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Aquatic and riparian plant management: controls for vegetation in watercourses

Field guide

Project: SC120008/R1

Flood and Coastal Erosion Risk Management Research and Development Programme

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- **Delivering information, advice, tools and techniques**, by making appropriate products available.

Miranda Kavanagh

Director of Evidence

Executive summary

The management of aquatic and riparian plants is essential to ensure the efficient functioning of many watercourses. It is important that management is cost-effective, takes account of relevant legislation/restrictions and meets the objectives of the greatest number of watercourse users, while minimising any negative environmental impacts.

This field guide provides watercourse managers in flood risk management operating authorities (both technical staff and field operatives) with a framework to help inform decisions on when and how to manage vegetation, taking into account the species present and the watercourse type.

It is designed to be read and used together with:

- Technical guide – detailed information on planning, undertaking and monitoring aquatic and riparian vegetation management
- Decision-making spreadsheet tool – a tool to help inform selection of the most appropriate technique(s) to manage a particular watercourse type, with a specific species problem

The field guide is a concise guide to help collect the information needed to complete the decision-making spreadsheet tool. It includes a blank recording form for practitioners to use in the field to collect the information to input into the tool.

The evidence on which this guidance is based is presented in an accompanying case study report and a literature review report.

Contents

1. Introduction

The management of aquatic and riparian plants is essential to ensure the efficient functioning of many watercourses. It is important that management is cost-effective, takes account of relevant legislation/restrictions and meets the objectives of the greatest number of watercourse users, while minimising any negative environmental impacts.

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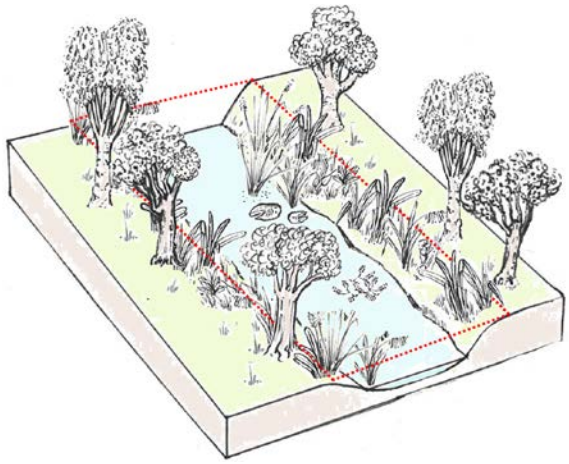


Figure 1.1 Riparian vegetation

This field guide is one of three interlinked items designed to be read and used together:

- **Technical guide** – detailed information on planning, undertaking and monitoring aquatic and riparian vegetation management
- **Decision-making spreadsheet tool** – a tool to help inform selection of the most appropriate technique(s) to manage a particular watercourse type, with a specific species problem
- **Field guide** – a concise guide to help collect the information needed to use the decision-making spreadsheet tool

Riparian vegetation is defined in the guidance as 'the characteristic vegetation along watercourses that forms the link between the environments of water and land' (Figure 1.1). The structure of the field guide is shown in Table 1.1.

Table 1.1 Structure of the field guide

Content	Information
Chapter 2 Planning	Outlines the issues and factors that need to be considered when planning any aquatic and riparian vegetation management operation.
Chapter 3 Aquatic and riparian plants	Provides key information on potential problem species, including aids to identification..
Chapter 4 Watercourse types	Provides information to assist in identifying the watercourse type.
Chapter 5 Management techniques	Provides an overview of the range of techniques available for managing aquatic and riparian plants.
Chapter 6 Data Collection	Helps users of the spreadsheet tool by describing and explaining the information it is necessary to collect in the field.

2. Planning

For it to be effective and beneficial, it is essential to plan aquatic and riparian plant management carefully.

2.1 Problem identification

The first stage of planning is to:

- identify if there is a problem
- determine if management is necessary

To identify the problem it is necessary to understand the function(s) of the watercourse. For example, if the watercourse performs a flood risk management function, is vegetation growth increasing flood risk?

The next step is to determine whether the extent and density of vegetation growth sufficiently impairs the watercourse function(s) for action to be taken. In some cases the function(s) of the watercourse may only be partially impaired and a decision could be made to take no action.

Further information on problem identification and watercourse function is given in Chapter 4 of the technical guide.

2.2 Develop a baseline understanding

Having decided that aquatic and riparian plant management is needed, the next step is to develop a baseline understanding of the watercourse, including:

- problematic species (Chapter 3)
- watercourse type (Chapter 4)
- other management considerations at the site (section 2.3)

2.3 Management considerations

A number of considerations need to be taken into account when planning vegetation management (Figure 2.1). Table 2.1 provides a checklist of questions relating to these considerations, the answers to which will influence the management technique selected.

It is recommended that watercourse managers consult the technical guide for additional details, including links to sources of further information and actions that may be required before management is carried out.

The list of considerations identified in Figure 2.1 is not exhaustive. There may be other factors that need to be considered before carrying out management; this should be determined on a site-by-site basis.

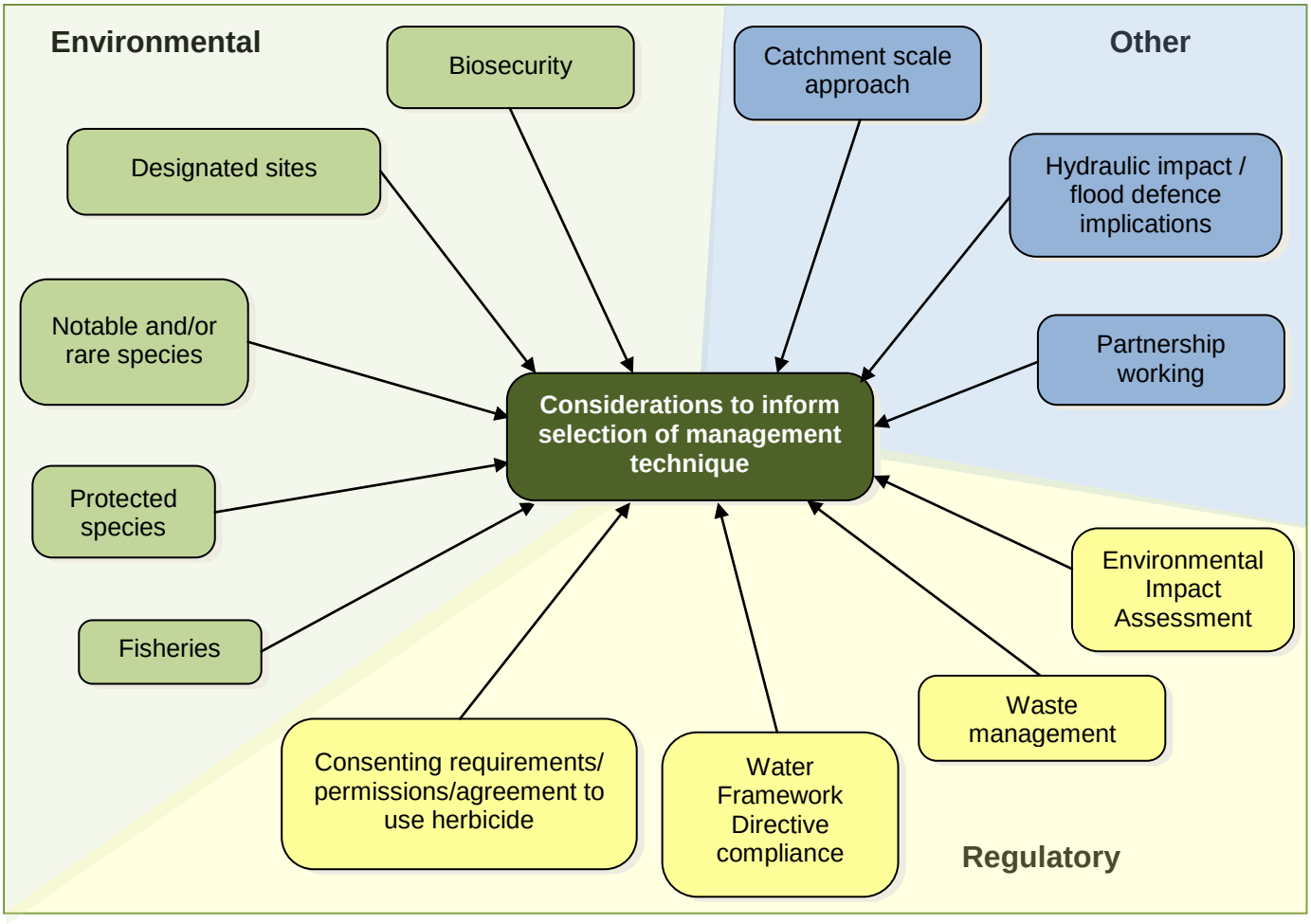


Figure 2.1 Considerations to inform selection of management technique

Table 2.1 Planning checklist

Is the watercourse designated or does it flow into, through or out of a designated nature conservation site?
Is the watercourse located adjacent to a Scheduled Monument?
Does the watercourse support protected, notable and/or rare species?
Are spawning fish present?
Has biosecurity been considered?
Do the proposed management works require a WFD Compliance Assessment?
Do the proposed management works fall under the EIA Regulations?
Have all health and safety implications been identified?
Will the proposed management works create waste which requires disposal?
Do the proposed management works require flood defence/land drainage consent?
Do the proposed management works require the use of herbicide in or near water?
Has the possibility of partnership working been explored?
Has management been considered in the context of the wider catchment?

