow them to dry out, or banks which have hard surfaces of stone, concrete or steel shuttering.

BEST OPTION

Spray infestations of Japanese Knotweed with glyphosate in May, cut the sprayed shoots after 3 weeks and spray any regrowth in July or August. Check for any reinfestation for at least two seasons and spot treat.

Do not use mechanical control as this is likely to spread and increase infestation.

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Note: *Herbicide should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of Herbicides on Weeds in or near Watercourses and Lakes. In most situations it is necessary to consult the local Water Authority before applying the herbicides.*

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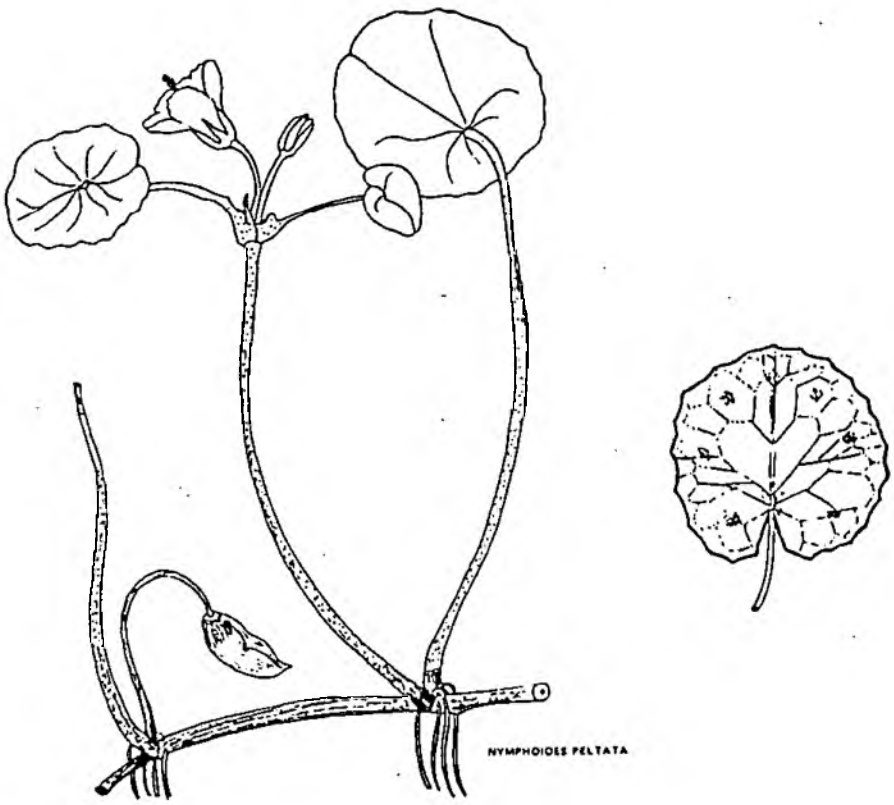
INFORMATION SHEET 8

Control of Fringed Waterlily

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research



INTRODUCTION

Fringed Waterlily (*Nymphoides peltata*) was regarded until recently as a relatively rare plant and was generally conserved. In recent years, it has spread and is now causing problems in waters which are usually static or very slow flowing. It produces floating leaves similar to, but smaller and rounder in shape, than the common Yellow or White Waterlily (see diagram). The flowers are yellow with distinctive fringed petals. It can grow in water up to 1.5 m deep. The leaves and flower stems grow from rhizomes buried in the mud and the plant can form a dense floating cover over the water surface, interfering with angling, swimming and boat traffic. The surface cover of leaves tends to shade out submerged plants and algae and this can be an advantage in shallow water where these weeds may be troublesome, but in deeper water bodies deoxygenation can be a problem.

MECHANICAL CONTROL

The leaf petioles are easily cut by hand scythe (in shallow water) or by weed cutting buckets or boats. However, the plant will form new leaves and one or two cuts may be necessary each spring and summer to maintain the water adequately for recreation or boat traffic. It is necessary to remove cut material otherwise the floating masses will continue to cause problems and may deoxygenate the water when they rot. Cutting will not eradicate the plant but may be the best option in water bodies where cutting of other weeds is regularly practised.

Mechanical eradication can only be achieved by dredging or raking out the rhizomes buried in the bottom silt. This is seldom 100% effective and is too expensive to be considered solely as a method of weed control but will produce useful results when dredging is required for other purposes. Hand raking, using a rope and grapnel, can be effective where the bottom silt is sufficiently soft and in very localised areas for creating fishing swims.

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CHEMICAL CONTROL

A formulation of dichlobenil (Casoron GSR) has been found to be effective against this plant. This is a granular formulation which is applied in the spring when growth is just starting but well before the leaves reach the surface. The granules sink into the bottom sediment and the herbicide is absorbed by the roots of the plant. Because the granules hold the herbicide and release it locally into the sediment, it is necessary to ensure that they are spread evenly within the treated area and appropriate motorised or hand operated granule applicators are recommended for this treatment. It is possible to treat small localised areas within a waterbody and the manufacturers recommend that not more than 20% of the waterbody is treated at any one time in densely infested waters. In experiments carried out by the CAPM, about 90% of the plants within a treated area were controlled by a single application of Casoron GSR. Where complete eradication is required, a second application in the following season may be necessary.

Casoron GSR is not recommended for use in water which flows at more than 90 m/hour.

The herbicide glyphosate has also been used to control *Nymphoides peltata* although it is less effective than Casoron GSR. In a number of trials, the floating leaves have been sprayed with glyphosate at times between July and early September. In some instances, control was estimated to be around 80-90%, lasting for at least two seasons, while in others, recovery started towards the end of the season and there was no long-term control. The reasons for this variation in results have not been established.

BIOLOGICAL CONTROL

None known.

ENVIRONMENTAL CONTROL

Fringed waterlily does not normally grow in water more than 1.5 m deep or in fast flowing waters. In some instances, it may be possible to alter water depth or flow characteristics in channels to make them unsuitable for this plant. Small areas can be eliminated by shading the plant with a floating opaque material.

BEST OPTION

Treat infected areas with Casoron GSR in early spring when growth is just starting. Treat localised areas, not exceeding 20% of the water area at any one time. If necessary re-treat surviving plants in the following season.

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Note: *Herbicide should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of Herbicides on Weeds in or near Watercourses and Lakes. In most situations it is necessary to consult the local Water Authority before applying the herbicides.*

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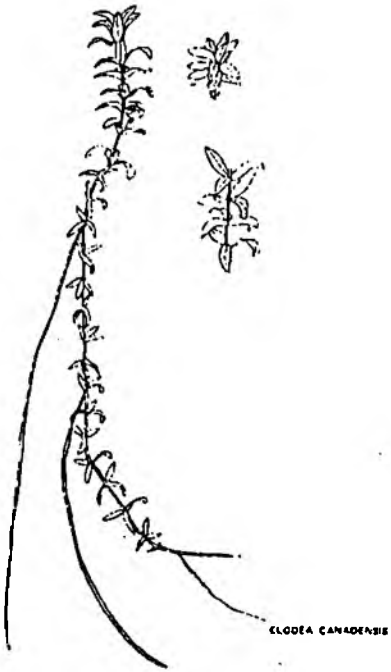
INFORMATION SHEET 9

Centre for Aquatic Plant Management
ACR Long Ashton Research Station
Integrated Approach to Crop Research

Control of Canadian Pondweed
Elodea canadensis



INTRODUCTION

Canadian Pondweed (*Elodea canadensis*) is native to North and South America where it occurs in lakes ponds, canals and slowly flowing water. It was introduced to Ireland in 1836 and spread rapidly to Europe soon after, occurring in the same habitats. In many regions of the world it is considered a pest. It grows from stolons (creeping stems) and has vertical, narrow, sparsely branched stems with leaves in whorls of three. The leaves are flat (not recurved like *Lagarosiphon* or *E. nutallii*). It can form dense mono-specific stands. It does not reproduce by seed in the UK and relies entirely on vegetative reproduction for its spread. Although it is now regarded as a naturalised aquatic plant, it causes problems by competing for nutrients and outgrowing many native species.

MECHANICAL CONTROL

This plant is easily cut and controlled for short periods (1-2 months in summer) by mechanical control methods. The cut weed should be removed from the water to avoid deoxygenation. The cut weed can be left to decompose in small heaps away from the side of the water, taking care to avoid seepage of the liquor back into the water. However, if large amounts are to be disposed of then it should be taken to a recognised local authority tip or landfill site.

There are several appropriate methods of mechanical control, removal by hand, raking, chains, weed bucket weed boat or dredging. All are suitable.

CHEMICAL CONTROL

E. canadensis is susceptible to terbutryn, diquat and dichlobenil applied in spring before the plant is fully grown. The only product approved for use in or near water containing terbutryn is Clarosan 1FG. It is a granule formulation. This herbicide will kill all submerged vegetation and can only be used in still water. Approved products containing dichlobenil are Casoron G and Casoron GSR. These are also granules. Only Casoron G should be used in shallow and/or narrow watercourses. Casoron GSR can give some degree of localised control if used carefully. The flow limitation with these products is up to 1.5 m per min. Dichlobenil affects most rooted submerged plants and some rushes too. The approved products containing diquat are Reglone and Midstream. Reglone is a liquid and can be applied as a spray to the water surface or directly by subsurface injection. Midstream is a viscous gel and can be used in flowing water or for localised control in still or slow flowing waters. It requires special application equipment. Diquat is not effective in muddy water.

The relative cost of each herbicide to treat a hectare (relative to Reglone equal to one at £275 per hectare) is as follows Reglone: 1 - 2; Clarosan 1FG: 1.56 - 3.09; Casoron GSR: 1.51; Casoron G: 1.75; Midstream: 2.47. This represents a range of between £275.00 and £850.00 per hectare at 1994 prices. Chemical control is always cheaper than mechanical control.

Chemical control will give effective eradication of the plant for between 2 and 3 years. Regular inspections should be made to check on re-infestation and spot treatments should be applied to prevent further spread.

Be sure to obtain the agreement of the local Environment Agency before applying any herbicide to water.

BIOLOGICAL CONTROL

The use of herbivorous Grass Carp is appropriate as a control method for this plant. Common Carp, and other bottom feeding fish, which create turbid water, can also be effective in preventing regrowth of the plant after mechanical removal or control by a herbicide. There have been reports of sudden population crashes of this species and it may be that some form of self regulation occurs in some situations. It is not known if this is due to a pathogen.

ENVIRONMENTAL CONTROL

Shade will control most submerged aquatic plants. This can be achieved by planting trees on the south side of waterbodies or by using a floating sheet of opaque material. Care must be taken when using the latter to prevent sudden deoxygenation.

BEST OPTION

In mixed stands: Remove as much of the plant as possible by mechanical means and apply spot treatments of Casoron GSR or Midstream to remaining infestations.

In mono-specific stands in enclosed still waters use Clarosan 1FG after mechanical removal.

If mechanical removal is not possible then treat with any of the appropriate herbicides being sure to read the label recommendations

If you prefer a biological control option then use Grass Carp. Be sure to obtain all the necessary agreements from MAFF, Environment Agency and English Nature (if near an SSSI).

The information provided in this document represents the current best available advice. Users should take all reasonable precautions to ensure that they comply with current Codes of Practice, and have notified the relevant authorities of their intentions. This document has no standing in law.

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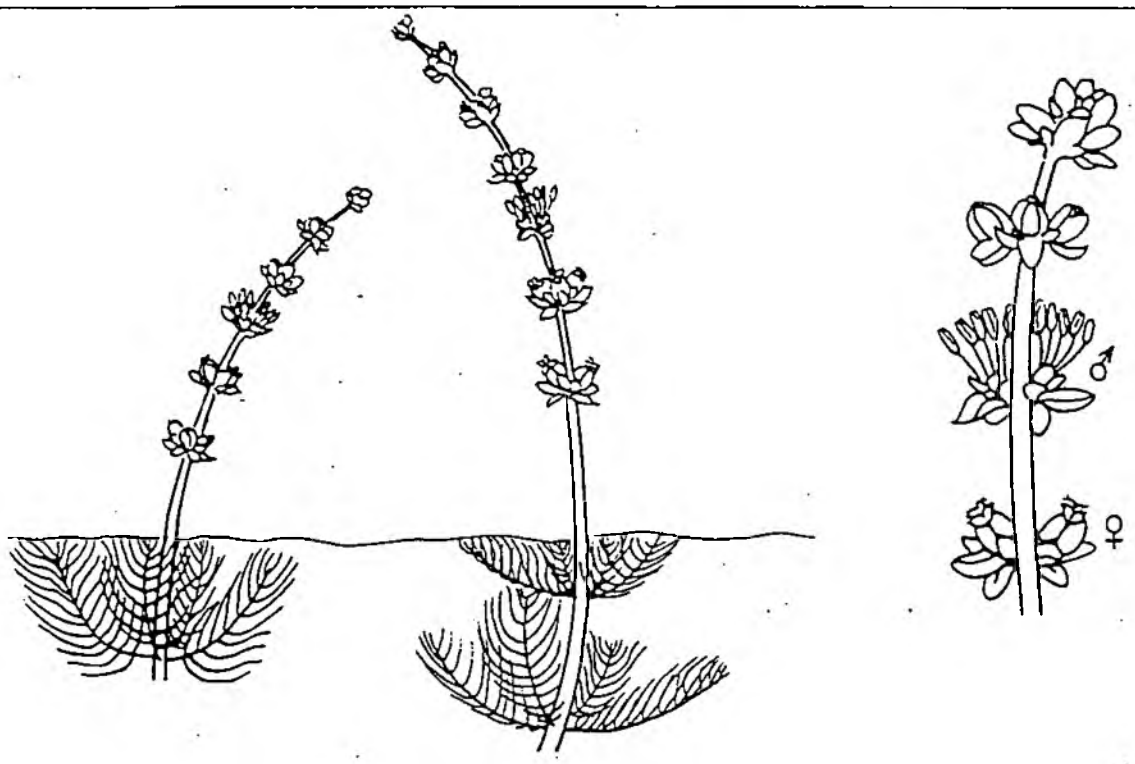
INFORMATION SHEET 10

Control of *Myriophyllum spicatum* (Spiked Water-milfoil)

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Institute of Arable Crops Research



INTRODUCTION

Myriophyllum spicatum (Spiked Water-milfoil) is a submerged aquatic macrophyte. It is characterised by groups of four feathery leaves arranged around a circular stem. The stem can be slightly reddish in colour. It should not be confused with *M. verticillatum* which has light green emergent leaves, or *M. alterniflorum*, a species characteristic of oligotrophic (low nutrient/slightly acidic) waters. It often forms dense mono-specific stands, or is commonly associated with Canadian Pondweed (*Elodea canadensis*). This plant often grows in lakes, ponds and ditches, but is not found in faster flowing water. It reproduces by seed and by vegetative growth and control measures should take this into account.

MECHANICAL CONTROL

This plant responds well to mechanical control. Dredging is the most effective means of removal, however, cutting has a relatively short term (1-2 months in summer) effect. The cut material must be removed from the water to avoid deoxygenation. The cut weed can be left to decompose in small heaps away from the side of the water, taking care to avoid seepage of the liquor back into the water. However, if large amounts are to be disposed of then it should be taken to a recognised local authority tip or landfill site.

There are several appropriate methods of mechanical control, removal by hand, raking, scythes, chains, weed bucket, weed boat or dredging. All are suitable.

CHEMICAL CONTROL

Myriophyllum spicatum is susceptible to terbutryn, diquat and dichlobenil applied in spring before the plant is fully grown. The only product approved for use in or near water containing terbutryn is Clarosan 1FG. It is a granule formulation. This herbicide will kill all submerged vegetation and can only be used in still

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water. Approved products containing dichlobenil are Casoron G and Casoron GSR. These are also granules. Only Casoron G should be used in shallow and/or narrow watercourses. Casoron GSR can give some degree of localised control if used carefully. The flow limitation with these products is up to 1.5 m per min. Dichlobenil affects most rooted submerged plants and some rushes too. The approved products containing diquat are Reglone and Midstream. Reglone is a liquid and can be applied as a spray to the water surface or directly by subsurface injection. Midstream is a viscous gel and can be used in flowing water or for localised control in still or slow flowing waters. It requires special application equipment. Diquat is not effective in muddy water.

The relative cost of each herbicide to treat a hectare (relative to Reglone equal to one at £275 per hectare) is as follows Reglone: 1 - 2; Clarosan 1FG: 1.56 - 3.09; Casoron GSR: 1.51; Casoron G: 1.75; Midstream: 2.47. This represents a range of between £275.00 and £850.00 per hectare at 1994 prices. Chemical control is always cheaper than mechanical control.

Chemical control will give effective eradication of the plant for between 2 and 3 years. Regular inspections should be made to check on re-infestation and spot treatments should be applied to prevent further spread.

Be sure to obtain the agreement from your local Environment Agency before applying any herbicide to water.

BIOLOGICAL CONTROL

The use of herbivorous Grass Carp is appropriate as a control method for this plant. Common Carp, and other bottom feeding fish, which create turbid water, can also be effective in preventing regrowth of the plant after mechanical removal or control by a herbicide. There have been reports of sudden population crashes of this species and it may be that some form of self regulation occurs in some situations. It is not known if this is due to a pathogen.

ENVIRONMENTAL CONTROL

Shade will control most submerged aquatic plants. This can be achieved by planting trees on the south side of waterbodies or by using a floating sheet of opaque material. Care must be taken when using the latter to prevent sudden deoxygenation.

BEST OPTION

In mixed stands: Remove as much of the plant as possible by mechanical means and apply spot treatments of Casoron GSR or Midstream to remaining infestations.

In mono-specific stands in enclosed still waters use Clarosan 1FG after mechanical removal.

If mechanical removal is not possible then treat with any of the appropriate herbicides being sure to read the label recommendations

If you prefer a biological control option then use Grass Carp. Be sure to obtain all the necessary agreements form MAFF, the Environment Agency and English Nature (if near an SSSI).