2.4.1 Biosecurity

A good biosecurity routine is vital when performing management activities within watercourses to reduce and minimise the risk of spreading non-native invasive plant species and other harmful organisms/diseases such as crayfish plague.

The most cost-effective method of managing non-native invasive species is to prevent their spread. Many forms of management result in disturbance and fragmentation, which can result in the spread of the plant. This may result in an offence under Section 14 of the Wildlife and Countryside Act 1981 (as amended).

All those carrying out aquatic and riparian plant management should follow the steps of the 'Check, Clean, Dry' campaign (www.nonnativespecies.org/checkcleandry/index.cfm).

- Inspect and clean clothing and equipment thoroughly before and after use.
- Avoid areas containing non-native invasive species that are not intended for management to reduce contamination.
- Dry equipment thoroughly for at least 48 hours before reusing it.
- Deploy stop-nets/booms to collect plant fragments, which should be disposed of safely.

In some instances disinfecting may also be appropriate, for example, when moving from watercourses where signal crayfish are present to catchments where native white-clawed crayfish occur.

Watercourse managers should be able to recognise the most important non-native invasive species and the propagules that cause their spread.

Some of the most problematic non-native invasive species can be recorded on the free PlantTracker (http://naturelocator.org/planttracker.html) and AquaInvaders (http://naturelocator.org/aquainvaders.html) apps developed by the Nature Locator Project team at University of Bristol for iPhone and Android devices.

3. Aquatic and riparian plants

The identification of different species of aquatic and riparian plant is vital to developing an effective programme of management. It is important to accurately identify and distinguish plants from other (sometimes similar) species.

3.1 Types of plants

Aquatic and riparian plants can be considered in four groups (Table 3.1).

Table 3.1 Types of aquatic and riparian plants

Submerged plants	Species with stems and leaves that grow beneath the surface of the water, although flowers may project above the surface. They are usually found in deeper water and rooted on the bottom.
Floating-leaved plants	Plants with some or all of the leaves floating on the water surface. This group can be sub-divided into: • rooted floating-leaved plants • free-floating species
Emergent plants	Plants whose stems and leaves are exposed above the normal water level. They have erect, aerial leaves and can grow both in water and temporarily damp conditions. This category can be sub-divided into: • tall emergent species with long, narrow leaves • generally smaller, broad-leaved emergent species
Algae	Algae are classified according to colour. Filamentous types mat together in large entangled masses often known as 'blanketweed' or 'cott', whereas microscopic, unicellular forms can float in the water and give rise to 'blooms'.

Three non-native invasive bank species associated with watercourses also require particular attention. These are:

- Japanese knotweed *Fallopia japonica*
- Giant hogweed *Heracleum mantegazzianum*
- Himalayan balsam *Impatiens glandulifera*

The following sections provide information to aid in the identification of a number of species that can be problematic in a range of different watercourses. Chapter 5 of the technical guide provides more detail about each of these species.

3.2 Submerged plants

Submerged aquatic species which may require management include:

- native water-milfoils *Myriophyllum* spp.
- parrot's-feather *Myriophyllum aquaticum*
- submerged pondweeds *Potamogeton* spp.
- water-crowfoots *Ranunculus* spp.
- rigid hornwort *Ceratophyllum demersum*
- mare's-tail *Hippurus vulgaris*
- Canadian waterweed *Elodea canadensis* and Nuttall's waterweed *Elodea nuttallii*
- curly water-thyme *Lagarosiphon major*

Some water-crowfoot *Ranunculus* species can also have floating leaves and therefore could be discussed in section 3.3. Those which tend to require management generally have a submerged growth habit and so this group of species is discussed in this section.

Useful identification guides

- *British Water Plants* (Haslam et al. 1982)
- *The Wildflower Key* (Rose 2006)
- *New Flora of the British Isles* (Stace 2010)
- *The Vegetative Key to the British Flora* (Poland and Clement 2009)
- *The Plant Crib* (BSBI 2013)
- *Pondweeds of Great Britain and Ireland* (Preston 2003)

Water-milfoils *Myriophyllum* spp.

There are a number of native water-milfoil *Myriophyllum* species in the UK:

- spiked water-milfoil *Myriophyllum spicatum*
- whorled water-milfoil *Myriophyllum verticillatum*
- alternate water-milfoil *Myriophyllum alternifolium*

© JBA Consulting
Spiked water-milfoil *Myriophyllum spicatum*

Spiked water-milfoil *Myriophyllum spicatum*	Whorled water-milfoil *Myriophyllum verticillatum*	Alternate water-milfoil *Myriophyllum alternifolium*
3–5 leaves with 13–38 segments	4–6 leaves with 24–35 segments, sometimes emerging from the water	3–4 leaves with 6–18 segments
Base-rich ponds, lakes and slow-flowing rivers and ditches, mostly in lowlands	Base-rich ponds, lakes, canals and slow-flowing rivers in lowlands	Base-poor lakes, ponds, slow streams and ditches, often in upland areas
Often has a reddish tinge	Generally light green in colour	
Flowers in whorls	Flowers in whorls	Upper flowers are alternate
Reproduces by seed and vegetative growth	Reproduces by turions produced in September to November. These over-winter on the bed until February.	
Tolerant of eutrophic and brackish waters		A species of nutrient-poor waters
Common throughout UK and often requires management	Scattered distribution and rarely needs management	Locally frequent and scarce and rarely needs management

Alternate water-milfoil rarely requires management – **check species and consider the need for management**.

Parrot's-feather *Myriophyllum aquaticum*

Parrot's-feather *Myriophyllum aquaticum*

Is a non-native invasive species listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended). It is an offence to plant or cause its spread in the wild.

Like all water-milfoil *Myriophyllum* species, it has feathery leaves which are arranged around the stem in whorls, usually of 4–6, with 8–30 segments. In contrast to the native members of this group, Parrot's-feather *Myriophyllum aquaticum* is readily able to grow on land when ponds dry out and could also be considered as an emergent species, producing feathery shoots in addition to the submerged leaves. Its leaves have dense stalkless glands which give the emergent leaves a blue-grey colour.

In the future, other non-native water-milfoil *Myriophyllum* species (*M. heterophyllum, M. verrucosum* and *M. robustum*) may become problematic.

Submerged pondweeds *Potamogeton* spp.

The true pondweeds *Potamogeton* spp. are a group of 21 native species, plus a number of hybrids. A large number of *Potamogeton* spp. grow entirely submerged.

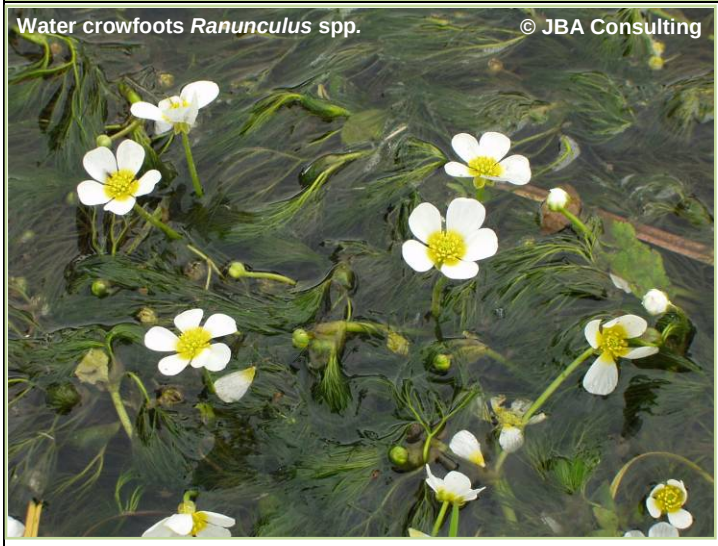
Some of the submerged pondweeds are common, whereas others are rare or localised in occurrence (for example, grass wrack pondweed *P. compressus* and sharp-leaved pondweed *P. acutifolius*). **Accurate species identification prior to management is essential.**

Fennel pondweed *Potamogeton pectinatus*

It is generally only certain species of submerged pondweed *Potamogeton* spp. that are problematic and often only in certain situations. Problematic submerged pondweed *Potamogeton* species of greatest concern are usually:

- Curled pondweed *Potamogeton crispus* – grows from creeping rhizomes and has leaves with a characteristic curled shape and a finely serrated edge. It grows in still and fast-flowing water and can tolerate a wide range of nutrient levels. It can grow in waters 0.5-2m deep.
- Fennel pondweed *Potamogeton pectinatus* – has fine leaves and grows from a creeping stolon rooted in the sediment of still or slow-flowing water bodies.

Water crowfoots *Ranunculus* spp.



There are many species of aquatic water-crowfoot *Ranunculus* spp. in Britain. They are a variable group of species and can be difficult to identify. All species have white flowers with a yellow base to the petals. These petals can vary in size from approximately 2 mm on the smallest flowered species to 15 mm on the largest.

Water-crowfoot *Ranunculus* species can either have submerged, finely divided (capillary) leaves or broad, floating (laminar) leaves, or a combination of the two. In the capillary leaves, the leaf initially divides into three, with potentially further divisions nearer the leaf tip depending on the species. Almost all species typical of flowing waters have these capillary leaves.