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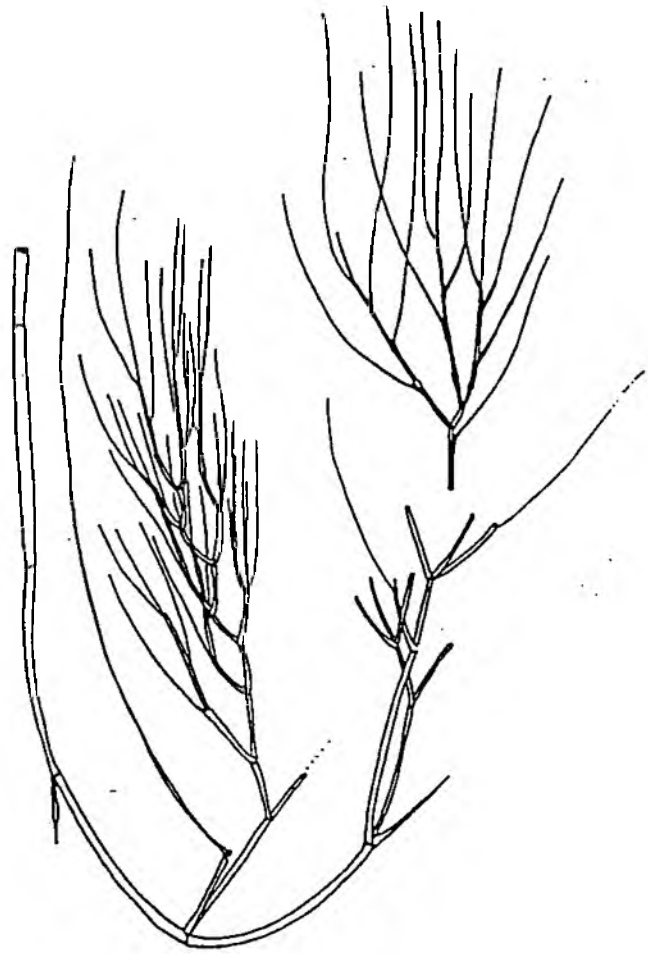
INFORMATION SHEET 11

Control of *Potamogeton pectinatus* (Fennel Pondweed)

Centre for Aquatic Plant Management
Long Ashton Research Station
Institute of Arable Crops Research



INTRODUCTION

In Britain there are 21 species of Pondweed and 4 hybrids, some of which are rare and others very scarce. Only *P. pectinatus, P. natans, P. crispus, P. perfoliatus* and occasionally *P. berchtoldii* and *P. pusillus* should be considered as weed species. Pondweeds can be locally troublesome, impeding flow and interfering with recreation and navigation. Probably the most troublesome species is Fennel Pondweed.

Potamogeton pectinatus is a submerged macrophyte. It is characterised by growth from a creeping stolon, which takes the form of dichotomously cylindrical branching stems and leaves. It only roots from the joint between the stolon and the stem. It takes its common name, Fennel Pondweed, from the feathery appearance of the leaves in water. It can grow in still or flowing water. It reproduces vegetatively and by the production of "turions", which are specialised leaf buds formed at the end of Summer and into Autumn, which drop off into the sediment and from which a new plant grows in the following Spring. Turions are resistant to all forms of control apart from dredging.

MECHANICAL CONTROL

All Pondweed species can be cut but regrowth, especially early in the summer, is often rapid. Where Pondweeds have been cut regularly there is usually no evidence of any reduction in regrowth and the plant will tolerate this form of management almost indefinitely.

Mechanical control can be achieved by hand cutting, by weed bucket or by weed boat. Cutting should be as deep as possible to reduce the risk of regrowth later in the season. Cutting can be carried out at any time when there is sufficient growth to merit control, but as there is a risk of regrowth after early season cuts, cutting should normally not be carried out until mid to late summer.

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CHEMICAL CONTROL

In static waters, herbicides can give good control of Fennel Pondweed, although this species is seldom eradicated, probably because the turions are unaffected and regrow after the herbicide has degraded. In flowing waters, diquat alginate has achieved good control of many Pondweeds although Fennel Pondweed in its flowing water form is generally unaffected.

Diquat alginate (Midstream) can be used for localised control in static water and for full or localised control in water flowing at more than 90 m/h. On Fennel Pondweed in fast flowing waters, diquat alginate will produce poor control, especially in hard water, and in these conditions cutting is probably the most cost effective form of control. Applications of diquat alginate should be made in spring or early summer when plants are young and growing actively but before they have reached the surface.

In static or slow flowing rivers with a velocity of less than 90 m/h dichlobenil (Casoron G or Casoron GSR) can be used and in lakes where flow is less than 20 m/h terbutryn (Clarosan) can be used as an alternative. Where localised control is required, use the slow-release formulation, Casoron GSR. Use terbutryn where control of algae as well as Pondweeds and other submerged weeds is required. Applications should be made early in the spring when growth is just starting.

BIOLOGICAL CONTROL

The use of herbivorous Grass Carp is appropriate as a control method for this plant. Common Carp, and other bottom feeding fish, which create turbid water, can also be effective in preventing regrowth of the plant after mechanical removal or control by a herbicide.

ENVIRONMENTAL CONTROL

Shade will control most submerged aquatic plants. This can be achieved by planting trees on the south side of waterbodies or by using a floating sheet of opaque material. Care must be taken when using the latter to prevent sudden deoxygenation. This is usually only appropriate in small areas.

BEST OPTION

In mixed stands: Remove as much of the plant as possible by mechanical means and apply spot treatments of Casoron GSR or Midstream to remaining plant material.

In mono-specific stands in enclosed still waters use Clarosan IFG.

If mechanical removal is not possible then treat with any of the appropriate herbicides being sure to read the label recommendations.

If you prefer a biological control option then use Grass Carp. Be sure to obain all the neessary agreements from MAFF, the Environment Agency and English Nature.

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INFORMATION SHEET 12

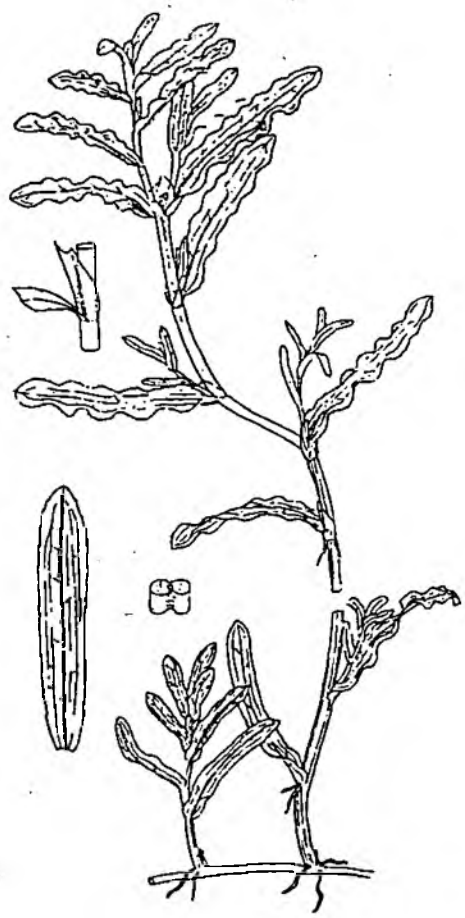
Control of *Potamogeton crispus* (Curled Pondweed)

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Institute of Arable Crops Research

INTRODUCTION

In Britain, there are 21 species of Pondweed and 4 hybrids, some of which are rare and others very scarce. Only *P. natans, P. pectinatus, P. crispus, P. peroliatus* and occasionally *P. berchtoldii* and *P. pusillus* should be considered as weed species. Pondweeds can be locally troublesome, impeding flow and interfering with recreation and navigation. Although these plants are often a nuisance they are an important food source for many animals.

P. crispus grows from creeping rhizomes, forming slender vertical stems and rooting from nodes on the rhizome. The leaves have a characteristic curly shape and have a finely serrated edge. It can grow in still and fast-flowing water. It prefers a mineral or organic-rich fine to medium substrate. It has no preference for nutrient status of the water and is found in clear mesotrophic to eutrophic waters of between 0.75 and 2 m deep. It is common throughout the British Isles except in the highland regions of Scotland.



MECHANICAL CONTROL

All pondweed species can be cut but regrowth, especially early in the summer is often rapid. Where pondweeds have been cut regularly there is usually no evidence of any reduction in regrowth and the plant will tolerate this form of management almost indefinitely.

Mechanical control can be achieved by hand cutting, by weed bucket or by weed boat. Cutting should be as deep as possible to reduce the risk of regrowth later in the season. Cutting can be carried out at any time when there is sufficient growth to merit control, but as there is a risk of regrowth after early season cuts, cutting should normally not be carried out until mid to late summer.

CHEMICAL CONTROL

In static water, herbicides can give good control of Pondweeds. In flowing waters, diquat alginate has achieved good control of many Pondweed species.

Diquat alginate (Midstream) can be used for localised control in static water. Applications of diquat alginate should be made in spring or early summer when plants are young and growing actively but before they have reached the surface.

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Where control of algae as well as Pondweeds and other submerged plants is required, the liquid formulation of diquat can be used (Reglone). This herbicide is applied by spraying onto water surface or by subsurface injection. The herbicide should be applied in spring or early summer when plants are young and growing actively.

In lakes and ponds dichlobenil (Casoron G or Casoron GSR) or terbutryn (Clarosan) can be used. Where localised control is required, use the slow-release formulation, Casoron GSR. Use terbutryn where control of algae as well as Pondweeds and other submerged weed is required. Applications should be made early in the spring when growth is just starting.

BIOLOGICAL CONTROL

The use of herbivorous Grass Carp is appropriate as a control method for this plant. Common Carp, and other bottom feeding fish, which create turbid water, can also be effective in preventing regrowth of the plant after mechanical removal or control by a herbicide.

ENVIRONMENTAL CONTROL

Shade will control most aquatic plants. This can be achieved by planting trees on the south side of waterbodies or by using a floating sheet of opaque material. Care must be taken when using the latter to prevent sudden deoxygenation. This is usually only appropriate in small areas.

BEST OPTION

In mixed stands: Remove as much of the plant as possible by mechanical means and apply spot treatments of Casoron GSR or Midstream to remaining plant material. In mono-specific stands in enclosed still waters use Clarosan 1FG. If mechanical removal is not possible then treat with any of the ppropriate herbicides being sure to read the label recommendations. If you prefer a biological control option then use Grass Carp. Be sure to obtain all the necessary agreements from MAFF, The Environment Agency and English Nature.

The information provided in this document represents the current best available advice. Users should take all reasonable precautions to ensure that they comply with current Codes of Practice, and have notified the relevant autorities of their intentions. This document has no standing in law.

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INFORMATION SHEET 13

Control of *Potamogeton natans* (Broad-leaved Pondweed)

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Institute of Arable Crops Research

INTRODUCTION

This plant is found mainly in static or slow-flowing water up to about 1.5 m deep. It has rhizomes buried in the mud from which leaf and flower stalks grow each spring. The leaf stalks produce a flat leaf blade (lamina) which floats on the surface. The veins in the leaf are more or less parallel converging at the tip, unlike Amphibious Bistort (*Polygonum amphibian*) which is very similar but has a central midrib with veins branching off each side. Flowers emerge above the water surface and are a dull yellow/green colour. Seeds are produced but spread is principally by rhizomes.

The leaves of this plant can form a dense surface cover of the water impeding fishing and other forms of recreation. It is often found in streams and drainage ditches where their numerous leaves can impede flow and so create a land drainage problem.

MECHANICAL CONTROL

Short-term control, for at best one season, can be achieved by cutting as late in the season as possible to reduce the risk of regrowth. New leaves will form from rhizomes later in the season and in the following spring. Because alternate nodes on the rhizomes have buds, breaking or cutting the rhizomes does not control the plant and physical removal of the whole rhizome by dredging is the only effective long-term method of mechanical control.

CHEMICAL CONTROL

Unlike the Water-lilies, spraying the floating leaves with glyphostae does not give satisfactory control. The treated leaves die off, giving the impression that the plant has been controlled, but new leaves emerge usually within a matter of weeks.

Broad-leaved Pondweed has been controlled with dichlobenil (Casoron GSR) early in the spring when growth is just starting, but well before floating leaves are formed. Once the floating leaves have been formed growth slows down and the herbicide is no longer effective. However, it has been noted that the plant can be controlled later in the season, if the plant is first cut so that new leaves are stimulated to grow and, at the same time or immediately afterwards, the plant is treated with dichlobenil. Even so, treatment is likely to be most effective in the earlier part of the season.

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Diquat alginate (Midstream) can be used in static or flowing waters of low calcium content. The herbicide should be applied early in the season when floating leaves are starting to appear but before the surface of the leaves and stalks become covered with epiphytes or silt.

ENVIRONMENTAL CONTROL

This species is susceptible to shade which can be created by planting trees or by using floating opaque maerial. Deepening of the channel, lake or pond to over 2 m may reduce the spread of the plant.

BIOLOGICAL CONTROL

There is no known biological control agent for this plant.

BEST OPTION

Apply Casoron GSR early in the spring before the floating leaves are formed.

The information provided in this document represents the current best available advice. Users should take all reasonable precautions to ensure that they comply with current Codes of Practice, and have notified the relevant authorities of their intentions. This document has no standing in law.

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BEST OPTION

Submerged: Treat with Midstream at least twice per growing season at intervals of between 3 and 5 weeks. Applications of herbicide can start as early as February. Re-treatment should take account of any material which remains green.

Emergent: Material on the banks should be treated with a formulation of glyphosate approved for use in aquatic situations. Re-treatment is not normally necessary. Emergent material in the water should be treated with glyphosate in addition to Midstream if access is possible.

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Note: *Herbicides should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of Herbicides on Weeds in or near Watercourses and Lakes. It is necessary to consult the local Environment Agency, SEPA or other Regulatory Water Authority before applying herbicides.*

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INFORMATION SHEET 14

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research

Control of Australian Swamp Stonecrop (*Crassula helmsii*)

Illustration provided by
IFAS, Center for Aquatic Plants
University of Florida, Gainesville, 1990

INTRODUCTION

Crassula helmsii was introduced to Britain in 1911 from Tasmania. It was first sold as an "oxygenating plant" in 1927 by Perry's Hardy Plant Farm in Enfield. The first recorded natural occurrence was at Greensted Pond in Essex in 1956. In recent years it has spread much more widely and rapidly due to the increased availability of the plant at Garden Centres and Aquatic Nurseries. It is sometimes mis-labelled as *Tillaea recurva* or *Tillaea helmsii*.

The plant will grow around the damp margins of ponds and in water up to 3m deep. It forms very dense stands. It first appears as a small light green tussock on the sediment. These tussocks grow and spread rapidly to form a dense mat of vegetation. The dense mat out-competes all other aquatic vegetation, eliminates native flora and creates a poorer ecosystem for invertebrates and fish. Severe oxygen depletion can occur below dense growths of this plant. The plant assimilates CO_2 for 20 hours of the day when submerged due to the possession of crassulacean acid metabolism and grows throughout the year. There is no dormant period.

MECHANICAL CONTROL

DO NOT PRACTICE MECHANICAL CONTROL ON THIS PLANT. The fragments that are produced by cutting and tearing can regrow and spread the infestation downstream or re-infest the treated area. Fragments as small as one node (~ 5mm) can regrow.

Mechanical removal of dead plant material which has been treated with herbicides is recommended to reduce oxygen depletion by decomposing plant material.

CHEMICAL CONTROL

C. helmsii is only really susceptible to herbicide formulations containing diquat and glyphosate. The use of "Midstream", a viscous gel formulation of diquat usually applied to flowing water, is recommended even in conditions of no flow. The sticky nature of this formulation allows a greater penetration of the herbicide into the plant than other formulations. This formulation can be applied to the plant when it has become emergent in water, *i.e.* when it has emerged from the water surface.

For successful control in one season, Midstream should be applied at least twice. If a [illegible]e infestation is to be treated the top layers of the [illegible]nt material

will prevent sufficient penetration of the herbicide into the water after the first application and regrowth from unaffected parts of the plant will occur. Fragments of potentially viable plant material are created by this treatment and careful containment procedures should be maintained for at least three weeks after treatment. We recommend that the time interval between the first and second treatment is between 3 and 5 weeks. Side shoots are initiated soon after the first treatment and these can break off and cause reinfestation. If there is any sign of this then retreat immediately.

Material which has been killed appears black and brittle. There may be a few very small side shoots from leaf nodes which are still green, but these are not viable. Viability appears to be limited to segments of at least 3-5mm in length arising from a node or containing a node..

We recommend that at least 70% of dense infestations is treated at one time to reduce re-colonisation from untreated areas. Treatment of the remaining 30% should be carried out after 1 week. The dead material should be removed two to three weeks after treatment. Fish should be removed from areas of light infestation and 100% of the infestation should be treated at the one time.

The modified Knapsack Sprayer for application of Midstream can be obtained from Claxton Engineering, 01476 860870.

Glyphosate can be applied to any emergent material, either on the bank or in the water, as long as it is dry. Only formulations of glyphosate which are specifically recommended for use in aquatic situations should be used. Re-treatment after an application of glyphosate is not usually necessary except to treat parts which were missed in the first application.

BIOLOGICAL CONTROL

There are no known biological control agents for this plant in this country. It will be eaten by grass carp if the infestation is small and not well developed, but dense infestations cause severe fluctuations in dissolved oxygen content of the water and the fish do not usually survive.

ENVIRONMENTAL CONTROL

C. helmsii is tolerant of shade for long periods. It is frost tolerant, desiccation tolerant and cannot easily be controlled by any method of environmental control.

INFORMATION SHEET 15

Control of Water-Lilies *Nuphar* and *Nymphaea* species

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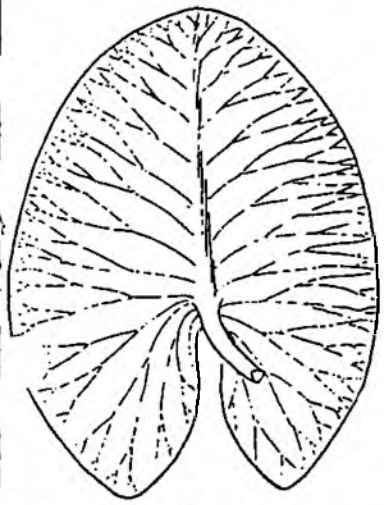
Integrated Approach to Crop Research

INTRODUCTION

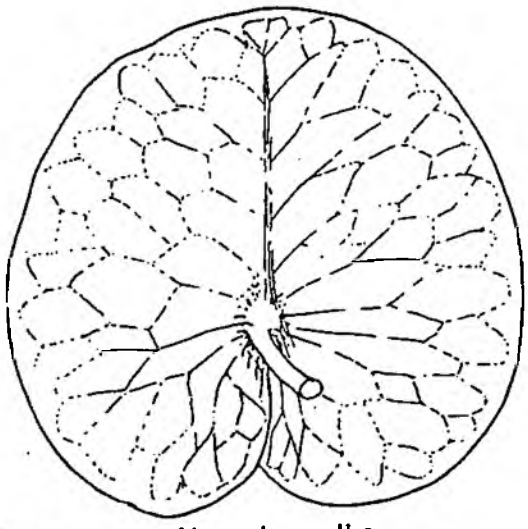
Water-lilies are perhaps the most picturesque of our native plants. They are characterised by their circular floating leaves and white or yellow flowers. They grow at the edges of slow flowing rivers, in canals, lakes and ponds. They can grow in water of up to 5m deep, but prefer depths of between 1m and 3m. *Nuphar lutea* (Yellow Water-lily) and *Nymphaea alba* (White Water-lily) are the most frequently encountered species with *Nuphar pumila* (Least Water-lily) being less common.

N. lutea (Yellow Water-lily) is common in rivers and, unlike *N. alba*, produces submerged as well as floating leaves. In faster situations the floating leaves of Yellow Water-lily are sometimes absent and the plant has been mistakenly identified as "Cabbage-lily" because of the appearance of the submerged leaves. The White Water-lily is becoming rarer and therefore has conservation value. The species can be distinguished before flowering by the different shaped floating leaves. *Nuphar* species have an oval shaped floating leaf and *Nymphaea* species have a round leaf which overlaps slightly behind the stalk.

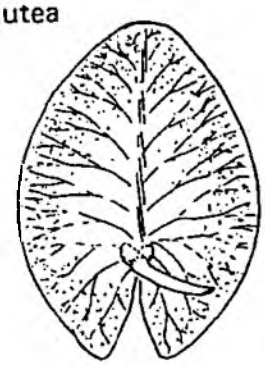
Water-lilies have extensive rhizome systems from which leaf and flower stalks emerge each year. The plants spread only slowly. Water-lilies are often preserved because the leaf stalks have little effect on flow and the shading effect of the floating leaves helps to suppress the growth of more troublesome submerged plants. However, if left unchecked they can produce a dense cover of the water surface and control is sometimes necessary. Where control is necessary, some plants should be left along the margins or in localised clumps where they do not cause a problem.



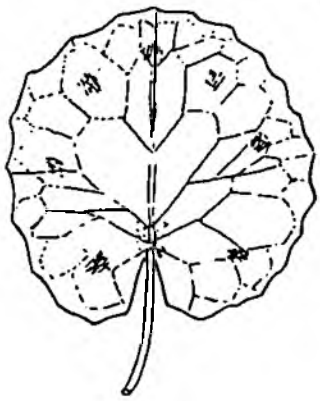
Nuphar lutea



Nymphaea alba



Nuphar pumila



Nymphoides peltata

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MECHANICAL CONTROL

Short term control can be achieved by cutting but new leaves will regrow from rhizomes later in the season or in the following year. Control for more than one season can only be achieved by killing or removing the rhizomes. These are extremely buoyant and will float if raked or dredged from the mud. However, they are very strongly held in the mud by roots and are not easily dislodged. Cutting should be carried out as late in the season as possible to reduce the risk of regrowth. Dredging can be carried out at any time of year but may be more effective in summer when the location of the rhizomes can be detected by the presence of floating leaves.

CHEMICAL CONTROL

Spraying the floating leaves of Yellow and White Water-lilies with glyphosate is a very cost-effective method of control. This technique cannot be used on the Yellow Water-lily when only submerged leaves are present (usually in fast flowing situations). Glyphosate can be applied to achieve localised control to create a clear channel down the centre of the river or a clear patch in a lake while retaining a fringe of Water-lilies at the margins.

In lakes, ponds, canals and rivers flowing at less than 90 m/h, Water-lilies can be controlled by applying dichlobenil early in the spring when growth starts. This will also control submerged weeds but localised control in selected areas can be achieved using the slow release formulation of dichlobenil (Casoron GSR). This technique is preferred in slow flowing situations where the Water-lilies are growing along with submerged weeds which also require control.

BIOLOGICAL CONTROL

Ducks are renowned for their appetite for the buds and submerged leaves of Water-lilies. Increasing wildfowl populations will have a marked effect on the amount of Water-lily growth.

ENVIRONMENTAL CONTROL

Shade is an effective method of control for this species.

BEST OPTION

In Spring: apply Casoron GSR as soon after growth starts as possible and before the leaves reach the surface.
In Summer: apply Glyphosate to floating leaves where localised or selective control is required.

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NOTE: *Herbicide should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of herbicides on weeds in or near watercourses and lakes. In most situations it is necessary to consult the local Water Authority before applying the herbicide.*

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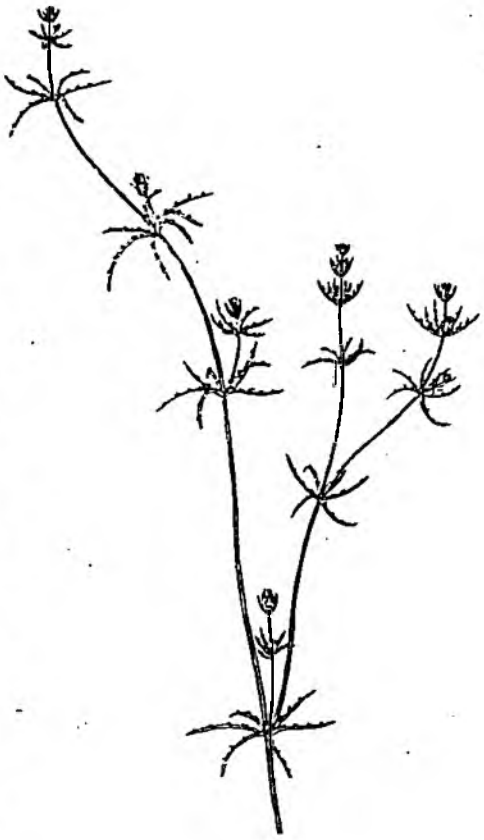
INFORMATION SHEET 16

Control of Stoneworts *Chara* and *Nitella*

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research



INTRODUCTION

The Characeae (Charophytes or Stoneworts) are among the largest and most complex of the green algae. The main axes (stems) have whorls of short lateral branchlets at intervals so the plants bear a superficial resemblance to *Equisetum* or *Ceratophyllum*. They are submerged species (although some are able to survive on wet mud, drying out for short periods) anchored to the substrate by rhizoids (hair-like filaments). Gaseous exchange and absorbtion of nutrients take place over the whole surface of the plant, although nutrients are also taken up through the rhizoids. Normal metabolic activity results in a layer of calcium carbonate over the surface of many species and, in some, a distinctive smell reminiscent of stale garlic is apparent. The cause of the smell is unknown. Charophytes have been credited with an inhibitory or larvicidal effect on insect pests like mosquitos. Charophytes are fast growing, *Chara globularis* having been observed to grow 20cm in two weeks.

Charophytes are found in lakes, ponds, ditches, streams, canals bog-pools concrete tanks, reservoirs and excavations such as gravel pits. They are characteristic of a disturbed habitat where periodic drastic change creates less favourable conditions for growth of other species. They are often the first plants to colonise newly dug or cleared ponds and ditches and some species are characteristic of ephemeral water bodies which dry up completely in summer. The fast maturing charophytes have an advantage over slower-growing macrophytes in these habitats. Charophytes are usually at a competitive disadvantage in shallow, moderately productive habitats, but tend to dominate in deeper water at low light intensities, particularly where the water has a high pH value. They are more often found in mesotrophic and eutrophic waters which are hard water, calcium rich and low in phosphate. They grow in silt, mud, peat or sand. They often form a dense carpet, known as a charophyte meadow, which restricts colonisation by other macrophytes. The more common species do not die down in winter. They have been recorded growing sown to 60m deep in clear water, but generally prefer depths between 1 and 10m.

Reproduction is by oospores which germinate either later in the same season as they are produced or in the following season, or even after a period of several years. This delayed germination may account for the sudden appearance of Charophytes in waters where they have not previously been recorded. In several species, vegetative propagules know as bulbils are formed at rhizoid joints and become buried in the substrate to germinate later.

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Charophytes are known to be spread by birds, stem fragments and bulbils have been found in the stomachs and crops of wildfowl. Oospores will survive the gut and be transported with the birds to colonise other areas.

Charophyte beds are ecologically important in several ways. They have a high biomass and therefore accumulate large concentrations of nutrients which they retain for long periods due to their slow rate of decomposition. Their large surface area is colonised by micro-organisms which can support a large invertebrate population throughout winter (when other macrophytes have died back). They often support good fisheries.

MECHANICAL CONTROL

Charophytes are easily removed by dredging and cutting. Regrowth from bulbils and oospores will occur in the following season and some regrowth from cut material will occur later in the same season.

CHEMICAL CONTROL

Charophytes are best controlled by dichlobenil (Casoron G or Casoron GSR). Applications should be made early in the growing season, when growth resumes after the winter, although timing is not as critical for these species as it is for submerged macrophytes.

BIOLOGICAL CONTROL

Charophytes tend to be unpalatable to grass carp. They are susceptible to turbid conditions created by the behaviour of bottom feeding fish such as carp and bream, but this method is unlikely to work because of the dense carpet formation of most charophyte species.

ENVIRONMENTAL CONTROL

They are susceptible to dense shade and are often out-competed by other submerged macrophyte species, or species with floating leaves. The charophytes are the only group of algae resistant to decomposing barley straw.

BEST OPTION

Treat with dichlobenil in the spring or early summer (April - June)

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NOTE: *Herbicide should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of herbicides on weeds in or near watercourses and lakes. In most situations it is necessary to consult the local Water Authority before applying the herbicide.*

Reference:

Moore, JA (1986) Charophytes of Great Britain and Ireland. BSBI Handbook No 5. Botanical Society of the British Isles, London. ISBN 0-901158-16-X. pp 140.

INFORMATION SHEET 17

Management of Poison-Hemlock *Conium maculatum*

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research

INTRODUCTION

Poison-Hemlock, *Conium maculatum*, is a tall (up to 2m) riparian herb found along the margins of watercourses in the UK. It is poisonous to humans and all livestock. There is a risk of fatalities to livestock once the plant has been cut as chemicals released by live plants which deter ingestion are no longer produced and animals are often attracted to the dead plant material as a source of "hay".

Hemlock growing on damp ground near a watercourse

IDENTIFICATION

Conium maculatum is a member of the Umbelliferae family and has white flowers which resemble cow parsley. The definitive feature of this plant are the light green smooth stems and distinctive purple-red spots on the stem. Leaves can be up to 30 cm long and have coarsely toothed edges. The plant can grow very tall, up to 2.5 m in favourable places.

It grows mainly in damp places along river margins but also on waste ground. It can often be seen along the hard shoulder and central reservations of motorways, especially near Heathrow airport.

Hemlock has characteristic purple-red spots on stems

The stems have characteristic purple-red spots and are smooth (unlike cow-parsley). The leaves are much more finely dissected than cow-parsley.

TOXICITY AND POISONING

Cattle, goats, horses, pigs, sheep, rabbits, poultry, deer and humans have been poisoned after ingesting Poison-Hemlock. It also causes teratogenic (birth defects) effects called crooked calf disease in pigs and cattle caused by the alkaloid content. Animal species vary in their susceptibility to acute toxicity:

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The following table gives information on the acute toxicity of hemlock to farm animals after ingestion:

Species	Acute Toxic Dose Rate (mg / kg body weight)	Time to death
Cows	3.3	1.5 - 2 hours
Mares	15.5	30-40 mins
Ewes	44.0	1.5 - 2 hours

The toxins in Hemlock are alkaloids. There are three main alkaloids which are responsible for the toxicity. All parts of the plant contain some level of the alkaloids, except for the sap in young plants. The most toxic chemical, gamma-coniceine, is abundant in leaves and flowers but less common in the fruits, where it is quickly converted to coniine and N-methylconiine. Gamma-coniceine is the precursor of the other alkaloids in Poison-Hemlock. This chemical is a partly unsaturated piperidine alkaloid. The other chemicals, including coniine and N-methylconiine, are saturated. During the first year of growth, gamma-coniceine is the predominant chemical. During the second year of growth, the content of the other two alkaloids increase, especially in the leaves and fruits, with a decrease in the first chemical. Gamma-coniceine is considered to be 7 or 8 times more toxic than coniine, with N-methylconiine less toxic.

Toxic Parts: ***Flowers, leaves, mature fruit, roots, seeds, stems, young shoots.***

The following LD50 (the concentration required to kill 50% of test organisms) in mice have been reported:

Alkaloid	Dose (mg / kg)	Mode of entry	Death time
gamma-coniceine	2.6	intravenous	30 sec
	12.0	subcutaneous	12 min
	12.0	oral	8 min
coniine	19.0	intravenous	30 sec
	80.0	subcutaneous	15 min
	100.0	oral	10 min
N-methylconiine	27.5	intravenous	30 sec
	150.5	subcutaneous	16 min
	204.5	oral	12 min

The symptoms of poisoning vary between species. The following table lists those which have been associated with hemlock poisoning for each type of animal.

Humans	Cattle	Sheep	Pigs
coma convulsions death by asphyxiation dizziness headache incoordination pupil dilation thirsty vomiting	arthrogryposis breathing, rapid carpal joint, flexure death depression diarrhoea elbow joint, flexure gait, unsteady incoordination limbs, lateral rotation muscle spasms salivation scoliosis teeth grinding torticolollis trembling urine, coffee coloured vomiting	ataxia carpal joint, flexure death defecation, frequent salivation tail, kinked trembling urination, frequent weakness	arthrogryposis articular rigidity ataxia blindness blindness, temporary breathing, laboured breathing, rapid carpal joint, flexure collapse death death by asphyxiation fetlock joint, flexure gait, staggering gait, unsteady heart rate, elevated lacrimation, severe palatoschisis paralysis prostration pupil dilation scoliosis syndactylism temperature, elevated trembling urination, frequent vision, impaired weakness

In most cases where ingestion has occurred, especially after the plant has been killed, the end result will be death in a very short time. Most of the symptoms listed above will occur if small amounts of live material have been ingested.

MANAGEMENT

Poison Hemlock can be cut, dug up or sprayed with a herbicide containing glyphosate.

Normally, these plants are avoided by grazing livestock but, after cutting or spraying, become palatable and retain the toxin within the dead plant tissue. Particular care should be taken to keep livestock away from treated river banks until the controlled plants have decomposed or been disposed of safely. Particular care should be taken that any poisonous plants are not dumped in reach of livestock.

DO NOT ALLOW ACCESS FOR LIVESTOCK UNTIL ALL THE PLANT MATERIAL HAS BEEN REMOVED

In situations where these plants are present there will be a risk to animals each time weed control operations take place. In these circumstances, it may be worth using a herbicide containing glyphosate to eradicate the plants so as to reduce the risks for future operations.

When a herbicide is used, it is important to fence the area to exclude livestock until **all the weed has died back completely**. If the weeds cannot be controlled by herbicide then, for each control operation, cut weed must be either transported to a safe disposal site or fenced off until all weed has decomposed or been destroyed by burning.

Care should be taken when cutting or digging up the plant as all parts are poisonous. Wear non-porous rubber gloves and a face shield for protection from cut ends of stems and contact with flowers and seeds. The poisonous roots should also be disposed of if the plant is dug up.

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The information contained in this information sheet was provided by the Canadian Poisonous Plants Information System, maintained by Agriculture Canada.

INFORMATION SHEET 18

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research

Control of Unbranched Bur-Reed
(Sparganium emersum)

INTRODUCTION

S. emersum is a plant of still or slow-flowing watercourses of moderate to high nutrient status. Although similar in appearance to *S. erectum* (Branched Bur-reed) it has slightly different habitat requirements. It is usually found in water deeper than *S. erectum* and can grow up to 1 m deep. It is common on clay substrates. It has deep rooted rhizomes which are not easily uprooted by fast flowing water, even in spate conditions. It is most common in lowland areas of Britain.

It is characterised by floating strap-like leaves which may become emergent in shallower water. It spreads by growth of rhizomes and although seeds are viable, the lack of suitable substrates may hinder recruitment by this method in most British rivers.

MECHANICAL CONTROL

This plant is controlled by cutting and dredging. The depth and persistence of the rhizomes makes mechanical control a short-term measure, with regrowth to original densities occurring in two to three years.

CHEMICAL CONTROL

The submerged and floating leaved plant is susceptible to diquat. The most appropriate formulation is the diquat alginate (Midstream) as growth is often in flowing conditions. In still water the plant is also susceptible to dichlobenil and terbutryn. Emergent leaves can be sprayed with glyphosate at 5 litres per hectare in 200 litres of water during August and September. Chemical methods will usually provide two to three years of adequate control. Early season applications of glyphosate are not an appropriate method of control for this species.