Those species found in fast-flowing rivers and streams are generally considered the most problematic. These species are often a key component of an important watercourse habitat type, listed in Annex I of the Habitats Directive. The presence of communities containing these species has led to certain rivers being designated as SACs. Management of water-crowfoot *Ranunculus* species must take this into account and liaison with Natural England or Natural Resources Wales should be conducted, where necessary. **The need to manage these species should be considered carefully.**

Rigid hornwort *Ceratophyllum demersum*

It has leaves which are arranged in whorls of usually 6–8, which regularly fork 1–2 times. The leaves are also toothed and the plant has a stiff, rigid structure. It can be found in still and slow-flowing waters. It is generally dark green in colour and does not root in the watercourse substrate; it is free-floating within the water column.

It can be confused with soft hornwort *Ceratophyllum submersum*, which is a much softer plant with leaves that are forked 3–4 times, with fewer teeth. When young or growing in shade, rigid hornwort *C. demersum* can be quite soft and resemble soft hornwort *C. submersum*. Soft hornwort is a much rarer species, often of coastal areas, which should not be managed. **Accurate species identification prior to management is essential.**

Mare's-tail *Hippuris vulgaris*

Can have both trailing submerged leaves and erect emergent leaves.

It has a thick spongy stem, due to the air cavities within it. Around the stem, are short, linear leaves arranged in whorls of 6–12. The tip of the leaf is very rounded. When submerged the leaves tend to be longer and softer, and the whorls more closely grouped. When emergent, the leaves tend to be shorter and stiffer, with the spacing between the whorls greater.

Mare's-tail *Hippuris vulgaris* © Sarah Warriss-Simmons

In flower, it has very small, green flowers without petals that form where the leaves join the stem on the emergent parts of the plant.

Canadian waterweed *Elodea canadensis* and Nuttall's waterweed *Elodea nuttallii*

Canadian waterweed *Elodea canadensis* © JBA Consulting

Both are non-native invasive species in the UK listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended). It is an offence to plant or cause their spread in the wild.

These species grow from stolons rooted in the sediments at the bottom of watercourses and have dark green translucent leaves in whorls of three (occasionally four).

Canadian waterweed *Elodea canadensis*	Nuttall's waterweed *Elodea nuttallii*
Broad leaves, widest at the middle	Narrower leaves, widest at the base
Leaf tip is blunt	Leaves taper to a pointed tip
Minute teeth on lower leaf margins	Minute teeth on all leaves
Leaves not strongly curved backwards or twisted	Leaves are curved backwards (that is, recurved) or twisted

Both these species have small white-pink flowers which float at the water surface on very long, thin stalks. They have three petals and sepals.

Curly water-thyme *Lagarosiphon major*

Curly water-thyme (sometimes also known as curly waterweed) is a non-native invasive species listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended). **I**t is an offence to plant or cause its spread in the wild.

The plant superficially resembles waterweed *Elodea* species with short, linear leaves between 1 and 3 mm in width and 6–30 mm in length. The leaves are strongly curved back on themselves (that is, re-curved), so that the leaf tips point at the stem below.

The leaves are either arranged in whorls or spirals of three around the stem, with those at the base of the plant always in spirals unlike waterweed *Elodea* species which have leaves which are always in whorls.

Curly water-thyme *Lagarosiphon major*

3.3 Floating-leaved plants

Free-floating aquatic species which may require management include:

- duckweeds (*Lemna* spp*., Spirodela* spp.)
- water fern *Azolla filiculoides*

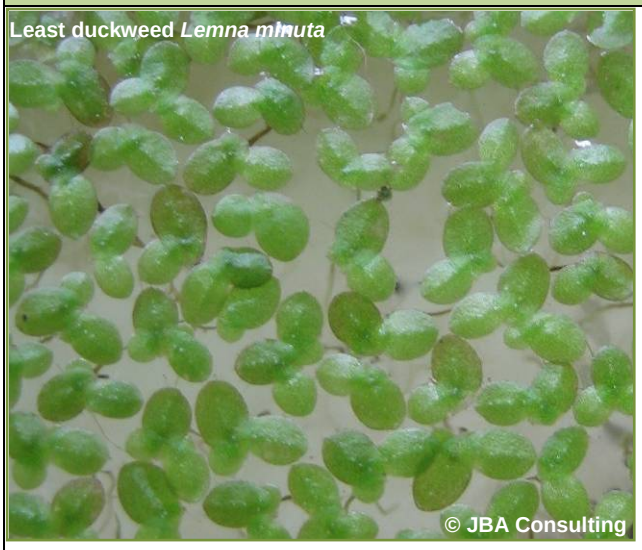
Rooted floating-leaved species which may require management include:

- broad-leaved pondweed *Potamogeton natans*
- water-lilies *Nuphar* spp. *and Nymphaea* spp*.*
- fringed water-lily *Nymphoides peltata*
- arrowhead *Sagittaria sagittifolia*
- water-crowfoots *Ranunculus* spp*.*

Useful identification guides

- *British Water Plants* (Haslam et al. 1982)
- *The Wildflower Key* (Rose 2006)
- *New Flora of the British Isles* (Stace 2010)
- *The Vegetative Key to the British Flora* (Poland and Clement 2009)
- *The Plant Crib* (BSBI 2013)
- *Pondweeds of Great Britain and Ireland* (Preston 2003)
- *Water Starworts: Callitriche of Europe* (Landsdown 2009)

Duckweeds (*Lemnaceae*)



There are several duckweed species in Britain, including:

- common duckweed *Lemna minor*
- greater duckweed *Spirodela polyrhiza*
- fat duckweed *Lemna gibba*
- ivy-leaved duckweed *Lemna trisulca*
- rootless duckweed *Wolffia arrhiza*
- least duckweed *Lemna minuta*

Common duckweed	Greater duckweed	Fat duckweed	Ivy-leaved duckweed	Rootless duckweed	Least duckweed
1–8 mm long	1.5–10 mm long	3–5 mm long	3–15 mm long (plus stalk)	0.5–1.5 mm long	0.8–4 mm long
Single long root	Several long roots	Single long root	No or only 1 root	No roots	Short roots
3–5 veins	Often red-purple below	Often white, spongy and swollen below (can be flat)	Complex branched structure Translucent	Ovoid in shape (can be rolled in your fingers)	1 vein

All of species are native with the exception of least duckweed *Lemna minuta* which is naturalised from North America.

Rootless duckweed *Wolffia arrhiza* is a very rare species and will not require management. **Take care to ensure this duckweed species is not present prior to management**.

All species produce small, round or oval floating plants on the surface of the water, with the exception of ivy-leaved duckweed *Lemna trisulca* which typically floats within the water column and is rarely problematic.

Water fern *Azolla filiculoides*

Water fern *Azolla filiculoides*
© Laura Thomas

Is a species native to North America and is currently considered as a non-native invasive species in the UK. It is listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended). It is an offence to plant or cause its spread in the wild.

It has very small, oval, closely overlapping leaves along short branched stems and can superficially resemble duckweed *Lemnaceae* species.

A key characteristic of water fern *Azolla filiculoides* is the red colouration that the plant takes on over winter, or when stressed. During the summer it is usually green in colour.

It can form dense mats which rapidly develop from vegetative growth or mass germination of spores. It is a species of static or slow-moving waters.

Broad-leaved pondweed *Potamogeton natans*


© JBA Consulting
Broad-leaved pondweed *Potamogeton natans*

Is a species of slow-flowing and static waters. It can grow in water up to 1.5 m deep from rhizomes rooted in the sediments at the bottom of watercourses.

This species has elliptical leaves that float on the water surface and flowers that emerge above, producing viable seed although the plant principally spreads vegetatively from rhizomes.

To allow the leaves to float on the water surface, this species has a flexible joint where the leaf stalk meets the leaf blade; as water levels change this joint moves so that leaves remain floating on the water surface.

While broad-leaved pondweed *Potamogeton natans* is the floating-leaved pondweed species that causes the most problems, others can be quite scarce (for example, fen pondweed *P. coloratus* and loddon pondweed *P. nodosus*).

Accurate species identification prior to management is essential.

Water-lilies *Nuphar* spp. and *Nymphaea* spp.

Are characterised by their floating oval/circular leaves and yellow or white flowers. They can grow in water depths of up to 5 m but favour 1–3 m.

There are three native water-lily species in the UK; the most common in watercourses is yellow water-lily *Nuphar lutea*. White water-lily *Nymphaea alba* occasionally occurs in watercourses and management of this species should be considered carefully. A third species, least water-lily *Nuphar pumila*, is quite uncommon.


Yellow water-lily *Nuphar lutea* © Laura Thomas

Yellow water-lily *Nuphar lutea*	White water-lily *Nymphaea alba*	Least water-lily *Nuphar pumila*
Leathery heart-shaped floating leaves	Almost circular floating leaves	Leathery heart-shaped floating leaves
Has submerged, thin 'cabbage' leaves on triangular stems	Mature leaves rarely submerged, and if so are like floating leaves	
Leaves up to 40 × 30 cm	Leaves 9–30 cm diameter	Leaves up to 17 × 12.5 cm
23 or more veins divided in parallel, 'tuning forks'	Leaf veins join up to form a network	18–11 veins divided in parallel, 'tuning forks'
Large yellow flowers	Large white flowers	Small yellow flowers

Accurate species identification prior to management is essential.

Fringed water-lily *Nymphoides peltata*


Fringed water-lily *Nymphoides peltata* © JBA Consulting

Has round to kidney-shaped leaves, which are purple below, 3–10 cm across and have an undulating margin. It has yellow flowers which have five petals and fringed yellow lobes, which give the species its name.

It occasionally grows in flowing waters, but is more typical of ponds and small lakes. It is uncertain as to whether this is a native species. It was once considered quite rare, but it is becoming increasingly common and widespread and has started to create problems.