BIOLOGICAL CONTROL

In still, enclosed waters, grass carp will eat leaves of *S. emersum* in the absence of anything else, but it is not their first choice. They do not provide long-term control as the rhizome persists and regrowth in subsequent seasons is relatively unaffected. The plant will be weakened by continued loss of its leaves and will die after four to five years of this type of treatment. No other form of biological control is known.

ENVIRONMENTAL CONTROL

The plant is very susceptible to shading and even a slight increase in the amount of shade will lead to a loss of this species in rivers. Increased turbidity created by bottom-feeding fish or other methods at critical times of the year (April - May) may also lead to reduced biomass of this species.

BEST OPTIONS

1. If there is a dense infestation then either cut and remove the vegetation in early summer or apply a herbicide containing diquat alginate before the leaves become emergent.

2. Emergent vegetation can be removed mechanically or treated with a herbicide containing glyphosate

3. In still waters treat with dichlobenil in April or terbutryn in late April or early May or diquat (Reglone) later in the season.

4. Partial control can be achieved with mechanical cutting, dichlobenil or diquat alginate herbicides.

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Jonathan Newman

Note: *Herbicides should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of Herbicides on Weeds in or near Watercourses and Lakes. It is necessary to consult the local Environment Agency, SEPA or other Regulatory Water Authority before applying herbicides.*

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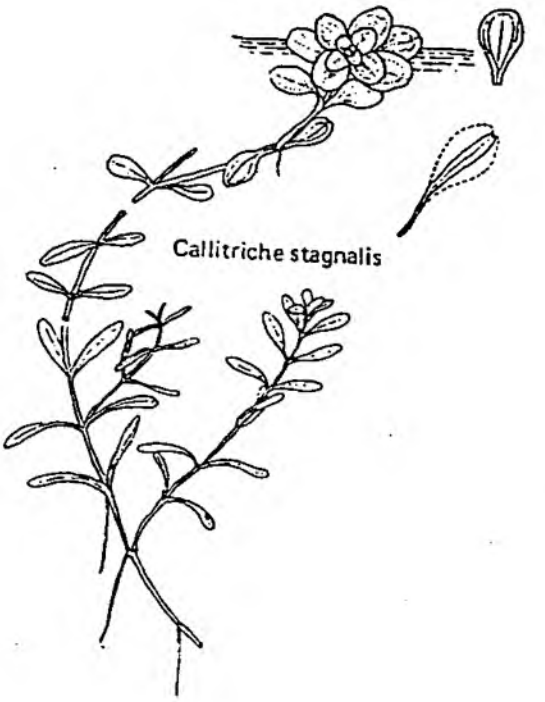
INFORMATION SHEET 19

Control of Water-Starworts (*Callitriche* sp.)

Centre for Aquatic Plant Management
IACR Long Ashton Research Station
Integrated Approach to Crop Research

INTRODUCTION

Water-Starworts are so called because of the shape of their floating apical rosettes. They are most common in slow-flowing waters where muddy and silty sediments predominate, although they will grow in still and fast-flowing conditions up to 1 m deep. They are intolerant of inorganic pollution. They have slender stems and long, thin submerged leaves which expand when they reach the surface. The submerged leaves are characterised by the notched ends. The genus is extremely polymorphic, taking on different leaf shapes in different environmental conditions. Classification and distinction between species is often only possible by examination of the flowers and seeds. The Water-Starworts should not be confused with *Crassula helmsii*, which has similar shaped leaves to the submerged type exhibited by *Callitriche* species but no notches in the leaf tips.



There are approximately 25 species worldwide, some of which are semi-terrestrial while all other species are restricted to freshwater aquatic habitats. There are nine species in Great Britain, *C. stagnalis* (Common Water-Starwort) and *C. obtusangula* (Blunt-fruited Water-Starwort) are the most commonly encountered species.

They are perennial and easily reproduce by seed and vegetative methods. Small, single-node fragments will grow rapidly. They have small insignificant flowers, with male and female flowers occurring on the same plant. The seeds contain four nutlets within an elastic coat. They sink to the bottom when released and can lie dormant in the mud for up to five years. Often this accounts for their sudden appearance in waters which have recently been cleared or dredged. Darkness inhibits the germination of the seed.

The Water-Starworts cause problems by blocking flow in drainage systems and by dominating slow-flowing ponds and canals. In such conditions they form dense mono-specific stands. They are important as food and shelter for fish, as an invertebrate habitat and as food for ducks.

MECHANICAL CONTROL

Cutting and dredging are acceptable methods of control for this species. Care should be taken to restrict the spread of viable fragments out of the area in which the plant is controlled. Cutting can be carried out at any time during the season but should be delayed until after July if longer term control is required. Cutting is not the preferred method of control because of the high viability of the fragments and the risk of spreading the plant to unaffected areas.

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Being perennial, they retain their leaves overwinter and rooting internodes bearing lateral buds can remain in the mud overwinter and regrow the following spring. This characteristic makes mechanical control late in the season less likely to produce a good long-term reduction in plant density.

CHEMICAL CONTROL

Diquat alginage (Midstream) can be used to control *Callitriche* species in static and flowing water. Dichlobenil (Casoron G or Casoron GSR) can be used in static waters and the GSR formulation can be used in flowing waters up to a maximum water velocity of 90 metres per hour (1.5 metres per minute). The timing of application should be as early as possible in the season for both herbicide formulations and definitely before the floating leaves have formed. This will usually be before mid-April.

BIOLOGICAL CONTROL

Grass carp will control the growth of *Callitriche* species. Wildfowl will also eat the submerged plant material. Increasing wildfowl numbers may reduce the amount of weed growth.

ENVIRONMENTAL CONTROL

Deepening the water to below 1 metre will make the conditions unsuitable for the growth of this plant. Shading is another possibility, although deep shade will be required.

BEST OPTION

In fast flowing water: Midstream in early April

In slow-flowing water: Midstream or Casoron GSR in early April

In static water: Midstream or Casoron GSR for selective control, Reglone or Casoron G for less selective control.

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Note: *The information provided in this document represents the current best available advice. Users should take all reasonable precautions to ensure that they comply with current Codes of Practice and have notified the relevant authorities of their intentions. This document has no standing in law.*

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below 1 metre may reduce the ability of *H. ranunculoides* to root at the margins. This, however, is unlikely to be a feasible option. Reducing the amount of suitable rooting substrate by piling or preventing access to suitable areas by netting off sections may prove effective. All these environmental options are likely to be expensive to implement and are untested.

BIOLOGICAL CONTROL

There are no known methods of biological control.

BEST PRACTICE

- For effective long term control of *H. ranunculoides* a thorough eradication programme using the herbicide 2,4-D Amine should be employed. Follow up any treatment programme with an inspection after a period of one month incorporating spot treatments of herbicide or physical removal where necessary.

- Where physical or mechanical cutting techniques are deemed necessary the affected areas should be fenced off to prevent the downstream spread of the plant. All cut foliage should be removed from the water body. Physical control methods are likely to have little effect other than a short-term reduction in the local extent of the plant.

Note: *Herbicides should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of Herbicides on Weeds in or near Watercourses and Lakes. It is necessary to consult the local Environment Agency, SEPA or other Regulatory Water Authority before applying herbicides.*

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INFORMATION SHEET 20

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research

Control of Floating Pennywort
(Hydrocotyle ranunculoides)

INTRODUCTION

Hydrocotyle ranunculoides, the floating pennywort, is a native of North America but has become naturalised in Central and South America and also occurs in the Netherlands and in southern mainland Europe. It was first brought to Britain in the 1980's by the aquatic nursery trade to sell as a marginal plant. *H. ranunculoides* roots in the shallow margins of slow-flowing water bodies, particularly ditches, slow flowing rivers and lakes and forms dense interwoven mats of vegetation which can quickly cover the water surface interfering with the ecology and amenity uses of the water body. Under UK conditions mats of vegetation have been observed to grow up to 8 metres from the bank in a single season. *H. ranunculoides* roots freely from nodes at approximately 40-60mm intervals, its roots are profuse and hairlike. The leaves are emergent, rising on stalks from the horizontally growing stem. Both the stem and the petioles are fleshy. The leaves range from being circular to kidney shaped and are deeply lobed, they can grow up to a maximum size of 180 mm in diameter under UK conditions. Leaf matter extends up to 40 cm above the water surface and the interwoven mat of roots and stems can sink up to 50 cm into the water. Reproduction is thought principally to be asexual and vegetative, and the plant is capable of forming extensive mats from the smallest root fragment. Reports from Australia have indicated that *H. ranunculoides* can double its biomass in 3 days under ideal conditions (Klemm *et al.* 1993). Although growth rates of this size have not been experienced in the UK the plant does exhibit a seasonal growth rate with maximum growth in the late summer when it typically forms extensive

floating mats of vegetation.

The plant is relatively restricted in its extent in the UK, reported on only 7 waterways in the south of England and south Wales, its existence a likely result of release from aquaria and garden ponds. *H. ranunculoides* has already proved to be difficult to control because of rapid growth rates combined with an ability to regrow from a single node. Although currently restricted in distribution it is likely to spread around UK watercourses and become a major nuisance for water resource managers in the future. Please report any occurrences of *H. ranunculoides*, along with a national grid reference, to the Centre for Aquatic Plant Management.

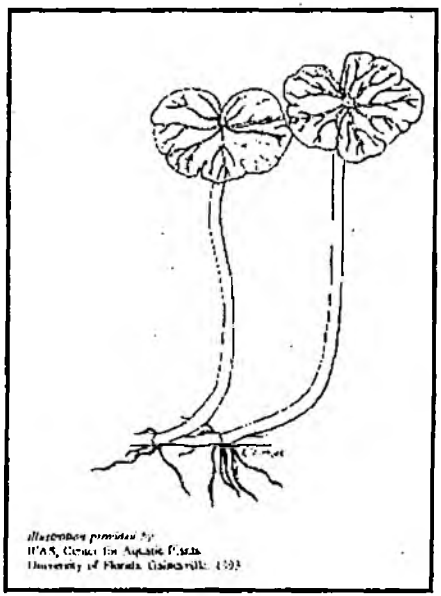
MECHANICAL CONTROL

H. ranunculoides can be cut by hand or with weed cutting buckets or boats. These techniques will only offer a very short term reduction in the local extent of the plant as it is capable of growing back rapidly from a single root node. Re-cutting will be necessary throughout the growth season. It should be noted that without thorough removal of all cut material the spread of the plant downstream will only be exacerbated. **Where cutting is deemed appropriate for the control of *H.ranunculoides* the affected areas should be carefully fenced or netted off to prevent downstream infestation and to insure that all cut plant material can be removed from the water body.** This is especially important in flowing situations.

CHEMICAL CONTROL

Herbicides containing 2,4-D Amine[1] are the most effective for controlling *H.ranunculoides*. **Glyphosate is ineffective on this species.** Treatment with 2,4-D Amine results in extensive die-back of vegetation, the first effects of which are noticeable within 24 hours of treatment. Decomposition and dissipation of the remaining plant material is often slow, as *H.ranunculoides* typically forms extensive beds, and may take as long as six weeks in slow flowing water bodies. Where *H.ranunculoides* covers a large proportion of an enclosed or slow flowing water body then no more than 20% should be treated at any one time to avoid de-oxygenation of the water. If this strategy is undesirable then treated plant material should be removed from the water

shortly after treatment. As *H.ranunculoides* forms such thick beds of vegetation conventional spray applications may not reach all the leaves at the first attempt. Small leaves under the main canopy may be shaded from the herbicide by those above leading to incomplete control and a source from which the plant will regrow. It is therefore necessary to incorporate a follow-up to any chemical control programme which allows spot treatment, or removal by hand, of any remaining stands of *H. ranunculoides* around one month after the initial herbicide application. Small plants whose leaves lie at or below the water surface will have to be physically removed as the efficacy of the herbicide will be negated by water flowing over the leaves. Although the growth of *H. ranunculoides* is noticeable throughout the growth season (and it may well cover small slow flowing channels or ditches throughout the summer) it does not usually reach nuisance proportions on larger water bodies until later in the summer. Treatment earlier in the season will however reduce the man-hours, equipment and chemicals needed to control the weed at a later date. **Agreement must be obtained from the local Environment Agency office before application of herbicides in, on or near controlled waters.**



1. 2,4-D Amine is available under the following product names: Agricom 2,4-D (Farmers Crop Chemicals Ltd); Atlas 2,4-D (Atlas Interlates, Atlas Crop Protection); Dormone (Rhone-Poulenc Amenity); and MSS 2,4-D Amine (Mirfield Sales Services).

ENVIRONMENTAL CONTROL

There are several methods which may be used, none of which give a complete solution. Shade may be an effective method of control as the plant does not establish well in shaded conditions, and is best achieved by planting trees on the south side of the water body. This is unlikely to be practical to implement on larger water bodies. Increasing flow will restrict the growth of *H. ranunculoides* in situ but may increase the spread of the plant downstream. Increasing rooting depth to

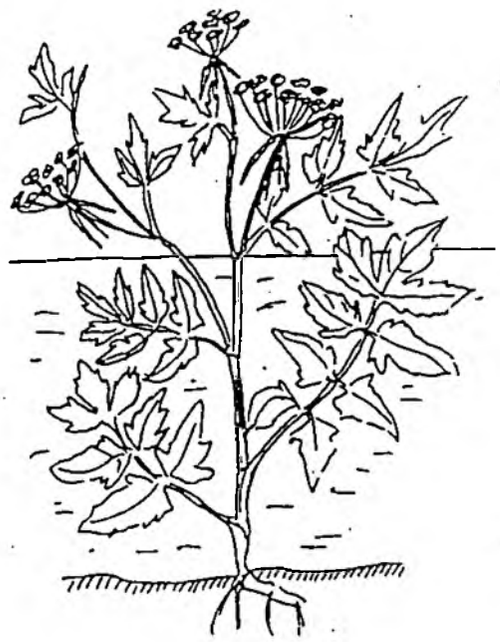
NFORMATION SHEET 23

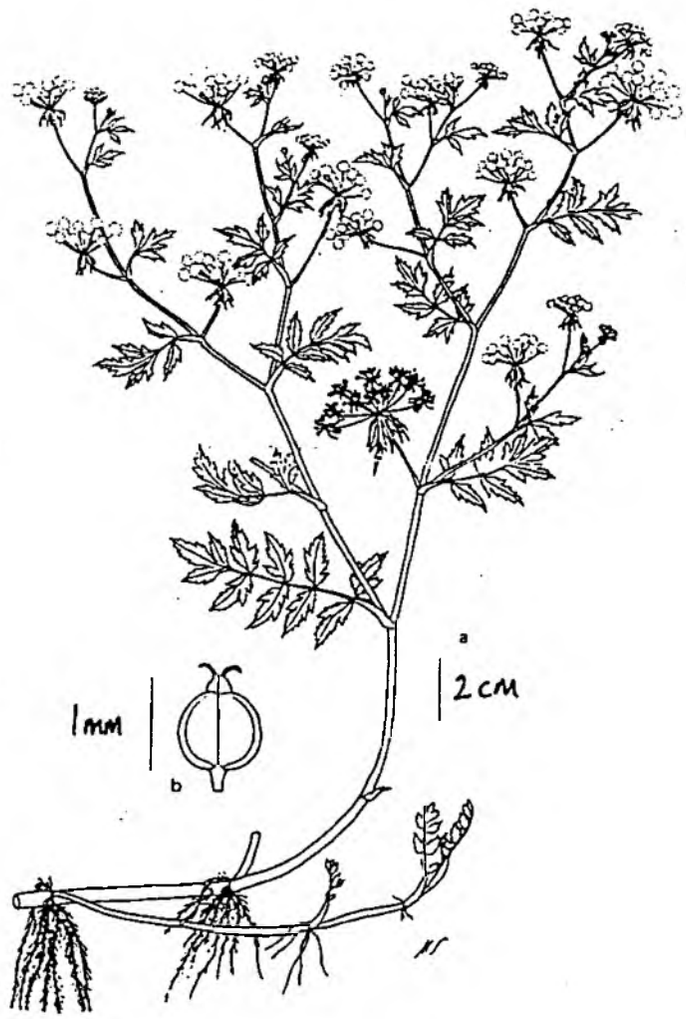
ntrol of Water-parsnip (*Berula erecta*)

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research

NTRODUCTION

erula erecta, the lesser or narrow-leaved Water-parsnip, is a perennial aquatic plant which grows in shallow, clear owing water at the margins of ditches, ponds, lakes and rivers. It grows to heights of between 30cm and 1m and has umbelliferous white flower heads. It has grooved hollow stems. The leaves can be up to 30cm long and are a dull bluish green. There are pinnate segments of between 2cm and 5cm which vary in number between 5 to 19 airs per leaf, the usual number is between 7 and 14 pairs per leaf. These leaflets have toothed edges. The characteristic features are a pale ring at the base of the leaf stalk and a smell of parsnip or carrot when crushed. It should not be confused with *Apium nodiflorum* (Fool's Watercress) or *Rorippa nasturtium-aquaticum* Watercress).





MECHANICAL CONTROL

The growth of *Berula* is easily reduced by cutting or strimming. Mechanical control will only give short-term control (less than one season). The optimum time to cut is before flowering to reduce the spread of the plant by seed dispersal. Quite often the plant will regrow and produce flowers in the same season after it has been cut and it may be necessary to cut again later in the season.

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CHEMICAL CONTROL

This plant is easily controlled by an application of glyphosate as Roundup Pro Biactive. The application should be made before the plant has flowered and any regrowth should be treated at the end of August. It is moderately susceptible to dichlobenil as Casoron GSR (in slow flowing water). If Casoron GSR is used it is preferable to stop the flow of water for at least one day to allow the herbicide to enter the plant.