Water-starworts *Callitriche* spp.

Water-starwort *Callitriche* spp.

They are slender, delicate plants, with opposite pairs of linear or oval leaves. Many species also have upper leaves very close together so that they form a floating terminal rosette. The leaf tips are also usually notched.

They are a very difficult group of species to identify; often only reliably done so by examination of the fruit shape and structure. Where these are not present species cannot often be successfully identified.

This group of species does not often cause problems and several of the species in this group are quite scarce. **Care should be taken when deciding whether or not to manage a water-starwort species**.

Arrowhead *Sagittaria sagittifolia*

Is an aquatic species with distinctive arrow-shaped floating and emergent leaves, although the leaf shape can be very variable with the floating leaves often elliptical in shape. It also has distinctly different submerged leaves which are long, linear and translucent in nature.

This species has white flowers, 2–3 cm across, with a purple base. They are held on a stalk in whorls of 3–5, which emerge above the water surface.


Arrowhead *Sagittaria sagittifolia*
© JBA Consulting

The species over-winters as detached submerged buds.

There are also a few non-native species within the *Sagittaria* family that occur in UK watercourses, including duck-potato *S. latifolia,* Canadian arrowhead *S. rigida* and narrow-leaved arrowhead *S. subulata,* which are very localised in their distribution. While these are non-native species, they are not currently causing significant issues in the wild in the UK.

Floating pennywort *Hydrocotyle ranunculoides*

Floating pennywort *Hydrocotyle ranunculoides*

Is a non-native invasive species in the UK. It is listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended). It is an offence to plant or cause its spread in the wild.

It has circular or kidney-shaped leaves which are divided around half way to the base; they are also lobed.

It is a species of slow-moving canals, rivers and ditches and can be very fast growing. It can grow at up to 20 cm per day. It can also form dense interwoven mats extending a significant distance above and beneath the water surface.

There are also other non-native pennywort *Hydrocotyle* species in the UK, including hairy pennywort *Hydrocotyle moschata* and New Zealand pennywort *H. novae-zeelandiae.* While these are non-native species, they are not currently causing significant issues in the wild in the UK.

Water-primroses *Ludwigia* spp.

Are non-native, invasive species listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended). It is an offence to plant or cause its spread in the wild.

© JBA Consulting

Water-primrose *Ludwigia grandiflora*

They are taxonomically a difficult group to separate out into different species. In the UK *Ludwigia grandiflora* and *L. peploides* have been recorded, although identification to species level is difficult.

Water-primroses *Ludwigia* spp. grow in water but also in marginal habitats and can look quite different when growing in these different habitats. They have leaves which are variable in shape, ranging from long and slender to oval and spoon-shaped. The leaves are green in colour, with distinctly paler veining.

Water-primroses *Ludwigia* spp. have flowers which are bright yellow, five-petalled and approximately 3 cm across. They flower between July and September, and during the winter die back leaving brown stems.

There is also one native *Ludwigia* species in the UK, Hampshire-purslane *Ludwigia palustris*. This species is very rare and a species found in pools in the New Forest. It is therefore highly unlikely to be encountered as part of watercourse management.

3.4 Emergent plants

Tall emergent species which may require management include:

- common reed *Phragmites australis*
- reedmaces *Typha* spp.
- reed sweet-grass *Glyceria maxima*
- reed canary-grass *Phalaris arundinacea*
- common club-rush *Schoenoplectus lacustris*

  branched bur-reed *Sparganium erectum*
- tall sedges *Carex* spp.

Broad-leaved emergent species which may require management include:

- fool's water-cress *Apium nodiflorum*
- lesser water-parsnip *Berula erecta*
- water-cress *Rorippa nasturtium-aquaticum*
- water-soldier *Stratiotes aloides*
- Australian swamp stonecrop *Crassula helmsii*

Useful identification guides

- *British Water Plants* (Haslam et al. 1982)
- *The Wildflower Key* (Rose 2006)
- *New Flora of the British Isles* (Stace 2010)
- *The Vegetative Key to the British Flora* (Poland and Clement 2009)
- *The Plant Crib* (BSBI 2013)
- *Sedges of the British Isles* (Jermy et al. 2007)

Common reed *Phragmites australis*

Is the tallest native grass species in the UK and can grow up to 3 m in height. It has greyish-green leaves with a ligule composed of a ring of white hairs. Its flowers are dark purplish-brown in colour and are very highly branched.

This perennial species spreads through creeping rhizomes, which can grow up to a metre below ground level. Common reed *Phragmites australis* can cover large areas of swamp and fen, as well as forming dense stands within watercourses within the riparian zone. It can grow in both static and flowing waters.

The dense network of rhizomes can be very useful on watercourses helping to stabilise banks and prevent erosion; management should aim to keep a fringe of this species along the toe of the banks to help protect and stabilise them.

Reedmaces *Typha* spp.

In the UK there are two species of reedmace: common reedmace *Typha latifolia* and lesser reedmace *Typha angustifolia*

Both species have long, flat leaves that arise alternately from opposite sides of the stem. Both have a cylindrical spike of densely packed, very small flowers, the lower part of which is dark brown in colour and contains female flowers, and the upper part of which is narrower, yellow-brown in colour and contains male flowers.

Common reedmace *Typha latifolia*	Lesser reedmace *Typha angustifolia*
1.5–2.5 m tall (possibly up to 3 m)	1.5–2.5 m tall
Leaves 8–24 mm wide	Leaves 3–6 mm wide and slightly curved on the back
Leaves grey-green in colour	Leaves bright in colour
No gap (or less than 2.5 cm) between the dark brown female part of the inflorescence and the yellow-brown male part	A gap of 3–8 cm between the dark brown female part of the inflorescence and the yellow-brown male part of the inflorescence
Female part of flower 3–4 cm wide	Female part of flower 1.5–2.5 cm wide
A large robust plant	A more slender plant, but equally as tall

Reed sweet-grass *Glyceria maxima*


© Sarah Warriss-Simmons
Reed sweet-grass *Glyceria maxima*

Inhabits the riparian zone of slow-flowing watercourses and canals.

It can grow up to heights of 2.5 m, although it is generally somewhat shorter than this. It is usually bright green in colour, hairless and smooth, with leaves that have a keeled, pointed tip. It has a membranous ligule, unlike common reed *Phragmites australis* which has a ring of hairs, and this membrane has a distinct central point. The flowers of this species have several branches which are open and light brown in colour. This species can occasionally form floating rafts of vegetation.

There are several sweet-grass *Glyceria* species in the UK. Reed sweet-grass *Glyceria maxima* is the largest species of this family, and is significantly taller and more robust, being much more upright in growth habit than the other species.

Reed canary-grass *Phalaris arundinacea*

Is a tall, wetland grass species that can grow up to 2 m in height, although it is usually smaller than this. It has hairless, green or grey-green leaves and, while superficially similar to common reed *Phragmites australis* when not in flower, this species has a membranous ligule as opposed to the ring of hairs of common reed *Phragmites australis*.

Its flower head usually has several branches with relatively dense clumps of flowers on each. These are often densely packed together, becoming more open through the season. This is a perennial species which has extensive creeping rhizomes.

It is a widely distributed species throughout the UK, often occurring along the margins of rivers, streams and drains, as well as in lakes, ponds and marshes. It generally grows in shallower waters than other tall emergent species (up to 30 cm).


© Sarah Warriss-Simmons
Reed canary-grass *Phalaris arundinacea*

Common club-rush *Schoenoplectus lacustris*


Common club-rush *Schoenoplectus lacustris*
© Sarah Warriss-Simmons

Is a tall emergent species from the sedge *Cyperaceae* family. It can grow up to 3 m (sometimes 3.5 m) in height and has spongy cylindrical stems, over 1 cm wide at the mid-point. It is dark green in colour, sometimes with a dark blue-green hue. Its flowers form at the top of the stem and are chestnut-brown and grouped in clusters. Although typically growing in emergent form, it can also form long (up to 1 m), linear submerged leaves, when growing in faster flowing waters.

It is a species of relatively shallow waters, but can tolerate water depths of up to 1.5 m, although it generally grows in depths less than this. It prefers slow-flowing and static waters of rivers, canals and ditches, along with lakes and ponds.

It has extensive creeping rhizomes and can often form single-species stands.

Branched bur-reed *Sparganium erectum*

Is a widespread, perennial species with extensive creeping rhizomes. It has leaves which have a distinctive triangular shape in cross-section, formed as a result of a strong keel down the back of the leaf blade. Its flowers, which form on branched stems, are globular, spiky-looking spheres, with the male and female different in form. It is usually bright green in colour and can grow to a height of 1.5 m.


© Sarah Warriss-Simmons
Branched bur-reed *Sparganium erectum*

In the UK there are four bur-reed *Sparganium* species. Branched bur-reed *Sparganium erectum* is the largest and the only one that has flower heads on a branched stem. It is also generally an erect species, whereas the others all have submerged linear leaves and are typically much smaller.

The other species – unbranched bur-reed *S. emersum*, least bur-reed *S. natans* and floating bur-reed *S. angustifolium* – are generally not problematic in the aquatic and riparian environment and therefore do not require management to the same extent as branched bur-reed *S. erectum*. Also, in the case of least bur-reed *Sparganium natans* and floating bur-reed *S. angustifolium*, these species are relatively scarce and should be retained.

Accurate species identification prior to management is essential.

Tall sedges *Carex* spp.

A number of the larger, taller sedge *Carex* species, with rhizomes and grass-like leaves, are frequently encountered along watercourses and can require management. Such species include greater pond-sedge *Carex riparia* and lesser pond-sedge *Carex acutiformis.*

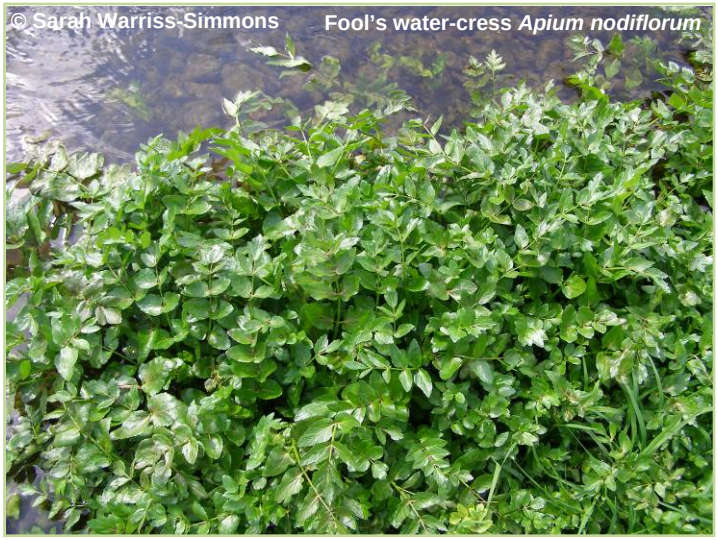
They generally grow to a height of 1.5 m and can grow in waters up to 0.5 m deep, though this varies between species. They will not tolerate deep water and they often just form fringes of marginal vegetation along the toe of the banks and do not encroach into deeper central parts of the channel.

There are also a number of tussock-forming tall sedge species that can be found along watercourses (for example, greater tussock-sedge *C. paniculata*, false fox-sedge *C. otrubae*, cyperus sedge *C. pseudocyperus* and tufted-sedge *C. elata*). Due to their growth habit they tend not be problematic or require management.

Identification of sedge species can be difficult but can be done through examination of features including flowering parts, fruiting bodies (utricles), ligules. **Accurate species identification prior to management is essential as some species can be locally scarce.**

Fool's water-cress *Apium nodiflorum*

Is a marginal species of ditches and rivers in lowland areas. It can grow relatively large, with hollow stems up to 1 m in length, which grow along the ground. In faster-flowing waters, particularly chalk rivers, submerged patches can develop and it can be very abundant in this habitat. This species can be confused with lesser water-parsnip *Berula erecta* and water-cress *Rorippa nasturtium-aquaticum*.



Fool's water-cress *Apium nodiflorum* has complex leaf composed of 4–6 pairs of opposite leaflets along a central leaf stalk, with a single leaflet at the end. These leaflets have shallow, blunt teeth along the margins. They are also usually bright green in colour. The flowers of this species are tiny and white, and are held on several branches that form an umbel, which emerges from where the leaf joins the stem.

Lesser water-parsnip *Berula erecta*

Is a species that frequently occurs in calcareous environments. It has relatively long, grooved, hollow stems of 0.3–1 m in length, in a low-growing, sprawling habit. It has complex leaf composed of 7–10 pairs of opposite leaflets which are 2–6 cm long and arranged along a central leaf stalk, with a single leaflet at the end. These leaflets have quite deep teeth along the margins. This species always has a pale ring-mark at the base of the stem (see photograph).

The flowers of this species are tiny and white, and are held on a few branches that form a small umbel (3–6 cm across) with branches that are only 1–3 cm long. This umbel emerges from where the leaf joins the stem.

This species can be confused with fool's water-cress *Apium nodiflorum* and water-cress *Rorippa nasturtium-aquaticum*. The ring-mark on the stems is the key feature which, in particular, distinguishes it from fool's Water-cress *Apium nodiflorum*.

A similar, but much larger species, greater water-parsnip *Sium latifolium*, can also be found in riparian habitats. This species is scarce and included on the UK Biodiversity Action Plan. Management of this species should not be carried out unless it is part of a programme of encouraging establishment and growth of the plant and creating appropriate habitat conditions.

Water-cress *Rorippa nasturtium-aquaticum*

Is a perennial wetland species with creeping stems (up to 1 m) and erect flowering shoots. Its leaves are dark green in colour and hairless.

It has complex leaf composed of a number of leaflets which are arranged slightly alternately along the stem, with a single leaflet at the end. These leaflets vary in size with broader leaflets at the bottom. The leaflets are also very rounded and untoothed. This species has small white flowers (4–6 mm across) and forms distinctive seed pods with two clear rows of seeds visible within the pod.

This species can be confused with fool's water-cress *Apium nodiflorum* and lesser water-parsnip *Berula erecta*. The much more rounded and slightly alternately arranged leaflets are the key diagnostic feature.

Water-soldier *Stratiotes aloides*


© Sarah Warriss-Simmons
Water-soldier *Stratiotes aloides*

Is an aquatic species that can be entirely submerged in growth habit (usually during the winter), sometimes floating, but in summer its leaves emerge above the water surface.

It has leaves arranged in a large crown-like rosette that are rigid, long, narrow and pointed with spines along the margins. The leaves can be up to 50 cm in length and are also often translucent and brown-green in colour. Its flowers emerge individually above the water, on stalks 5–8 cm tall. The flowers are three-petalled, white and 3–4 cm across.

This species is considered native to the east of England, where it is now very localised in its distribution, but introduced elsewhere. It can be found in canals and ditches, and also fens and ponds. It is also more frequent in calcareous environments. As a localised species in its natural range in the east of England, management of this species should be performed with care.

Australian swamp stonecrop *Crassula helmsii*

Is a non-native, highly invasive species (also known as New Zealand pigmyweed) listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended). It is an offence to plant or cause its spread in the wild.

© JBA Consulting
Australian swamp stonecrop *Crassula helmsii*

It has stems (up to 30 cm in length) which can either be erect or trailing in the water or on mud. Its leaves are short (4–15 mm), linear and fleshy. They are arranged oppositely along the stem and sometimes fuse at the base. Below the point where leaves attach (that is, the node), there is a dark ring.

It has whitish flowers with four petals, which are held on stalks.

Superficially this species can resemble water-starwort *Callitriche* species; however, water-starworts *Callitriche* spp. do not have fleshy leaves or the dark ring below the node. Water-starworts *Callitriche* spp. also have notched leaf tips whereas Australian swamp stonecrop *Crassula helmsii* does not.

It will grow in a variety of habitats, is highly tolerant of extreme environmental conditions (including shade, frost and drought) and has three distinct growth forms – terrestrial, emergent and submerged. It grows throughout the year and can regenerate from very small fragments.

3.5 Algae

Algae are a widely diverse group of plants, with several thousand different species, which are classified botanically according to the colour of pigment they contain. They can occur in a wide range of aquatic and riparian habitats.

It is generally certain groups of algae that create problems in watercourses and therefore require management.

The groups of algae covered by this guide include:

- filamentous green algae
- unicellular green algae and cyanobacteria
- stoneworts (Charophytes)

Algae problems are most likely to occur:

- when weather conditions are warm
- during low flows
- after pollution incidents
- following management or engineering works

Filamentous green algae

Also commonly referred to as 'cott' or 'blanketweed'. Common genera of this group, which can be problematic, include:

- *Cladophora* – a large group that can occur in a wide range of habitats. Some species form floating spheres and others mats.
- *Enteromorpha* – primarily marine algae, but there are some freshwater species in this group. They usually consist of branches, tubes or sac-like structures.
- *Rhizoclonium* – common in a range of aquatic habitats, often entangled with other algae.
- *Spirogyra* – a large group which contain spirally arranged structures.
- *Vaucheria* – forms mats in either terrestrial or freshwater environments

Unicellular green algae and cyanobacteria

Unicellular green algae consist of single cells which are microscopic.

Cyanobacteria are also unicellular although some can form fine filaments. They can form dense blooms, which are usually green or blue-green, but can also be purple or red. Once developed it may also look like a surface scum on the water. They also often have unpleasant odours.

Stoneworts (Charophytes)

The group contains six genera, the most frequently encountered of which are *Chara* and *Nitella*.

They have stems with branches in a number of whorls and can resemble submerged vascular plants.

Stoneworts do not usually require management, although, in certain circumstances, they can be problematic. Stonewort beds are ecologically important supporting a number of aquatic invertebrate species and also fisheries; **management should only be conducted where absolutely necessary.**

3.6 Non-native invasive bank species

Three non-native invasive species cause problems along the banks of watercourses in the UK. Although they are really terrestrial plants, they are associated in the UK with waterways which provide corridors along which they can spread.

These three plants are:

- Japanese knotweed *Fallopia japonica*
- Himalayan balsam *Impatiens glandulifera*
- giant hogweed *Heracleum mantegazzianum*

All three are listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended) making it an offence to 'plant or otherwise cause to grow in the wild'.

Useful identification guides

- *The Wildflower Key* (Rose 2006)
- *New Flora of the British Isles* (Stace 2010)
- *The Vegetative Key to the British Flora* (Poland and Clement 2009)

Japanese knotweed *Fallopia japonica*

Japanese knotweed *Fallopia japonica*
© JBA Consulting

Is a perennial species, growing from rhizomes to a height of 3 m in summer with stiff bamboo-like stems, which often remain standing into the winter months. It has large, oval-triangular leaves, with a distinct point. The leaves are held on reddish stems in an alternate arrangement which gives the stem a zigzag nature. Masses of small creamy-white flowers are produced in late summer, but do not, at present, produce viable seed. The plant is spread from broken fragments of stems or rhizomes, often via contaminated topsoil or from cut or detached material floating downstream in watercourses.