Other members of the Apiaceae (*Apium* and *Rorippa*) are controlled by 2,4-D (suitable products: Atlas 2,4-D, Dormone or MSS 2,4-D Amine). In our opinion *Berula* should be controlled by this chemical. 2,4-D will control only broad-leaved weeds and it may be preferable to use a product with a restricted range of target species in circumstances where the plant is growing mixed with reeds, rushes or other plants which are to be retained. This herbicide should be used on an experimental basis on short sections to test for efficacy before large areas of plant are treated. Neither the CAPM or the Manufacturer can be held responsible for a failure of 2,4-D to control this species.

BIOLOGICAL CONTROL

None known.

ENVIRONMENTAL CONTROL

The plant will be controlled by shading (planting trees or opaque material) and by deepening the channel at the margins. These options may not be possible, but if an opportunity arises to incorporate the alterations into a future management plan combined with limited chemical or mechanical control then they should be adopted.

BEST OPTION

Spray with glyphosate before flowering. Monitor regrowth and retreat in autumn if necessary.

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Dr Jonathan Newman

NOTE: *Herbicide should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of herbicides on weeds in or near watercourses and lakes. In most situations it is necessary to consult the local Water Authority before applying the herbicide.*

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BEST OPTION

Remove as much of the plant as possible by mechanical means before sporulation has occurred and treat the remaining infestation with a surface spray of glyphosate or diquat as required.

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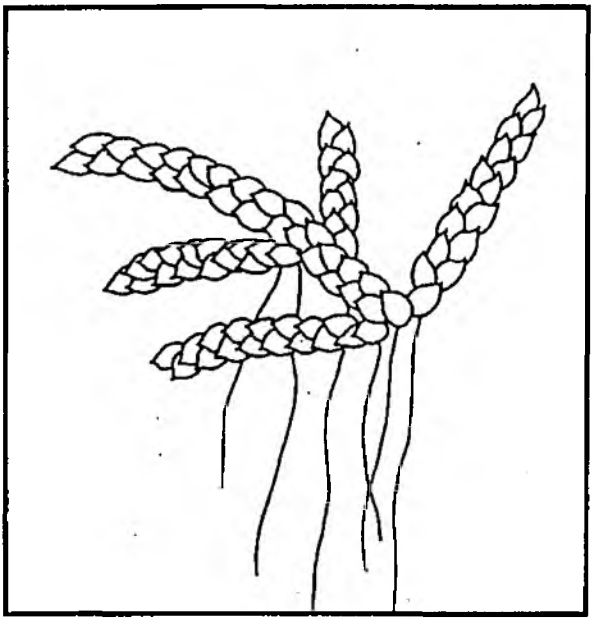
INFORMATION SHEET 24

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research

Control of Water Fern
(*Azolla filiculoides*)

INTRODUCTION

Azolla filiculoides is the only species of floating fern found in Britain. The most characteristic feature of this plant is the red colouration taken on over the winter, the plant is usually green during the summer months. It reproduces both vegetatively as the fronds grow and sexually by producing spores. Germinating spores can give rise to dense infestations of this plant and are the main method of overwintering. Spore production occurs as a result of stress when the plants start to form dense mats. The spores are released into the water so that controlling or harvesting the floating mats after this stage will not prevent reinfestation. The plant is free-floating often building up into thick layers where wind and currents collect it. *Azolla* can grow in any depth of water but is not tolerant of waves or turbulence and can be flushed away in fast flowing waters.



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Free-floating weeds tend to be most troublesome in static or very slow moving water and are usually flushed out of faster flowing rivers, except where they are held back by dams or weirs. It is unusual for *Azolla* to cause serious land drainage problems because it causes relatively low impedance to flow and tends to be washed out in periods of high flow. Dense infestations, which completely cover the water surface, are a danger to children, pets and livestock who may attempt to walk onto the apparently dry land without appreciating that there is deep water underneath. The dense cover of floating weeds also reduces the light level beneath the surface so that submerged weeds and algae die off causing serious deoxygenation problems. Free-floating weeds can also be drawn into water intakes, blocking pumps and filters, and can mat together forming floating rafts which cause flow problems and obstructions to weirs, locks and other structures.

MECHANICAL CONTROL

Conventional cutting equipment has no effect on this plant. It can be harvested with weed buckets and weed rakes. The efficiency of removal can be considerably improved by fitting fine meshed netting of wire or nylon to prevent fronds escaping through the bucket. Floating booms or barriers may help to hold and concentrate the weed in areas where harvesting is taking place. Control can sometimes be achieved by flushing out the weed using baffle boards or barriers to raise the water level temporarily and then removing the barrier when wind and currents have collected the weed against the barrier. This technique is generally effective only in smaller water bodies and requires frequent operation. If spores have already been released in the current or previous year, it may be necessary to carry out repeated control operations until all the spores have germinated and been controlled.

CHEMICAL CONTROL

Herbicides are the most effective form of control. The floating fronds can be sprayed with either diquat or glyphosate. Glyphosate will kill almost all emergent and floating weeds onto which the spray is directed. Diquat (as Reglone produced by Miracle Professional Products) will burn off emergent

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and other floating weeds but will not kill them (except Duckweeds). Surviving fronds may require a second or subsequent treatment if the weed is to be eliminated. This is best carried out when a gentle wind or currents have collected floating fronds together at suitable points.

This plant can also be controlled by subsurface injection of diquat (as Reglone) or by an application of terbutryn granules (as Clarosan 1FG, produced by Ciba Agriculture, Whittlesford, Cambridge). Both of these herbicides will control other submerged weeds and algae. If spores have already been released in the current or previous year, it may be necessary to carry out repeated control operations until all the spores have germinated and been controlled.

Herbicides should be applied before a complete surface cover has developed to increase effectiveness. If this is not possible a repeat application may be necessary to kill any surviving plants.

Azolla is very susceptible to the selective herbicide Asulam (as Asulox produced by Rhone Poulenc) **but the herbicide is not approved for use in water.**

BIOLOGICAL CONTROL

There are no known biological control agents for this plant, although grass carp have been observed to feed on small infestations.

ENVIRONMENTAL CONTROL

Azolla can be controlled by dense and prolonged shading with an opaque material.

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BEST OPTION

Remove as much weed as possible by mechanical means. Spray the remainder with glyphosate if the surface layer is thin enough, otherwise use Reglone. Spot treat any re-infestation with glyphosate.

Plant species with floating leaves to compete with the *Lemna* for space.

Increase the disturbance of the water surface.

Complete control is not possible and a careful watch should be kept on regrowth from any plants left unaffected by treatments and remedial action taken before the problem reaches nuisance proportions.

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INFORMATION SHEET 25

Centre for Aquatic Plant Management
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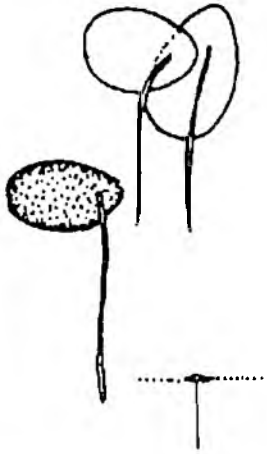
Integrated Approach to Crop Research

Control of Duckweeds (*Lemna* species)

INTRODUCTION

Duckweeds are small free-floating plants often forming dense mats on the surface of still or slow flowing water. They grow best in eutrophic (nutrient rich) waters. The leaves are small, often not exceeding 5mm in length (except *Lemna polyrrhiza* which can be up to 1 cm), either single (*Lemna minuta* and *Lemna gibba*) or in groups of two or three (*Lemna minor*). *Lemna trisulca* has a more complex branched structure and is more likely to be submerged. This species is not often a nuisance. The leaves of *Lemna gibba* are swollen. The plants grow mainly by vegetative reproduction, two daughter plants bud off from the adult plant. This form of growth allows very rapid colonisation of new water and re-colonisation after treatment in previously infested areas. Continuous removal of this plant is often necessary.



Lemna minor

Lemna minuta

MECHANICAL CONTROL

Mechanical removal is often possible in small ponds by dragging a floating boom stretched across the pond and removing the collected mass of weed at the end of the pond. There are some harvesting machines which will remove *Lemna* quite well in larger lakes. Infestation is often prevented by stretching a boom across inflows to catch any plants coming in from upstream. It is impossible to remove every plant by mechanical means and regrowth will be inevitable. Mechanical methods of control give an instant effect which can last for a reasonable length of time. The removed weed can be composted.

CHEMICAL CONTROL

Lemna species are susceptible to herbicides containing diquat, terbutryn and glyphosate. Reglone (diquat) is a liquid concentrate applied directly to the water. It will kill most submerged vegetation, waterlilies will be scorched but will recover. Clarosan IFG (terbutryn) is a granule formulation applied directly to the water. It will kill all submerged plants, waterlilies are moderately resistant but may be killed if they have not been exposed to the herbicide before. There are many formulations of glyphosate which are suitable for the control of *Lemna* species, however, only formulations which state clearly on the label that they are suitable for use in water should be used. Glyphosate formulations are applied as a spray and will only kill plants that the spray touches (this includes waterlilies and all emergent reeds, rushes and grasses). It is not advisable to use glyphosate on thick mats of duckweed as only the top layers will be killed and regrowth will be very rapid. However, glyphosate formulations are the best option for single layers and small infestations. Where dense mats are present use either Reglone or Clarosan IFG.

Lemna gibba

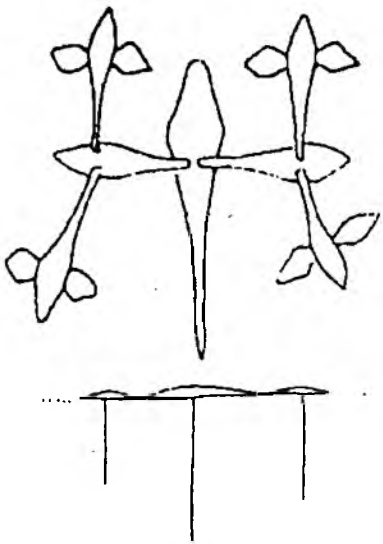
BIOLOGICAL CONTROL

Grass carp will eat *Lemna* species. Further information on the use of Grass Carp for Aquatic Weed Control, is available from the Environment Agency in R&D Note 57.

ENVIRONMENTAL CONTROL

The use of shade has been successful in reducing the amount of duckweed growth although very deep shade is often required. Shade can be achieved by planting trees on the south side of a waterbody. *Lemna* does not compete well with other floating leaved plants such as waterlilies and planti species with floating leaves can substantially reduce the nuisance level of a weeds.

Duckweeds prefer still water and increasing the disturbance of the water surface can reduce the amount of duckweed . This can be achieved by the use of a fountain or, on canals, by increasing the amount of boat traffic. The minimum amount of boat traffic required to eliminate *Lemna* is reckoned to be about 1500 boat movements per annum. Boat traffic of less than this will reduce the competitive ability of the species and may aid in their eventual elimination.

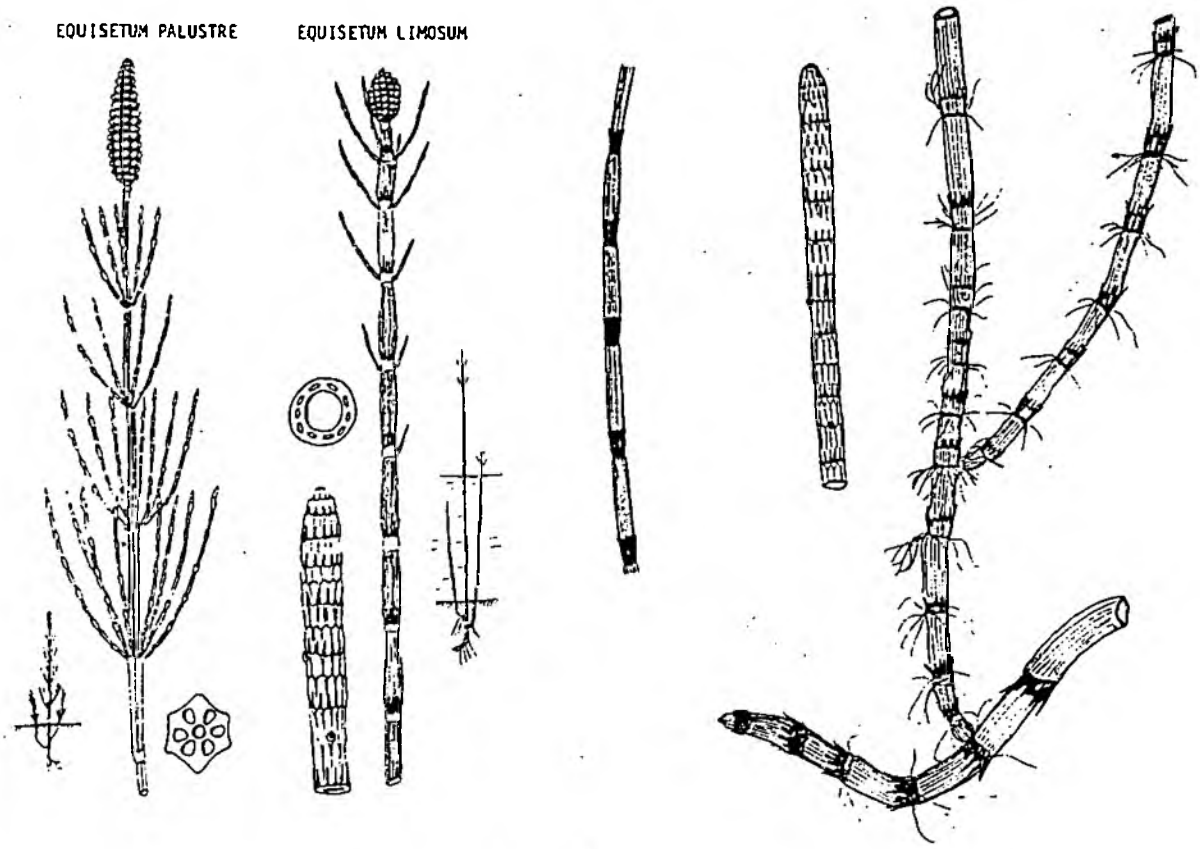


Lemna trisulca

INFORMATION SHEET 26

Control of Horsetails (*Equisetum* species)

Centre for Aquatic Plant Management
IACR Long Ashton Research Station
Integrated Approach to Crop Research



INTRODUCTION

Horsetails are members of a very ancient plant family, distant relatives of which were alive during the Carboniferous era. As such they have a relatively simple growth type, producing upright stems from creeping rhizomes. The stems often support whorls of filament like leaves at intervals up the stem. They reproduce by means of spores, not seeds, and are related to ferns. **They are poisonous, and remain poisonous even when they are dead. Animals should not be allowed into areas where treated plants are present.**

MECHANICAL CONTROL

Mowing is an effective way of controlling the growth of these plants. Regular mowing will keep the growth down but will not kill the plant. If you are mowing these plants on land that does not belong to you, you will be subject to the "Duty of Care" regulations, made under the Environmental Protection Act, 1991, which means you must dispose of the cut material at a registered disposal site.

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Centre for Aquatic Plant Management, Broadmoor Lane, Sonning-on-Thames, Reading, Berkshire, RG4 6TH, UK.
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CHEMICAL CONTROL

Horsetails are susceptible to herbicides containing the active ingredient dichlobenil. There are three herbicides which are appropriate for use in or near water. Fydulan (dalapon / dichlobenil mix) available from Nomix Chipman ((0117 957 4574) which can be used near water but not applied directly to water. Casoron G and Casoron GSR available from Zeneca Professional Products (01428 645454). Both are granule formulations but Casoron GSR is a slow release formulation. The herbicide should be applied in the spring when growth is active. Only one treatment per season should be necessary. Re-treatment in following seasons may be necessary to control areas which were missed at the first application. **Be sure to keep livestock out of treated areas.**

BIOLOGICAL CONTROL

There is no known biological control agent for these plants. Because they are poisonous, livestock will not eat them.

ENVIRONMENTAL CONTROL

Short term control be achieved by shading the areas in which horsetails are known to occur with a thick sheet of black polythene. As soon as the polythene is removed the spores from previous generations will geminate and produce a fresh growth in the following Spring. The spores are very tolerant of adverse environmental conditions and cannot be destroyed.

BEST OPTION

The selection of the best method of control is determined by the time of treatment. If you want to control horsetails in the Spring then apply a herbicide. If you miss any plant with this treatment then mow the plants regularly.

If you want to control the plants in the Summer and Autumn, the mow the growth regularly and treat with a herbicide in the following Spring.

Repeat treatments of these plants may be necessary for a number of years due to spore survival.

The information provided in this document represents the current best available advice. Users should take all reasonable precautions to ensure that they comply with current Codes of Practice relating to use of herbicides, and have notified the relevant authorities of their intentions. This document has no standing in law.

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BEST OPTION

Spray with Reglone to control infestations in the short-term.

Take action to reduce nutrient inputs to water for long-term eradication.