Strict biosecurity measures are crucial when managing this species.

There are also a number of other non-native knotweed species in the UK, similar to Japanese knotweed *Fallopia japonica*, that may be found in a riparian environment including giant knotweed *Fallopia sachalinensis* and the hybrid *Fallopia japonica x sachalinensis* (sometimes known as bohemian knotweed *Fallopia x bohemica*). Both giant knotweed *Fallopia sachalinensis* and the hybrid are listed in Schedule 9 of the Wildlife and Countryside Act 1981 (as amended).

Himalayan balsam *Impatiens glandulifera*

Himalayan balsam *Impatiens glandulifera*
© JBA Consulting

Is an annual plant which grows to approximately 2 m in height, forming dense stands. It has reddish stems and oval leaves with distinct teeth which are arranged around the stem in whorls of three. It has large, trumpet-shaped, pink flowers which can vary considerably in depth of colour, with some almost white and others deep purple-pink. The seed pods of this species are explosive to touch and can spread seeds up to 7 m from the plant.

Strict biosecurity measures are crucial when managing this species.

There are two other non-native balsam species in the UK, orange balsam *Impatiens capensis*, which is a smaller plant with orange, red-spotted flowers, and small balsam *Impatiens parviflora* which is, again, a much smaller plant with pale yellow flowers. Both species have alternately arranged leaves and should not be confused with Himalayan balsam. There is also a native balsam species in the UK, touch-me-not balsam *Impatiens noli-tangere* which is similar to small balsam with yellow flowers.

Giant hogweed *Heracleum mantegazzianum*

© Shire Group of IDBs
Giant hogweed *Heracleum mantegazzianum*

Is a vigorous perennial plant which takes 3–4 years to mature. Seedlings appear in February, producing immature plants, reaching 0.4 m in their first year. Foliage dies back in September/October and subsequent growth from tap roots is very rapid in the second and third years.

Flowering stalks start to elongate in May, with peak flowering in June/July. In its fourth year of flowering, plants can reach 4–5 m in height and disperse 50,000–100,000 viable seeds per plant. Seeds which fall into water are spread downstream resulting in new stands of this species. It has a red-spotted stem which can be 0.1 m across, with lobed leaves up to 1 m with very sharp, pointed lobes. It has small whitish-pink flowers which are held on small branches to form an umbel; these can be up to 0.5 m across. It should not be confused with the native hogweed *Heracleum sphondylium*, which is a significantly smaller plant, growing only up to 2 m, with less angular lobed leaves.

Giant hogweed *Heracleum mantegazzianum* contains a toxic chemical which sensitises skin and leads to severe blistering when exposed to sunlight (a reaction which can recur for many years).

Potential risks to health must be taken into account when working with this species.

Strict biosecurity measures are crucial when managing this species.

4. Watercourse types

Before carrying out any form of channel or bank management, it is vital to identify the watercourse type correctly. Damage to watercourse processes could occur if the watercourse type is incorrectly identified and an inappropriate management technique is subsequently applied. Table 4.1 provides a summary of geomorphic watercourse types while the flowchart in Figure 4.1 will guide watercourse managers to the most appropriate type for your watercourse. Further information can be found in Chapter 6 of the technical guide.

Table 4.1 Summary of geomorphic watercourse types

Watercourse type	Examples (Photographs © JBA Consulting)	
Step pool channel Often narrow, dominated by short steps over bedrock and cobbles. Gravels and finer sediments may be deposited in pools.		
Bedrock channel Significant coverage of bedrock on the river channel. Sometimes cobbles and some gravels may be deposited**.**		
Wandering channel Dominated by active bank erosion and wide scale deposition of gravels		
Active meandering, pool riffle and plane bed channel Deposition evident at the channel edges and at bends in the channel. Some bank erosion will be evident**.**		

Watercourse type	Examples (Photographs © JBA Consulting)	
Inactive single thread channel Mainly found in lowland areas with low gradient. Deposition will be dominated by fine sediment. Gravels will be uncommon.		
Canal and reinforced drainage channel Artificial reinforced banks dominate this class. Will often have a 'tow path' adjacent to the channel.		
Modified urban watercourse Artificial bank profiles dominate this class. Often the bed will be modified.		
Ditch/ small drain Mainly found in lowland areas with low gradient. The channel will often be narrow.		
Artificial drainage channel Mainly found in lowland areas with low gradient. Deposition will be dominated by fine sediment. Gravels will be uncommon.		

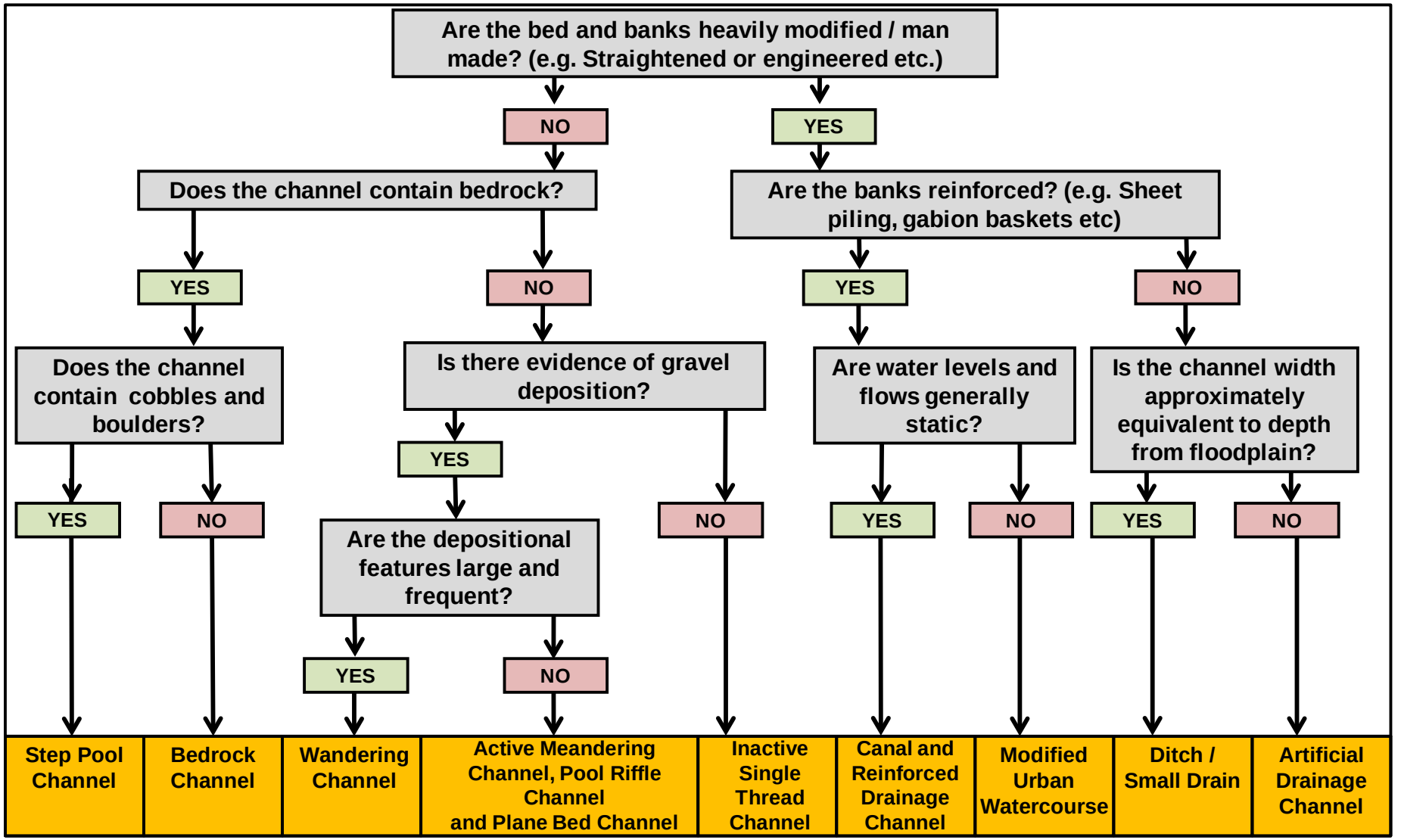


Figure 4.1 Flowchart for identifying the geomorphic watercourse type

5. Management techniques

The following sections summarise the techniques available to manage aquatic and riparian vegetation. In some cases an integrated approach of two or more of these techniques may be the most effective approach.

The management techniques can be divided into four colour-coded categories (Table 5.1).

Table 5.1 Categories of management techniques

Category	Description
Physical	The active removal of plant material from a watercourse
Chemical	The application of herbicides and other substances to manage growth of plants
Environmental	The alteration of the conditions within or surrounding the watercourse to reduce or prevent plant growth
Biological	The use of biological control agents to control unwanted species or excessive plant growth

The summaries provided in this guide are to prompt and assist watercourse managers when collecting information in the field to inform the selection of the most suitable management technique.

More detailed information about each technique can be found in the technical guide.

5.1 Physical techniques

- Include a range of manual or mechanical activities.
- One of the most widespread means of managing aquatic and riparian vegetation.
- Effectively control most native submerged, rooted floating-leaved and emergent plants.
- Less effective for free-floating species and filamentous green algae.
- Ineffective against unicellular green algae and cyanobacteria.
- Often not advisable for non-native invasive species due to the potential for spread. Care is essential when managing such species using physical techniques.

Technique	Description	Cost	Timescale	Section in technical guide
Hand pulling, cutting and raking	Removal of plant material by hand pulling, cutting or raking using tools. Generally only feasible on small localised patches.	£££ / £ (if volunteers are used)	Short-term option	7.3.1
Mechanical harvesters, weed boats, amphibious vehicles	Management of vegetation using a vehicle working from within the channel. A range of vehicles are available for this work.	£ / ££ (depending on type of vehicle used)	Short-term option	7.3.2
De-weeding with a weed bucket	Management of vegetation using an excavator or tractor fitted with a weed cutting bucket/basket. Work is carried out from the banksides, not from within the channel.	££	Short-term option	7.3.3
De-weeding with a solid bucket	Management of vegetation using an excavator or tractor fitted with a solid bucket. Work is carried out from the banksides, not from within the channel.	£££	Short-Medium term option	7.3.4
Excavator and tractor mounted cutter/flail	Cutting of bankside and riparian vegetation using a specialist cutter/mower, usually fitted to an excavator or tractor. Work is carried out from the banksides.	££	Short-term option	7.3.5

Timing is critical (Figure 5.1) as it can stimulate regrowth, worsening the problem during the same growing season and requiring a second treatment.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Submerged					Physical management now will likely require repeat treatment					Die-back reduces need for management		
Rooted Floating Leaved					Physical management now will likely require repeat treatment					Die-back reduces need for management		
Tall Emergent					Physical management now will likely require repeat treatment					Standing dead material may require management		
Broad-leaved Emergent					Physical management now will likely require repeat treatment							
			Caution required with all physical techniques as birds nests may be present									
	Optimal period											
	Sub-optimal period											

Figure 5.1 Indicative timings for physical management of species groups

5.2 Chemical techniques

Technique	Description	Cost	Timescale	Section in technical guide
Glyphosate-based herbicide and use of adjuvants	Control of emergent and floating vegetation through the application of chemicals containing the active herbicide ingredient glyphosate. Special additives, adjuvants, can also be used to increase their effectiveness.	£	Medium-term option	7.4.1
Barley straw and barley straw extract	Management of watercourses where algae are problematic through the application of barley straw and chemicals derived from decomposing barley straw.	££	Short–medium term option	7.4.2

5.2.1 Glyphosate-based herbicide and use of adjuvants


© Jamie Bagnell, Staphyt

- Only effective on emergent and floating vegetation.
- Only herbicides containing the active ingredient glyphosate are currently approved for use in or near water.
- They can be applied quickly and relatively cheaply in comparison with physical techniques, and are less intrusive.
- Agreement must be obtained from the Environment Agency or Natural Resources Wales to use herbicides in or near water.
- Spraying needs to be carried out at the optimal time for the problem species.

Agreement to use herbicides in or near water

When seeking agreement from the Environment Agency/ Natural Resources Wales a range of information will need to be supplied including details on the site, the problem species, any nature conservation sites, downstream users and fish presence, along with details of the herbicide to be used and how it will be applied.

Anyone who uses herbicides in or near water must have the necessary skills, knowledge and qualifications. They must hold a relevant National Proficiency Test Certificate (NPTC) certificate of competence, which must be supplied with the application. The NPTC certificate must be for applying herbicides in or near water.

Indicative timings for use of chemical techniques are shown in Figure 5.2.

Group	Common name	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Submerged	Parrot's-feather (emergent parts only)												
Free-floating	Duckweeds (excluding least duckweed)					Before thick mats form							
	Water fern				Before thick mats form and spores are released								
Rooted Floating-leaved	Broad-leaved pondweed												
	Water-lillies												
	Fringed water-lily												
	Arrowhead												
	Floating pennywort												
	Water-primroses												
Tall Emergent	Common reed												
	Reedmaces												
	Reed sweet-grass					Can reduce summer flood risk							
	Reed canary-grass												
	Common club-rush												
	Branched bur-reed							Before first frosts					
	Tall sedges					Can reduce summer flood risk							
Broad-leaved Emergent	Fool's water-cress												
	Lesser water-parsnip			Before Flowering					Treat Re-growth				
	Water-cress												
	Water solider (emergent parts only)												
	Australian swamp stonecrop (emergent)												
Non-native Invasive Bank Species	Japanese knotweed								Applied to mature plant when flowering				
	Himalayan balsam				Before Flowering								
	Giant hogweed			Before Flowering									
		Optimal treatment period						Sub-optimal treatment period					

Figure 5.2 Indicative timings for chemical management of species groups

5.2.2 Barley straw and barley straw extract

- Can be installed as bales, by filling nets with straw to create barley straw 'sausages' or by filling baskets.
- Should be applied twice each year, preferably in early spring and then again in autumn.
- The process is temperature dependent (being faster in summer than in winter).
- Barley straw extract will only be successful in slow-flowing and stagnant watercourses.
- Not effective on stoneworts (Charophytes).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5.3 Environmental techniques

Environmental techniques aim to modify the conditions within or surrounding a watercourse to make it less favourable to the species of plant requiring control.

Factors that can be modified include:

- light
- water levels
- flow characteristics
- water quality

Technique	Description	Cost	Timescale	Section in technical guide
Shading with vegetation (that is, trees, hedges, tall bankside plants, floating broad-leaved plants)	Using tall vegetation to restrict light to the problem species so as to limit their growth. There are several methods of creating shade with vegetation.	£–££	Long-term option	7.5.1
Shading with materials	Shading using man-made materials, either suspended above, or submerged below the water surface.	£££	Medium-term option	7.5.2
Dyes	Preventing light penetration of the water column through the use of dyes in static waters to control the growth of some species.	£	Short-term option	7.5.3
Water level manipulation	Plants have specific water level tolerance limits within which they grow. Altering water levels to be above or below these tolerance limits can help to reduce the growth of, or eliminate, problematic species.	££–£££	Medium to Long-term option	7.5.4
Manipulation of flow characteristics	Plants have specific water flow requirements within which they grow. Increasing flow rates to faster than the problem plant species can tolerate can reduce their growth/eliminate them.	££–£££	Medium to long-term option	7.5.5
Nutrient management	Management of nutrient inputs to watercourses, including the use of buffer strips or nutrient-binding chemicals, may help to reduce problems in the long term.	££–£££	Long-term option	7.5.6

5.4 Biological techniques

- Include grazing by cattle, waterfowl, fish and invertebrates to reduce the abundance of vegetation.
- Can be unpredictable, difficult to control and potentially damaging to the wider environment.
- Fragmentation by wildfowl and trampling by livestock can spread non-native species.
- In appropriate circumstances, biological control methods can be cost-effective and can provide a longer-term solution.
- The greatest benefits may be gained when used in combination with other more short-term measures.
- If native fish are to be introduced, Environment Agency consent is required.
- The *Azolla* weevil provides effective control of water fern and has a number of advantages over other methods.

Technique	Description	Cost	Timescale	Section in technical guide
Cattle, sheep and horses	Control of aquatic and riparian vegetation, particularly on the banksides of watercourses, by grazing cattle, horses and sheep.	£	Medium-term option	7.6.1
Waterfowl	Control of submerged aquatic plants by grazing ducks, geese and swans.	£	Medium-term option	7.6.2
Native fish species	Control of submerged aquatic plants due to turbidity caused by bottom-feeding native fish species.	£ or £££ if stocking of fish is required	Medium-term option	7.6.3
Invertebrates – *Azolla* weevil	Release of a weevil to control water fern *Azolla*.	££	Short- to long-term option	7.6.4

6. Data collection

As part of this project a spreadsheet tool has been developed to help watercourse managers choose the most appropriate aquatic and riparian plant management technique(s) for their watercourse.

This tool has three elements:

- an assessment of the effectiveness of each technique in managing a **species**
- an assessment of the potential impact of each technique on different **watercourse types**
- an appraisal of the **technical feasibility** of each technique (for example, channel width, water depth, watercourse length)

To determine which management technique(s) is the most suitable for a particular watercourse, information on these three elements has to be entered in the spreadsheet tool (Figure 6.1).