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Note: *Herbicides should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of Herbicides on Weeds in or near Watercourses and Lakes. It is necessary to consult the local Environment Agency, SEPA or other Regulatory Water Authority before applying herbicides.*

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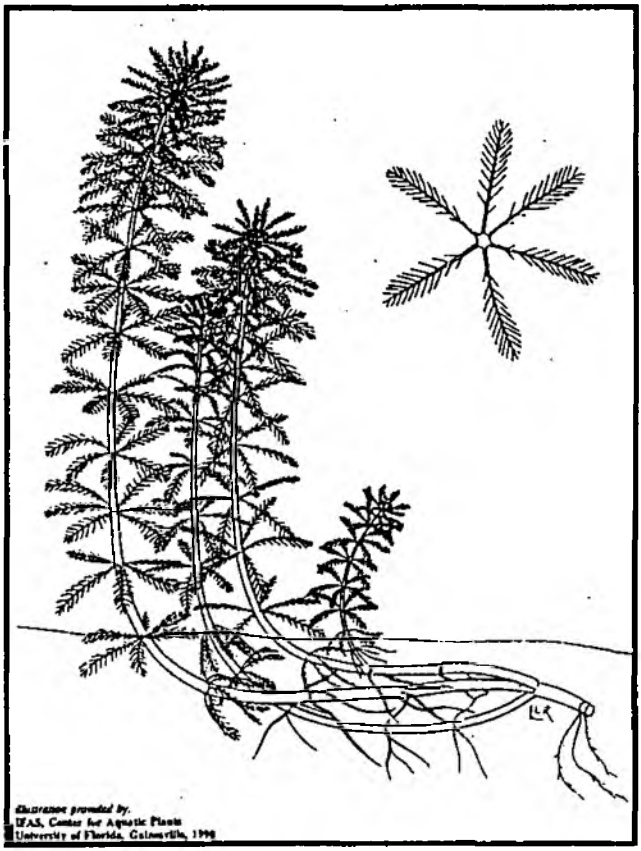
INFORMATION SHEET 27

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research

Control of Parrot's Feather
Myriophyllum aquaticum

INTRODUCTION

This is an alien invasive species. It was first found in Britain in 1960 and is now found in about 90 sites in the UK. It is found mostly in ponds, but has also been found in reservoirs, gravel pits, streams, canals and ditches. It is most often found in eutrophic water bodies. In contrast to other members of the genus, which are native to the UK, it is able to grow as a terrestrial plant when ponds dry out and has even been found growing on the dry bank of a council tip in Cornwall..



It produces emergent shoots in addition to submerged ones which give it the characteristic feathery appearance reflected in its common name.

Only female plants have become established in the

UK. It spreads by asexual means. Stems are brittle and it can propagate itself by fragmentation of parent plants and recolonisation by growth of the small fragments.

Unfortunately the species is widely grown in small garden ponds and sold by aquatic garden centres and nurseries. It is most likely that all the introductions have been made as a result of escapes or discards from these situations. Often garden centres also sell *M. brasiliense* which is the same plant under a different name.

It is a native of lowland central South America. It has become established in Europe in France and Austria.

MECHANICAL CONTROL

Mechanical control is effective at removing large infestations of this plant in areas where access is available for weed cutting buckets or boats. Care should be taken to restrict the downstream movement of stem fragments which will result from cutting operations as regrowth is rapid from this type of propagule. The stems of this species are especially brittle and fragmentation occurs readily when the plant is cut.

CHEMICAL CONTROL

The plant is controlled by applications of dichlobenil as Casoron G or Casoron GSR in April. It is also controlled by diquat as Reglone when applied as a surface spray to emergent vegetation after June or as a sub-surface treatment earlier in the season.

It is also controlled by herbicides containing 2,4-D amine as the active ingredient (Atlas 2,4-D and Dormone).

It is not controlled well by applications of glyphosate as the waxy cuticle prevents entry of the herbicide to the plant which reduces its toxicity to the plant.

Chem[illegible] control will lead to a short term eradicatior[illegible] this species as recolonisation from original sources will often occur. [illegible] is important to

establish where the infestation has been derived from and take action to eliminate the source of material.

BIOLOGICAL CONTROL

Grass carp will not eat this species unless they are at least 2 years of age and then only reluctantly as long as no other preferred species are present

ENVIRONMENTAL CONTROL

This species is not tolerant of fast flow and does not appear to grow in rivers or fast flowing streams. Increasing flow by narrowing slow flowing channels may be a way of controlling the growth of this species. This effect is achieved when the plant itself grows in slow flowing systems and may result in self limitation in this type of channel.

Most emergent species are controlled by increasing shade. This can be achieved by planting trees along the south side of water bodies or by placing a floating opaque material over the water surface in early spring. Shade needs to be maintained for at least two months to effect control.

Because of the association with eutrophic waters a reduction in the nutrient loading to the water may help reduce the competitive ability of this species and lead to a re-establishment of the native species. This can be achieved by buffer strips if non-point nutrient sources can be identified and by a reduction in phosphate loading from other point sources such as sewage works and farm effluents.

BEST OPTIONS

1. Remove as much of the plant as possible by mechanical means after the end of June and before the end of August; apply Midstream to remaining infestations.

2. For early season control use dichlobenil before the end of April or diquat after this time.

3. If you prefer a biological control option then use Grass Carp. Be sure to obtain all the necessary agreements from MAFF, the Environment Agency and English Nature.

Note: *Herbicides should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of Herbicides on Weeds in or near Watercourses and Lakes. It is necessary to consult the local Environment Agency, SEPA or other Regulatory Water Authority before applying herbicides.*

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INFORMATION SHEET 28

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research

Control of Nuttall's Pondweed (*Elodea nuttallii*)

INTRODUCTION

Elodea nuttallii grows in still or slow flowing eutrophic waters. It has replaced *E. canadensis* at many sites due to increased eutrophication. It was first found in Europe in 1939 and in Britain in 1966. It has spread to 415 sites since then. It is often found in species poor macrophyte communities subject to boat traffic, management and in eutrophic drainage ditches. It is tolerant of disturbance, oil pollution and salinity up to 14 ppt (approximately half seawater). All *Elodea* species tend to act as metal ion pumps, taking up metals from the sediment and releasing them to the water. *E. nuttallii* is very tolerant of Copper in particular.

E. nuttallii

It is most common in calcareous waters and eutrophic waters because it has a high tissue demand for both phosphorus and nitrogen. It overwinters as prostrate shoots which start to regenerate new lateral shoots as the temperature reaches 10°C. The shoots grow rapidly towards the surface without branching where they form a densely branched canopy.

Both species have whorls of three leaves around the stem. Subsequent internodes are rotated at 60° giving the appearance of being arranged in 6 rows.

E. nuttallii is distinguished from *E. canadensis* by the possession of leaves which are in most cases narrower than 1.75 mm (mean 1.4 mm, range 0.4 to 2.4 mm); u[illegible]ly no longer than 10 mm (mean 7.7 mm, range 4[illegible]15.5 mm);

E. canadensis

..*nadensis* has leaves which are usually wider than 1.75 mm (mean 2.0 mm, range 1.1 to 5 mm); mean leaf length is 8.1 mm (range 5 to 13 mm). The leaves are flat and are widely acute to obtuse or obtuse-acuminate at the tip (this means it has approximately blunt or rounded leaf tips). The leaves are dark green and crisp. *E. canadensis* also develops axillary or apical stem turions.

MECHANICAL CONTROL

Mechanical control is best practised In July and early August. This is because during June the roots of this species die and in September the plant attains maximum biomass. Root death is one of the reasons why large masses of this plant are often observed floating in flowing systems. It is therefore desirable to cut after the time when regrowth will be slow and, only from stem fragments left after the treatment. Cutting before the end of June will require a second cut later in the season. To limit the amount of biomass required to be harvested it is also necessary to cut before September. Cutting later than September will limit the effectiveness because biomass will be reduced by washout and the plant will have adopted the prostrate form characteristic of overwintering plants.

CHEMICAL CONTROL

?. *nuttallii* is susceptible to terbutryn, diquat and dichlobenil applied in ›ring before the plant is fully grown. Terbutryn will kill all submerged

...on and can only be used in still water. Of the two dichlo formulations, only Casoron G should be used in shallow and/or na watercourses. Dichlobenil affects most rooted submerged plants and s rushes too. The approved products containing diquat are Reglone a Midstream. Reglone is a liquid and can be applied as a spray to the wat surface or directly by subsurface injection. Midstream is a viscous gel an can be used in flowing water or for localised control in still or slow flowin waters. It requires special application equipment. Diquat is not effective in muddy water. Diquat can be used for chemical control later in the season then the other two herbicides.

Chemical control will give effective eradication of the plant for between 2 and 3 years. Regular inspections should be made to check on re-infestation and spot treatments should be applied to prevent further spread.

BIOLOGICAL CONTROL

The use of herbivorous Chinese Grass Carp is appropriate as a control method for this plant. Common Carp, and other bottom feeding fish, which create turbid water, can also be effective in preventing regrowth of the plant after mechanical removal or control by a herbicide.

ENVIRONMENTAL CONTROL

Shade will control most submerged aquatic plants. This can be achieved by planting trees on the south side of water bodies or by using a floating sheet of opaque material. Care must be taken when using the latter to prevent sudden deoxygenation.

suspension (O'Clear available from Aqua Company Ltd. 01252 712307). This process is only effective in waters of pH above 7.5. Other flocculating products are based on the addition of chalk granules to the water (Aquaplankton, 01449 774532; Hydroperfect, 03186 870387).

The removal of nutrients from the water is an environmental strategy for control of unicellular algae. Phosphate can be precipitated out of solution by the addition of ferric sulphate and by encouraging the flow of water over limestone. Removal of nutrients is possible by using reed bed pre-filtration systems with sedimentation traps and vertical flow pathways.

These strategies will product a short term, temporary reduction in the algal problem. If steps are not taken to eliminate some of the environmental factors stimulating unicellular growth then reapplication of these techniques and processes will always be necessary.

The information provided in this document represents the current best available advice. Users should take all reasonable precautions to ensure that they comply with current Codes of Practice relating to use of herbicides, and have notified the relevant authorities of their intentions. This document has no standing in law.

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INFORMATION SHEET 29

Chemical Control of Algae

Centre for Aquatic Plant Management
IACR Long Ashton Research Station
Integrated Approach to Crop Research

INTRODUCTION

Chemicals should be used for the control of algae if a "quick-fix" solution is required. Often, the problem will re-occur when the chemical has been washed out of the system. Because most of the appropriate herbicides kill other plants they tend to remove a lot of the vegetation, leaving a bare habitat. The first plants to recolonise bare habitats in water are usually algae and, often, the new problems will be worse than the problem which was treated. Some algae can become resistant to herbicides if they are treated regularly with the same compounds. The only solution in these situations is regular mechanical removal or treatment with barley straw. Long-term control of algae can be achieved by the use of barley straw.

Use chemicals for algal control if you need to clear an area of water quickly and you are prepared to adopt their use as part of an on-going management system. They are also useful as the first part of an integrated management regime for algae. The problem can be removed quickly by the use of chemicals in the first instance followed by environmental management techniques to reduce the potential for recolonisation by algae. Appropriate environmental methods include planting more submerged plants, more plants with floating leaves, and increasing shade or reducing nutrient concentrations in incoming water. (N.B. Water plants should not be introduced until at least 3 months after the water has been treated with Clarosan 1FG or for at least 1 month after treatment with Reglone).

There are several disadvantages to using chemicals. Professional herbicides which kill algae are non-selective and will kill other desirable vegetation. Amateur products (sold in garden centres to gardeners) often contain copper compounds which can be harmful to invertebrates and fish if over-applied.

CONTROL OF FILAMENTOUS AND MACROPHYTIC ALGAE

There are three commercially available professional herbicides which can be used to control filamentous algae. Filamentous algae are characterised by their ability to form floating mats and their adherence to submerged structures. Commonly encountered species are *Cladophora glomerata* (Blanket weed), *Vaucheria dichotoma* (Cott), *Spiorgyra* and *Rhizoclonium* species. *Chara* species, although not classed as filamentous algae are included in this section.

Clarosan 1FG **(contains terbutryn)** (available from Ciba Agriculture 01223 833621)

This is a granular product containing 1% active ingredient. is product

will kill most submerged vegetation. The granules should be spread evenly over the surface of the water. Susceptible algae should be treated at an application rate of 5 kg per 1000 m^3 water. Moderately resistant algae should be treated at 10 kg per 1000 m^3 water. The product should be applied early in the growing season. Growth ceases almost immediately but signs of death usually occur after 2-4 weeks. Regrowth will not usually occur for at least 3-4 months after treatment. If dense weed growth is present only use the product on 400 m long stretches of watercourses separated by at least 400 m untreated gaps and on not more than one quarter of the total area of a lake. Leave 14 days before treating remaining sections. Clarosan 1FG works by inhibiting photosynthesis (production of oxygen) but does not inhibit respiration (consumption of oxygen). Therefore levels of dissolved oxygen in treated areas will fall dramatically after treatment and may cause harm to fish and other animals in the area. It is very important not to treat the entire watercourse at one time to allow fish and invertebrates to find unaffected areas. It is important that the entire lake is treated within a 6-8 week period otherwise control may be reduced.

Clarosan 1FG is only effective in static water and in situations where the flow is less than 1 metre in 3 minutes (effectively static). If there is any observable flow then it should be stopped for at least 7 days. Water treated with this product may be used for irrigation of crops and livestock 7 days after treatment.

Susceptible:
Cladophora glomerata
Enteromorpha intestinalis
Rhizoclonium species
Spirogyra species
Moderately resistant:
Vaucheria dichotoma
Vaucheria sessilis

Reglone **(contains diquat)** (available from Zeneca 01428 656564)

Reglone is a liquid formulation containing 20% active ingredient. It will control many submerged vascular plants and floating plants such as Duckweeds. It is applied with or without dilution by surface spray or by subsurface injection (by trailing a nozzle below the water surface) at a rate of 5 litres per 1000 m^3 water. It can be used in static water or where the flow is less than 90 metres per hour. It should be applied in spring when rapid algal growth occurs. Plants become yellow within 2-4 days. Plants sink and start to decay within 1-2 weeks. Where a dense filamentous growth has occurred later in the summer, Reglone can be applied to localised areas. The treated areas should be small enough the allow fish and invertebrates to move away from the area. Do not treat more than 25% of the total surface of a pond at any one time. Further localised control can be practised after a two week interval. Reglone is rapidly absorbed by plants and mud. Do not apply to water containing high levels of suspended sediments and avoid stirring up the mud during application. Reglone persists for a few days only and algal growth will return later in the season.

Moderately susceptible:
Cladophora glomerata
Enteromorpha intestinalis
Spirogyra species
Resistant:
Vaucheria dichotoma
Vaucheria sessilis

Casoron G/Casoron GSR (contains dichlobenil) (available from Zeneca 01428 656564)

These products are granular formulations. The only species of algae that are controlled are *Chara* species. All other filamentous algae are resistant. In shallow (less than 60 cm) and narrow watercourses (less than 1.5 m) use Casoron G and in wider and deeper watercourses use Casoron GSR. These products will control most submerged rooted plants. Do not plant additional plants for at least 4 months after treatment with Casoron G or GSR.

The following products can be obtained from garden centres and similar retail outlets for treatment of filamentous algae in garden ponds.

Aquaplancton
Bio-Claire
Blagdon Pool Clinic Algicide
Blanc-Kit
Hozelock Pond Balance
Hydroperfect Starter Combi-Pack
Interpret Pond Balance
King British Green Algae Control
Lotus Pool Balance
O'Clear
Remanoid Aquaclear
Sera Pond Water Peat
TetraPond Algofin Plus
Waterlife Algizin P

CONTROL OF UNICELLULAR ALGAE

This type of algae creates green water and pea soup like conditions. There are no professional herbicides available for the control of unicellular algae, although Reglone will have a temporary effect. However, there is one herbicide product available to amateurs for use in garden ponds which is based on terbutryn, called Algae-Kit (Ciba Geigy 01223 833621). This can be obtained from garden centres and similar retail outlets.

The following products can be obtained from garden centres and similar retail outlets for treatment of unicellular algae in garden ponds.

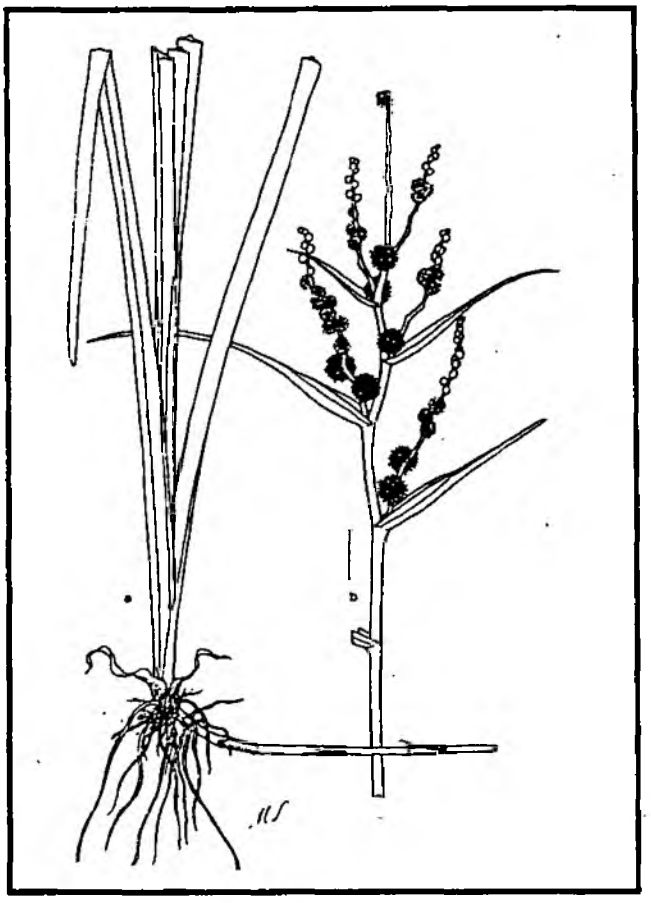
Algae-Kit
Aquaplancton
Bio-Claire
Blagdon Pool Clinic Algae Clear
Blagdon Pool Clinic Algicide
Blanc-Kit
Hozelock Green Water Treatment
Hozelock Pond Balance
Hydroperfect Starter Combi-Pack
Interpret Green Away
Interpret Pond Balance
King British Green Algae Control
King British Green Water To Go
Lotus Green Water Treatment
Lotus Pond Block
Lotus Pool Balance
O'Clear
Pond Care Accu-Clear
Remanoid Aquaclear
Sera Pond Water Peat
TetraPond Algofin Plus
TetraPond AlgoRem
Waterlife Algizin A
Waterlife Algizin P

Unicellular algae can be flocculated and precipitated out of suspension by non-herbicidal chemical means. The addition of aluminium sulphate to the water will remove algae from

INFORMATION SHEET 30

Control of Branched Bur-reed (*Sparganium erectum*)

Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research



INTRODUCTION

There are 14 species of *Sparganium* of which 4 occur in Britain and Ireland. *Sparganium erectum* (Branched Bur-reed) and *Sparganium emersum* (Unbranched Bur-reed) are most likely to cause a weed problem. *S. angustifolium* (Floating Bur-reed) and *S. natans* (Least Bur-reed) are most common in the north and west of the UK, although there are isolated reports of both species in Hampshire and East Anglia. There are four recognised subspecies of *S. erectum* which can be treated as the same for control purposes.