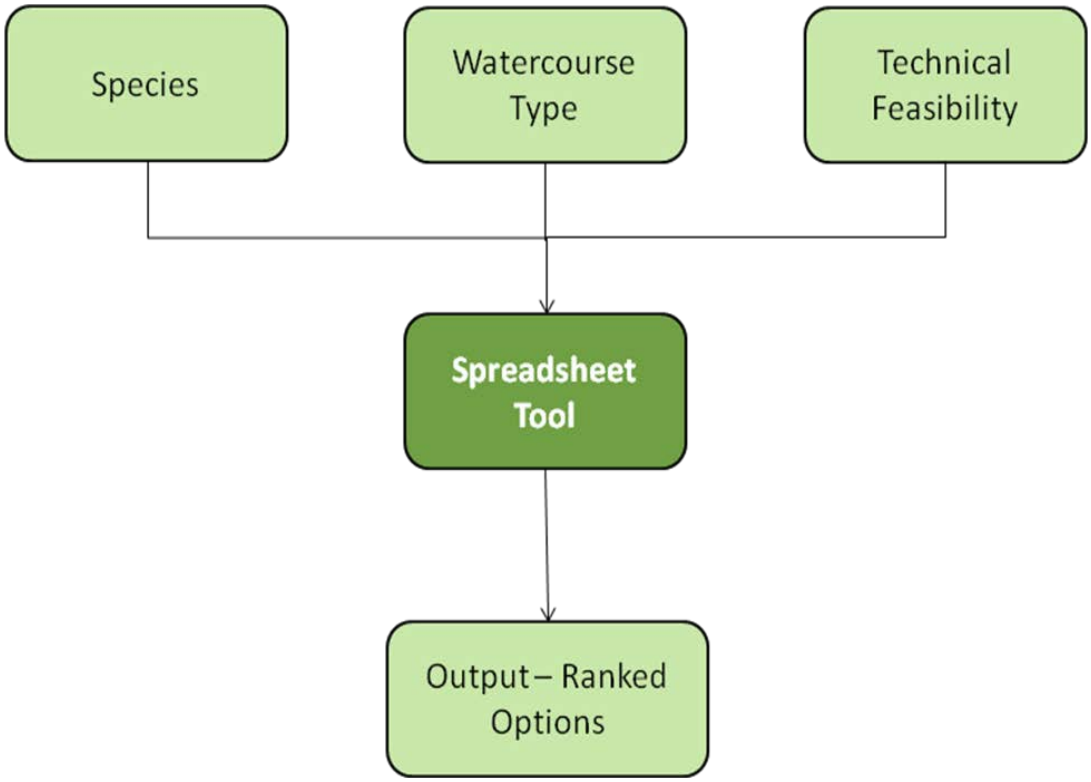

Figure 6.1 Summary of decision-making spreadsheet tool process

The information it is necessary to collect to input into the spreadsheet tool is described in Table 6.1. A blank recording form is provided at the end of this section for use in the field.

Table 6.1 Information required for the spreadsheet tool

Information	Input required
Author	Your name
Date	The date of your assessment
Watercourse name	The name of the watercourse requiring management
Location	The location of the watercourse, or section of watercourse requiring management
WFD ID Number	The Water Framework Directive ID code for the watercourse as given in the relevant river basin management plan
Start grid reference	The grid reference for the start of the length of watercourse to be managed
End grid reference	The grid reference for the end of the length of watercourse to be managed
Designated sites	Is the watercourse designated, or is it adjacent to a designated site? Enter Yes or No and also any further details if available such as the name of the site and whether it is Ramsar, SAC, SPA, SSSI, NNR, LWS.
Protected species	Does the watercourse support populations of protected species? Enter Yes or No and also any further details if available such as what species are present and where.
Plant species	Place a ✓ next to the species of aquatic and riparian plants present within the watercourse, or section of watercourse, to be managed. Identify those which are problematic and require management with a 'P'. (See Chapter 3 for details of problem species.)
Watercourse type	Place a ✓ next to the watercourse type. (See Chapter 4 for information on different watercourse types.)
Length of watercourse to be managed (m)	The length of watercourse to be managed – not necessarily the full length of the watercourse
Channel width (m)	The minimum width at water level (that is, wetted width).of the length of watercourse to be managed
Water depth (m)	The minimum depth of water within the channel of the length of watercourse to be managed
Access	Is access with a boat or a machine such as a tractor or excavator possible? Enter Yes or No.

Aquatic and riparian plant management – watercourse recording form			
Author:		Date:	
Watercourse name:		WFD ID number:	
Location:		Start grid ref:	
		End grid ref:	
Is the watercourse designated, or is it adjacent to a designated site?			
Notes:			
Does the watercourse support populations of protected species?			
Notes:			

Plant species					
Arrowhead		Himalayan balsam		Unicellular algae	
Branched bur-reed		Japanese knotweed		Cyanobacteria	
Broad-leaved pondweed		Least duckweed		Water fern	
Charophytes/stoneworts		Lesser water-parsnip		Water milfoils	
Common club-rush		Mare's-tail		Water solider	
Common reed		Australian swamp stonecrop		Water-cress	
Curly water-thyme		Parrot's feather		Water-crowfoots	
Duckweeds		Reed canary-grass		Water-lilies	
Filamentous green algae		Reed sweet-grass		Water-primroses	
Floating pennywort		Reedmaces		Water-starworts	
Fool's water-cress		Rigid hornwort		Water-weeds	
Fringed water-lily		Submerged pondweeds			
Giant hogweed		Tall sedges			
Other species					
Species groups					
Submerged		Free-floating		Broad-leaved emergent	
		Rooted floating-leaved		Tall emergent	
Watercourse type					
Active meandering/riffle – pool/ plane bed		Canal/ reinforced drainage channel		Modified urban watercourse	
Artificial drainage channel		Ditch/ small drain		Step-pool	
Bedrock		Inactive single thread		Wandering	

Length of watercourse to be managed (m)		Access possible by:	
Channel width (m) (that is, wetted width)		Machine?	
Water depth (m)		Boat?	

7. Monitoring

Monitoring the impacts from management of aquatic and riparian vegetation, by all techniques, is important to ensure that:

- the management has been successful
- the need for any repeat or follow-up treatments is highlighted
- any unanticipated environmental or geomorphological impacts are identified so that the management regime can be adapted

The flowchart in Figure 7.1 summarises the monitoring framework.

Existing monitoring programmes should be used where these are already in place. Alternatively a monitoring programme should be devised which:

- is based on a good understanding of the baseline ecology and geomorphology
- has clear objectives and targets which are SMART (Specific, Measurable, Achievable, Realistic and Time-scaled)
- is proportionate to the scale and nature of the management
- is implemented over appropriate timescales and spatial extents.

Suggestions for a generic monitoring protocol include undertaking:

- fixed point photography
- river corridor survey – mapping of habitats, vegetation and geomorphological features over a 50 m length

Further information can be found in Chapter 10 of the technical guide.

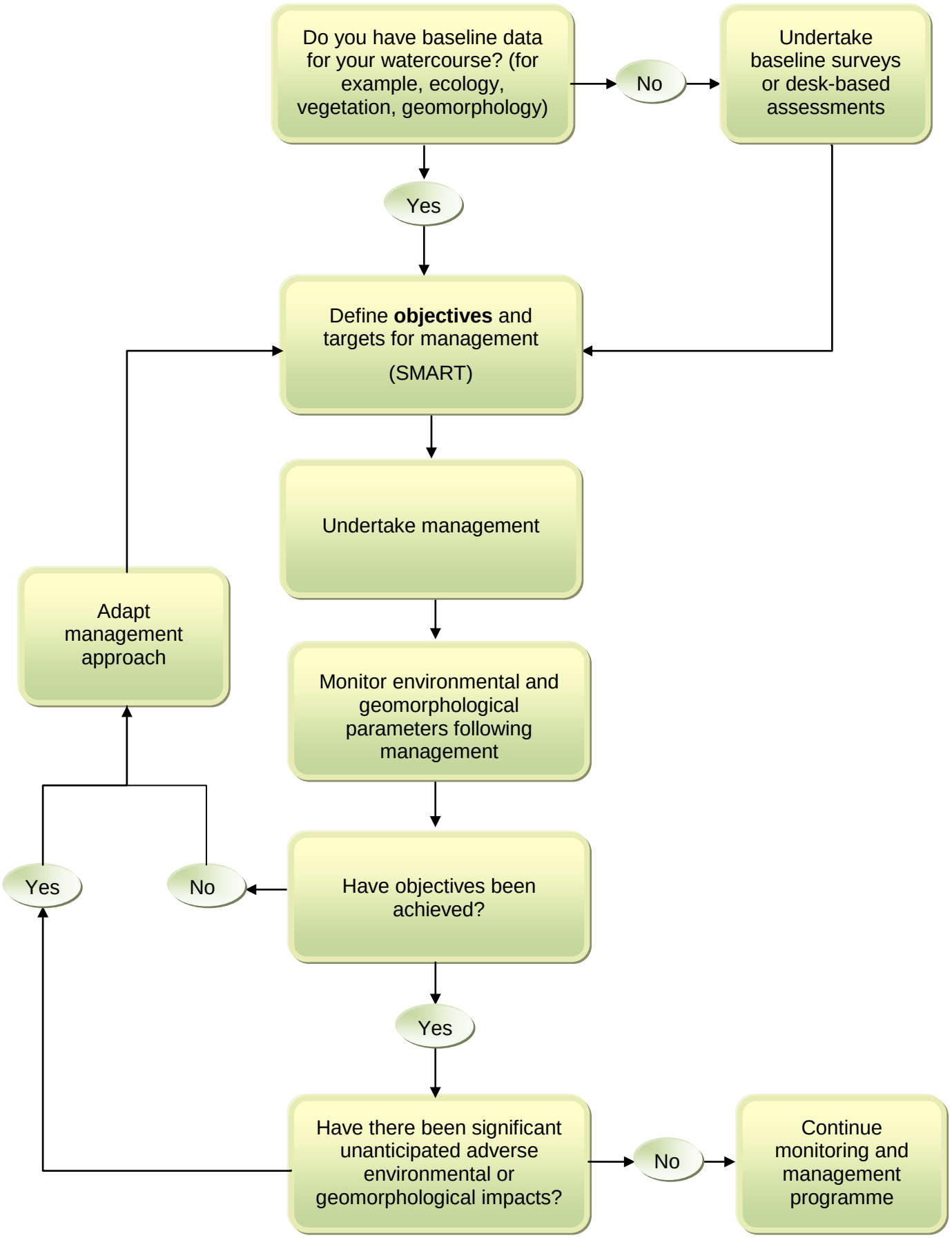

Figure 7.1 Flowchart of the role of monitoring in watercourse management

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List of abbreviations

LWS	Local Wildlife Site
NNR	National Nature Reserve
SAC	Special Area of Conservation
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest

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