S. erectum is most often found at the margins of lakes, rivers, streams, canals and drainage ditches in permanent water. It grows best in water between 10 and 20 cm deep in silty mud. It is easily uprooted and therefore does not grow well by fast-flowing rivers or streams. It is restricted to the shallow margins and cannot withstand prolonged emersion. It is found in relatively nutrient rich waters. It grows actively from April and flowers from July to September with the fruits ripening in November. Plants spread by vegetative methods including growth of the rhizome, dispersal of detached rhizomes and by relocation of uprooted plants. Seedling survival is not high and may only be important for spread in undisturbed habitats.

The plants are an important habitat for wildfowl nesting, roosting and feeding. The fruits form an important part of their diets in late Autumn and early Winter. For this reason complete elimination of stands should not be undertaken unless absolutely necessary.

MECHANICAL CONTROL

The plant is easily controlled by mechanical methods. It is easily uprooted and can be pulled out and disposed of if the stand is small enough. Regular cutting in summer (between June and August) will also eliminate this plant.

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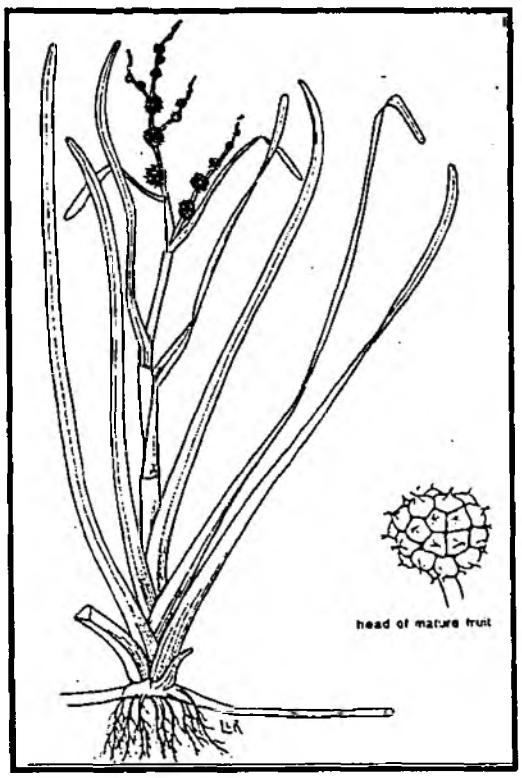
CHEMICAL CONTROL



All emergent species are susceptible to the herbicide glyphosate. This should be applied at a rate of 5 litres per hectare in 200 litres of water to the emergent material between July and September. It should be remembered that early applications will reduce the efficacy of control with some plants surviving to regrow in following seasons. This may be advantageous where complete elimination is not required. The effect of thinning dense stands can be achieved by earlier applications to retain a wildlife habitat while not restricting flow capacity to a significant extent. Repeated applications will be necessary after two or three years if the stand has regrown.

BIOLOGICAL CONTROL

Cattle and other livestock which drink from water margins will eliminate this species both by uprooting it and eating it. Although not a classical method of biological control the extent and spread of stands can be limited by controlled access of livestock to marginal vegetation.

ENVIRONMENTAL CONTROL

This species is controlled by shade created by planting trees. It is also controlled by lowering water levels to dry out stands for a period of between 6 weeks and 3 months. It is controlled by increasing water depth to greater than 50 cm or by increasing flow significantly.

BEST OPTION

If the stand is small then remove by hand, pulling out each plant.

If the stand is larger either cut repeatedly for three to four years during July or apply a herbicide containing glyphosate to areas which are required to be controlled.

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Note: *Herbicides should be used in accordance with the manufacturer's instructions (printed on the product label or accompanying leaflets) and the MAFF Guidelines for the use of Herbicides on Weeds in or near Watercourses and Lakes. It is necessary to consult the local Environment Agency, SEPA or other Regulatory Water Authority before applying herbicides.*

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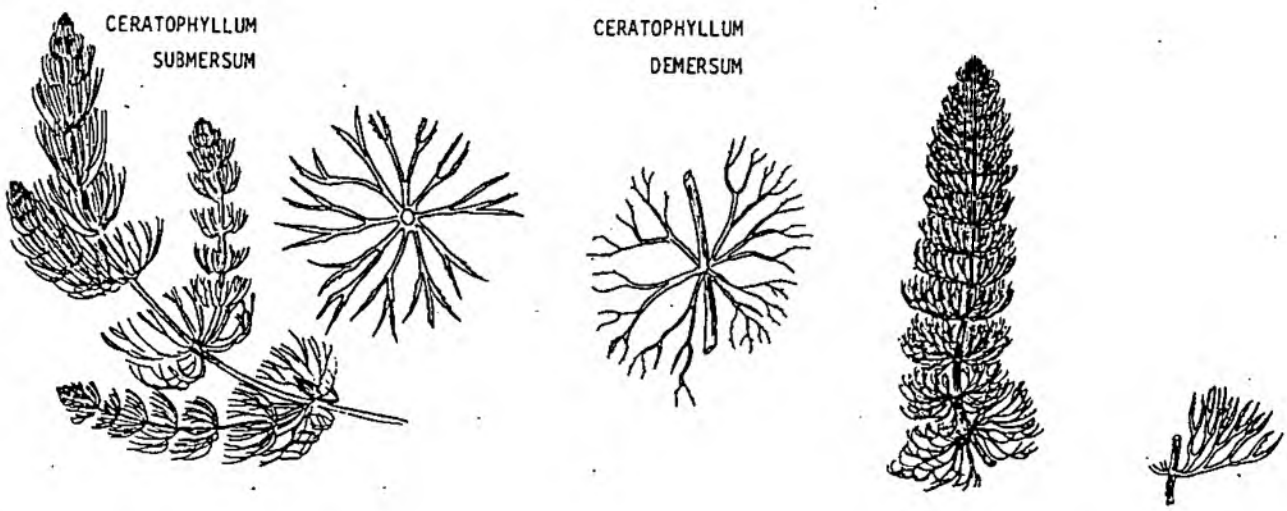
INFORMATION SHEET 31

Control of *Ceratophyllum demersum* (Rigid Hornwort)

Centre for Aquatic Plant Management
IACR Long Ashton Research Station
Integrated Approach to Crop Research

INTRODUCTION

Ceratophyllum demersum is unusual among submerged aquatic plants because it does not have any root system and is technically free floating. This restricts the types of waterbody in which it can grow successfully to ponds, lakes, gravel pits, drainage ditches, canals and other areas where flow is very slow or the water is static. There are two species of *Ceratophyllum* in Britain. *C. demersum* (Rigid Hornwort) occurs in mesotrophic to eutrophic waters with a high ionic content (conductivity) including brackish waters, growing at a depth of about 1 m, although it can grow down to 8.5 m in clear waters. It is tolerant of low light levels. The leaves are rather stiff, resembling forked antlers. *C. submersum* (Soft Hornwort) is less tolerant of pollution and shade than *C. demersum* and is therefore much less frequently found. The two species can be separated on the basis of leaf shape. *C* demersum usually has leaves which are once or twice forked at most, dark green in colour and many teeth at the leaf margins. *C. submersum* usually has leaves which are mostly forked three times, grass green in colour and have very few, if any, teeth at the leaf margins.



Ceratophyllum demersum is most often reported to be troublesome in static lakes in the early stages of eutrophication and the presence of this species as a dominant part of the lake flora is characteristic of deteriorating water quality.

MECHANICAL CONTROL

Cutting free floating plants is not the best method of control. However, if cutting operations are being carried out where the plant is known to occur then successful removal can be achieved by entrainment with other submerged plant material. Mechanical harvesting may offer a better method of selective mechanical management of this plant.

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CHEMICAL CONTROL

C. demersum is susceptible to herbicides approved for use in or near water containing diquat or terbutryn. Terbutryn (Clarosan 1FG; Ciba Agriculture, Whittlesford, Cambridge) will kill most submerged vegetation and can be only used in water flowing at less than 20 metres per hour (effectively static). For these reasons it should only be used in enclosed waters where *C. demersum* is the dominant submerged plant and complete eradication is required.

Diquat as Reglone will control a large number of other submerged plants and should only be used in waters flowing at less than 90 metres per hour (1.5 m/minute). Diquat as Midstream can be used in slow flowing or static situations for localised control of *C. demersum* where it is growing among other desirable submerged plants. The effectiveness of diquat is limited in turbid conditions, in conditions of high Calcium alkalinity and in conditions where a surface film of chalk deposits and epiphytes occurs on the leaves of submerged plants. The latter two conditions are common in situations where *C. demersum* grows and care should be taken to treat the plant as early as possible in the growing season before the development of a substantial surface layer. Both diquat formulations are manufactured by Zeneca, Haselmere, Surrey.

C. demersum is also moderately susceptible to herbicides containing dichlobenil (Casoron G and Casoron GSR; Zeneca. The mode of uptake of dichlobenil is by root absorbtion. *Ceratophyllum* species do not have true roots although some chemical may be absorbed by contact with other plant surfaces. The lack of a good uptake route is the most likely explanation of the lower degree of control of *Ceratophyllum* achieved with dichlobenil.

BIOLOGICAL CONTROL

Grass Carp are not particularly fond of this plant although they will eat it if nothing else is available. The fish should be on the large size (at least 500 g) if deliberately stocking for control of this plant.

ENVIRONMENTAL CONTROL

Deep shade will control this plant relatively easily. The shade should be maintained for at least six months to ensure complete eradication. Shading can be achieved by planting trees along the south side of ditches or narrow watercourses.

BEST OPTION

Treat with diquat in April or early May to prevent the occurence of an infestation.

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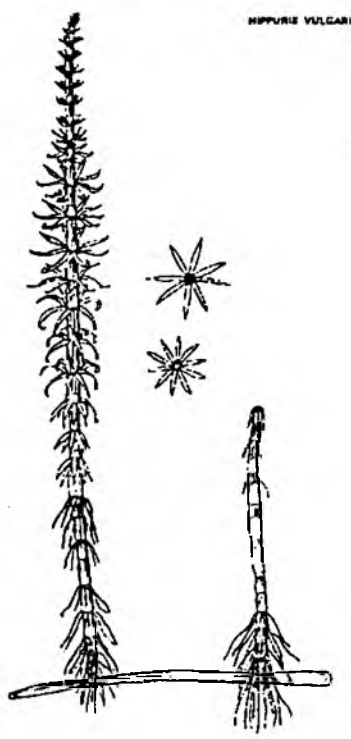
INFORMATION SHEET 32
Control of *Hippuris vulgaris* (Mare's-tail)

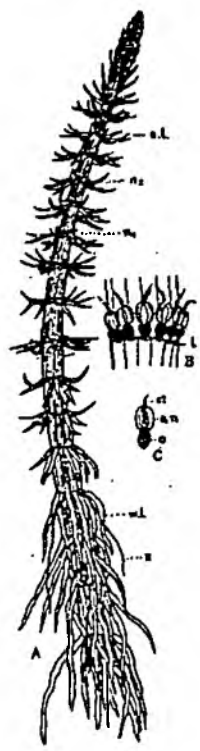
Centre for Aquatic Plant Management
IACR-Long Ashton Research Station
Integrated Approach to Crop Research

INTRODUCTION

Hippuris vulgaris (Mare's-tail) is an emergent, amphibious, heterophyllous, rhizomatous perennial aquatic macrophyte common throughout the UK. It is thought to be an original native of the British Isles, having been present since late glacial times and may even have been a survivor from before the last Ice Age. That it can survive cold conditions is evidenced by the occurrence of the plant at 2000m in the Swiss Alps today. It is a plant of the Northern Hemisphere only, being confined to temperate, boreal and sub-arctic regions. It is the only species in the genus *Hippuris*, which in turn is the only genus in the family Hippuridaceae. It is therefore not closely related to many other aquatic plants, although there may be a relationship with the family Haloragaceae, which contains many other aquatic nuisance species such as *Elodea* and *Myriophyllum*.



It can grow in water up to 3m deep. It exhibits heterophylly (two types of leaf form). When submerged the leaves are soft and the ascending stems bear close whorls of long, flaccid, stomata-less leaves, 1·5 to 7 cm long and 0·75 to 3 mm wide, which can number between 2 and 16 per whorl, whilst above the surface they have relatively longer internodes and whorls of shorter rigid leaves, 0·4 to 3·5 cm long by 1 to 3 mm wide, bearing functional stomata. The emergent type stems and leaves are much stiffer and, unusually for aquatic plants, the stems develop xylem thickenings for added strength. The trigger for development of emergent type leaves appears to be high light intensity at temperatures above 10°C. Although the transition normally takes place as shoots emerge form the water, aerial type shoots can be formed underwater in very clear conditions in midsummer.



Growth when submerged is mainly by cell division, but as soon as the plant forms emergent type leaves, growth is maintained by cell elongation. Growth of the horizontal rhizome is maintained by tremendous cell elongation of the lowest internode of a lateral bud. Adventitious roots develop at all nodes where lateral buds appear. The plant shows sympodial growth, in that it grows actively in front and dies away behind. This mode of growth maintains a healthy invasive front while encouraging siltation at the rear of the stand. It thus increases the speed of succession to fen and carr vegetation in small lakes and ponds.

It reproduces sexually. The flowers are very small and appear in the axils of emergent leaves. The hermaphrodite flowers are pollinated by wind. It then forms small, drupe-like, nutlet seeds which are dense and sink rapidly close to the parent plant. In most cases, rapid expansion of stands

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is probably due to vegetative growth while maintenance of growth within the stand is probably due to seedling recruitment.

The plant grows as an aquatic in clear base-rich water and as a terrestrial plant at the edges of standing waters in often meso- to eutrophic substrates. It can tolerate up to 5 parts per thousand of salinity.

MECHANICAL CONTROL

The plant can be cut mechanically using a weed cutting boat, or by hand in shallow water. The rate of regrowth is rapid before July (the period of maximum growth activity) and control will be short term. A recut will be necessary later in the season. If the plant is cut after July then control will usually last until the end of the season. Further cutting will be necessary in following seasons as the plant is perennial.

CHEMICAL CONTROL

Hippuris is susceptible to herbicides containing dichlobenil (Casoron G and Casoron GSR) and terbutryn (Clarosan). Successful control is only possible when the pant is fully submerged.

Casoron G and Casoron GSR. These herbicides must be applied in April and will only be successful if the plant has no emergent type leaves (which can be formed underwater) usually at the beginning of May. Dichlobenil acts on cell division processes within the plant which are only operative when the plant is forming submerged leaves. Emergent leaves are formed by elongation of cells already formed underwater. The length of control period will probably be for two seasons.

Clarosan. This must be applied in early April or late March because the plant must remain submerged for at least three weeks for the herbicide to kill it. Clarosan causes severe deoxygenation of water and should only be used in the spring when biomass of plants is low. Again the period of control is likely to be for at least one season and maybe, under favourable conditions for up to two seasons

ENVIRONMENTAL CONTROL

Shading is not an appropriate method of control for this species as it responds to low light by rapid elongation of internodes, which will usually reach the edge of any shading material. The stands may be less dense if grown in shade and emergent parts may form later in the year than usual but successful control will not be achieved.

BIOLOGICAL CONTROL

There are no known biological control agents for this species. Grass carp will not damage the plant sufficiently to kill it.

BEST OPTION

Apply Casoron GSR in early April when the plant is submerged. Cut any regrowth after July in the same year and re-apply the herbicide again in the following year.

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INFORMATION SHEET 36

Reed Beds

Centre for Aquatic Plant Management
IACR Long Ashton Research Station
Integrated Approach to Crop Research

INTRODUCTION

Both naturally occurring and constructed wetlands or reed bed systems can be used to reduce the amount of nutrients entering water from the terrestrial environment. In true natural systems water usually flows from surrounding land into a marshy area with trees and scrub vegetation and then into a reed bed before entering the open water of lakes. This process removes a large amount of the nutrients before they reach the open water, reducing the potential for growth of troublesome algae and plants. This process can be encouraged by using deliberately planted reed beds or constructed wetland systems.

Constructed wetlands would most often be used where there is a point source of pollution, i.e from a field drain, from hard surface runoff (eg car parks or road surfaces), or as an intentional waste water treatment process. Reed beds in lakes and at the margins of rivers are more appropriate for reducing the impact of diffuse pollution sources, i.e. from surface runoff and groundwater sources.

In recent years there has been an increase in the use of constructed wetlands for treating waste water. There are now some 200 commercial working systems in use in Britain. They are mainly used as tertiary treatment systems in rural sewage works to reduce the nutrient loading (nitrogen (N) and phosphorus (P)); Biological Oxygen Demand (BOD); and suspended solids (SS) to levels required by national and european water quality legislation. At the moment, they are only used for treating waste water from populations of up to about 2000 people, although a system to treat sewage from 10,000 people is being constructed in Scotland. They are used widely to treat effluent from farming activities. They are cheaper to build and operate than traditional systems and their use is predicted to increase dramatically in the next few years.

The underlying principles of water quality improvement operate in all reed bed systems. The main advantage of constructed wetland systems are that they can be designed to treat the exact form of pollution problem. Natural systems are not as specialised and generally have to be much larger to achieve similar water quality standards.

This leaflet gives information on the necessary ingredients for reed beds and constructed wetlands. It is not a design handbook. Further information can be found in the references listed at the end of this publication.

PRINCIPLES OF NUTRIENT REMOVAL

Nitrogen (Ammonia, Nitrate and Nitrite)

Removal of ammonia (NH_3) depends on the conversion to nitrate (NO_3) under aerobic conditions (oxygen rich) This is termed nitrification. NO_3 is reduced to nitrogen gas (N_2) under anaerobic conditions (no oxygen, or oxygen poor). This process is termed de-nitrification It is difficult to achieve both aerobic and anaerobic conditions in the same system. Vertical flow constructed wetland systems are good at nitrification because they encourage aeration, while horizontal flow systems are good at de-nitrification because oxygen levels are usually lower (see later). Natural reed beds usually have aerobic and anaerobic zones but they may not be in the right place relative to each other to act efficiently. This contributes to the lower nutrient removal efficiency observed in natural wetland systems.

Phosphorus (Phosphate)

The removal of phosphate is achieved by two main processes in wetland systems. The first is by sedimentation of silt and soil particles. The second is by absorption and precipitation caused by complexing with Iron (Fe), Aluminium (Al) or Calcium (Ca) salts. The easiest way to encourage removal of phosphate

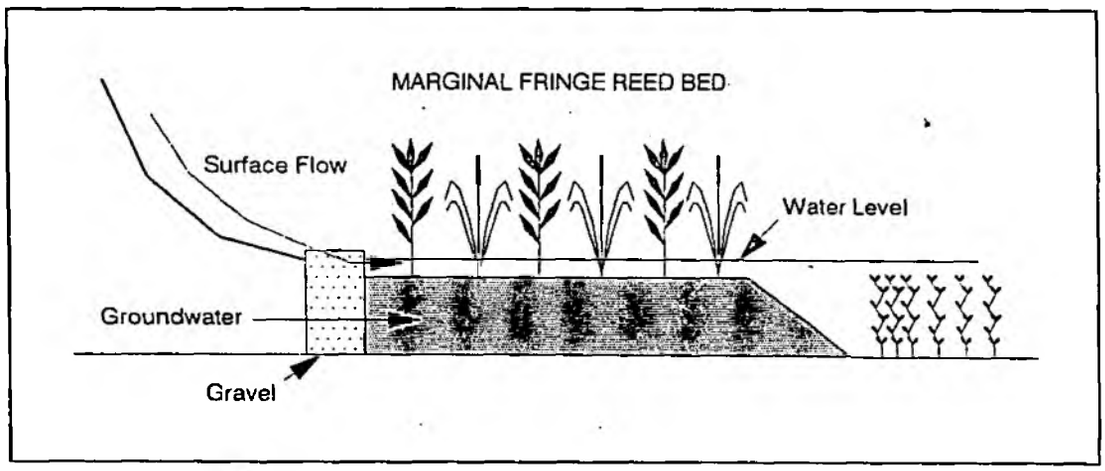
is to add Fe or Al salts or to allow water to flow over or through chalk. The chalk will often become encrusted with phosphate salts and will need to be replaced at regular intervals. Scrap iron can also be added to the system to encourage precipitation.

Carbon

Organic carbon is generally removed by precipitation of suspended solids in a settling tank or by physical filtration in the gravel bed of a constructed wetland system. In natural reed beds sedimentation is the main method of carbon removal. Microbial action also immobilises a large percentage of dissolved organic carbon. A source of organic carbon is important for the bacteria which carry out the nitrification and denitrification reactions. In new systems the organic carbon takes time to build up and the efficiency of nutrient removal often increases when the system "matures".

REED BEDS

These are primarily natural systems for control of diffuse pollution sources. The flow of water through systems determines the efficiency of nutrient removal. For maximum efficiency in natural systems a mixture of free surface flow and subsurface flow should be encouraged. This can be achieved by filling a trench of approximately 30-50 cm wide with coarse gravel to a depth of 50-100 cm to intercept the flow of surface water before it reaches the reed bed. The narrow width of the gravel will allow some water to percolate downward while the remainder flows over the surface. This also has the effect of intercepting ground water influx and mixing it with surface water runoff to dilute any sudden pollution incidents. The greater the width of the reed bed the more efficient the nutrient removal becomes.



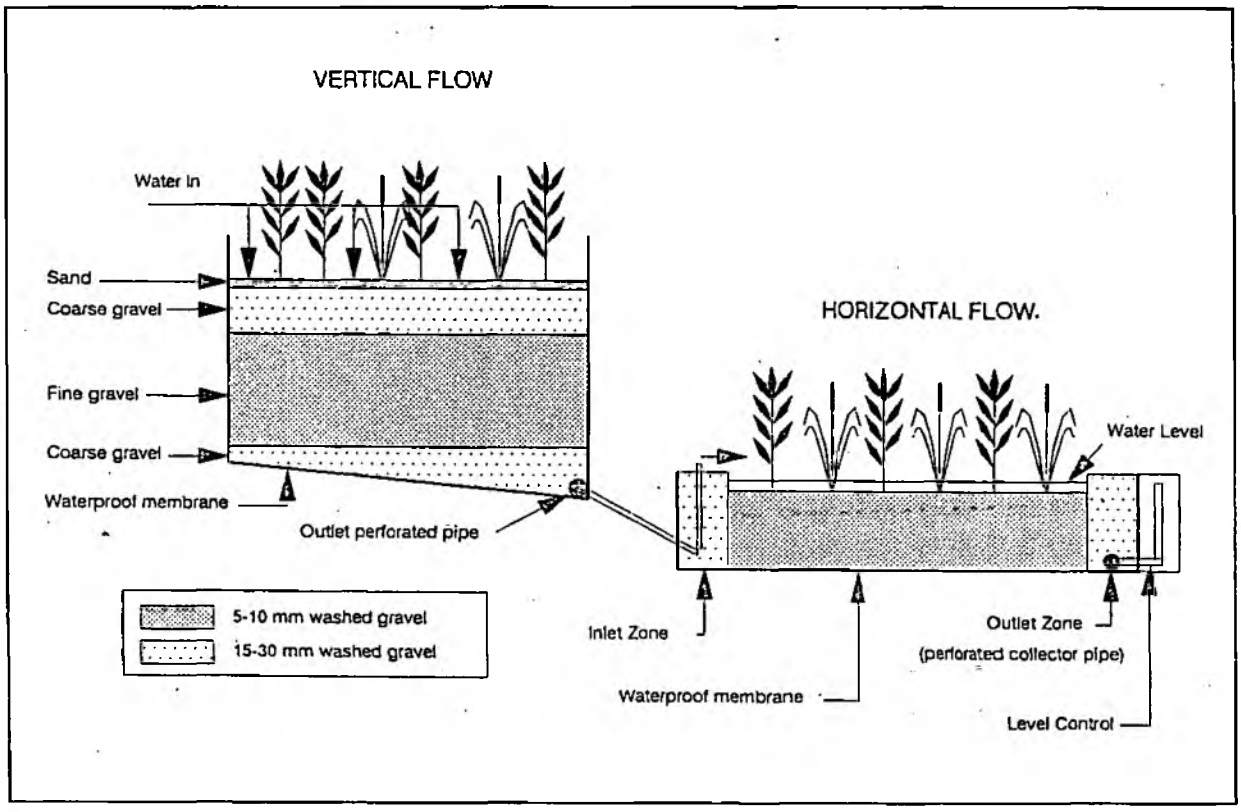
When establishing new reed fringes at the margins of a lake or pond, be prepared to leave a wide shallow shelf for establishment of reeds and rushes. Plant as many different species as possible but always include, *Schoenoplectus*, *Phragmites* and *Typha*. Other suitable species are *Phalaris* and *Glyceria*. Plants provide an important source of organic carbon, both from root exudates and from leaf litter decomposition.

The removal of nutrients can be enhanced by allowing water to flow through a waterlogged zone containing willow or poplar trees. This tree zone should be between 1 and 5 metres wide

CONSTRUCTED WETLANDS

There are two types of constructed wetland, classified according to the direction of water flow that predominates in the system, vertical flow systems and horizontal free surface flow systems. Each has advantages in terms of nutrient removal and the best option is to have a series of systems which will optimise the water treatment capacity. The first stage is always a settling tank or septic tank system, followed by a vertical flow system, and lastly a horizontal free surface flow system. The size of constructed wetlands is determined by the nutrient loading. This is often expressed as "population equivalents". Progress in the design of constructed wetland systems has benefitted from their use as tertiary treatment in commercial waste water polishing. Gravel is the preferred substrate because it does not tend to become clogged like soil.

Diagram of a "hybrid" system (vertical flow followed by horizontal flow)



VERTICAL FLOW SYSTEMS

Vertical flow systems are ones in which the water flows from the top to the bottom of the bed. In UK climatic conditions the surface area of a vertical flow system should be at least 1 m^2 per population equivalent (pe) for removal of BOD, and at least 2 m^2/pe for BOD removal followed by nitrification (NH_3 to NO_3). If the inlet water is not well aerated it may be necessary to split the system into two halves to re-aerate the water for sufficient nitrification to occur. The bed should have a flat surface, but the bottom should slope towards the outlet pipe to allow flow by gravity to occur. The systems should not be flooded unless weed control is necessary. Flooding decreases the amount of oxygen in the system and decreases the amount of nitrification. Consideration should be given to constructing a number of beds in parallel to allow for rotation of loading on a regular basis. Depending on the water quality required at the outlet the water from vertical flow systems can be fed to horizontal free surface flow systems for further cleaning. Reeds and rushes should be planted at an initial density of 4 per square metre. Pot grown seedlings are the quickest to establish and are usually available from specialist nurseries.

If possible, it is important not to flood the surface of the bed continuously as this reduces aeration of the bed. Water should be applied intermittently at intervals and should not be re-applied until the surface o. the bed has dried. Waste water should be applied intermittently to achieve a depth of water of approx 5-6 cm on the surface of the bed. The time interval between applications should be approximately 5 or 6 hours. Intermittent application can be achieved by a siphon system or by a pumped system on a timer. In order to achieve the correct aerobic conditions in the bed, waste water should be applied from points distributed evenly over the surface of the bed, preferably from a sprinkler system, although this is not always possible. To achieve sufficient aeration water can be allowed to fall onto a hard surface (paving slab or similar) so that it splashes off and is allowed to flow onto the bed.

Vertical flow systems are usually constructed of a layer of sand (approx 5 cm), coarse gravel (20 cm), fine gravel (60 cm) and coarse gravel at the bottom to allow for free drainage out of the system. This construction has the advantage that it does not usually clog with debris and plant root growth maintains preferential flow routes down through the bed.

HORIZONTAL FREE SURFACE FLOW SYSTEMS

Horizontal flow systems are ones in which the majority of the flow occurs across the surface of the bed through the stems of the plants. Horizontal flow systems are appropriate for reduction of BOD and SS. Nitrification is not usually accomplished by these systems but denitrification processes are often commonplace due to the saturated nature of the substrate (hence lower oxygen concentrations). The advantage of having a horizontal system after a vertical flow system is that the NO_3 formed in the vertical flow system is converted to N_2 in the horizontal flow system, achieving better total Nitrogen removal. For treatment of settled sewage the area should be equivalent to 5 m^2 /pe. For tertiary water cleanup the area should be a minimum of 1 m^2 /pe. The bed should be at least 0.6 m deep with a level surface. The bottom can have a gradient towards the outflow if required. Reeds and rushes should be planted at an initial density of 4 per square metre. If bacterial contamination is a specific problem, *Schoenoplectus* (syn. *Scirpus*) species should be planted, as there is some evidence to suggest an antibiotic effect of root exudates from this genus.

The water level should be maintained at or above the surface of the bed, with the capability of draining down the bed to dry it out to encourage aeration and decomposition of the litter layer which will build up. This can be achieved by the use of an elbow joint at the outlet which can be turned through 90° so that the outlet can be at the bottom of the bed or above the surface of the bed (see diagram).

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INFORMATION SHEET 60

Opportunities for Biological Control of Aquatic Weeds In Britain

Centre for Aquatic Plant Management
IACR Long Ashton Research Station
Integrated Approach to Crop Research

INTRODUCTION

Biological control is the deliberate use of natural enemies to reduce the population of a target weed. The classical and the inundative methods are the two main approaches, with classical biological control directed towards controlling naturalised weeds through the introduction of exotic natural enemies from the weed's native range and inundative biological control directed towards mass production and release of endemic natural enemies.

The agent may eat the weed or may cause damage to it by inducing disease or by causing physical damage by, for example, trampling on it. In other instances, biological agents cause weeds to be controlled by indirect action but this is because they alter the environment in which the weeds are growing. This is termed environmental control.

The choice of a bio-control agent should be limited to those agents which target susceptible parts of plants. Agents can cause limited damage to very important parts of the plant which easily kill the target species. Other agents can cause extensive damage to parts of the plant which recover easily. Some target weed species may be able to tolerate different levels of damage than others. In Britain, small floating plants will be more likely to be damaged extensively by bio-control agents, while submerged rooted species will be more likely to be able to deal with a greater amount of sustained damaged.

The research needed to find effective biological control agents and then to ensure that it will not attack other non-target species is complex and expensive. Because the range of potentially troublesome weeds in Britain is wide and, because even troublesome species can be valuable in some habitats, relatively little research has been done on finding exotic biological control agents. Therefore, biological control in Britain is limited mainly to native agents and has very limited applications at present. Biological control of aquatic weeds is most effective where there is a single species (or a very limited number of species).

ECONOMICS

There are several principles governing the decision to use a bio-control agent. One of the most important is the relative cost. It is essential that a bio-control technique should yield equivalent or greater net returns to users than existing measures. Returns are best if the target weed is causing a severe economic problem; existing methods are expensive or inappropriate; and, the bio-control agent is effective rapid and reliable. Detailed costs of individual control agents are not given here as prices vary according to source and quantity.

RISKS

Ecosystem dynamics. Natural, self-sustaining and balanced ecosystems tend to resist change. An introduction of a biological control agent should not upset the balance of a mature, well balanced aquatic ecosystem. Such ecosystems will represent a barrier to the dramatic spread of control agents due to a decrease in the density of the target species. However, in an ecosystem dominated by weed species, the control agent should reduce the infestation and enable the ecosystem to restore itself and become self-sustaining.

Genetics. Consideration should be given to bottleneck and founder effects when small samples of a control agent are introduced into habitats with the potential for rapid population explosion. Limited genetic resources may make the control agent susceptible to predation or confer change on the agent to make it less effective than anticipated. There is a possibility for species creation. For this reason, individual control agents should be mixed before release; maintained as a large stock culture; and, making a few releases of a large number of individuals. Alternatively, if the habitat is significantly different from the natural habitat of the control agent, diversity should be maximised to allow for adaptation. This can be done by introducing lots of small populations and allowing interaction between them to create an adapted population in the new environment.

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HOW TO ASSESS BIOLOGICAL CONTROL

The hall mark of successful biological control is a persistent, marked reduction in the weed population. A measure of the success of control can be expressed as the ratio q, where:

$$q = N^*/K$$

where N* is the density of the weed in the presence of a control agent and K is the density of the weed before control. In good control situations q should be less than 0.01. In most control situations the success is dependent on the ability of the control agent to seek out the weed and on the presence of a spatially aggregated weed population (*i.e.* discrete dense mono-specific populations).

Rigorous testing of the species-specificity of introduced organisms is necessary to reduce the chance of accidental damage to desirable native species.

LIST OF SPECIES WITH POTENTIAL FOR BIOLOGICAL CONTROL IN BRITAIN

Any plant which grows in dense mono-specific stands such as:

Potamogeton pectinatus
Myriophyllum spicatum
Lemna sp.
Elodea canadensis
Azolla filiculoides
Crassula helmsii
Nymphoides peltata
Cladophora glomerata

LIST OF POTENTIAL BIOLOGICAL AGENTS SUITABLE FOR USE IN BRITAIN

Phytophagous insects:	Leaf miners, stem borers, weevils, mites, grasshoppers and moths
Aquatic Invertebrates:	*Daphnia*
Herbivorous fish:	Chinese grass carp
Benthic feeding fish:	Common carp, bream
Pathogens:	Fungi
Wildfowl:	Ducks, geese, swans
Mammals:	Horses, sheep, cattle, goats.

GRASS CARP These introduced fish are effective biological control agents of many submerged and floating weeds. They will also eat filamentous algae and even some emergent weeds when the food supply is limited. At present, their use is limited to enclosed waters where they cannot escape into river systems. A MAFF licence is required for their use. Further details of their use are available in the NRA R&D Note 53 "The use of Grass Carp for Aquatic Weed Control", available from Environment Agency Offices.

CATTLE, SHEEP, GOATS and HORSES. Grazing animals will eat vegetation on river banks, controlling bankside and some emergent weeds. Where control of only bankside weeds is required, sheep are preferable because they cause less damage to the banks. Cattle and horses will wade into shallow water, causing erosion to the banks, graze on emergent and even submerged weeds especially in summer when the grazing in pastures is poor. A traditional method of weed control in shallow watercourses was to drive cattle along the river bed where they trampled and grazed on the vegetation and produced some control. Common Reed has been controlled in situations where it is regularly exposed to grazing and trampling by cattle.

DUCKS, GEESE AND SWANS These waterfowl consume significant quantities of the softer water weeds. Domestic ducks and geese can be controlled and will remain in one place where they can control excessive growth of plants. Wild birds tend to migrate and are difficult to manage. Juvenile swans tend to congregate in sections of rivers where there are no adults to drive them away and these have sometimes been blamed for denuding valuable stretches of trout river of all vegetation.

MANAGEMENT AND CONTACTS:

The Environment Agency delivers a service to its customers, with the emphasis on authority and accountability at the most local level possible. It aims to be cost-effective and efficient and to offer the best service and value for money.

Head Office is responsible for overall policy and relationships with national bodies including Government.

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For general enquiries please call your local Environment Agency office. If you are unsure who to contact, or which is your local office, please call our general enquiry line.

ENVIRONMENT AGENCY GENERAL ENQUIRY LINE
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The 24-hour emergency hotline number for reporting all environmental incidents relating to air, land and water.

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