Pond design principles for biodiversity

MILLION PONDS PROJECT

A 50-YEAR PROJECT TO CREATE A NETWORK OF CLEAN WATER PONDS FOR FRESHWATER WILDLIFE

1. Ponds are one of the easiest and most rewarding habitats to create

Opportunities for pond creation on aggregate sites are often overlooked. Ponds are small (from 1 m^2 to 2 ha in surface area), so they are dwarfed next to the large landforms (for example, gravel pit lakes or reedbeds) that are often the main focus of restoration plans. However, forgetting them is a missed opportunity, because ponds can add significantly to the wildlife value of restored aggregate sites.

Ponds are a priority habitat in the UK Biodiversity Action Plan (BAP), so adding new ponds and pond complexes into the matrix of habitats restored after aggregates extraction can contribute to the national Pond Habitat Action Plan (HAP). Ponds also provide habitats for 100 or so Biodiversity Action Plan priority species.

2. Planning pond creation

When planning a pond scheme there are a number of things to consider at the planning stage in order to get the best biodiversity value out of the scheme. The most important is to establish the objective of your pond creation scheme and how it will fit in with the wider restoration plan.

What is the objective of your pond creation scheme?

Ponds can have many purposes, including wildlife conservation, flood water storage, angling and amenity. This factsheet is focused on designing clean water ponds for wildlife. If your scheme is about creating ponds for other purposes, try to create one or more clean water ponds for wildlife as well. You can also incorporate some of the features outlined in this factsheet into all new ponds, to enhance their biodiversity value.

A summary of how to create clean water ponds for wildlife is outlined in the Box: *Recipe for a clean water pond* overleaf.

Who should read this factsheet?

This factsheet is intended for landscape architects, consultants and ecologists, and anyone who wants to design high quality ponds for wildlife.

Aims of this factsheet

This factsheet aims to set out the principles of planning, locating and designing pond creation schemes on aggregate extraction sites.

From extraction (above) to nature conservation (below), there are many opportunities for pond creation on aggregate sites.

Recipe for a clean water pond

1. Find a place with a clean water source. To do this:

- Make sure the pond has natural surrounds.
- Avoid linking the pond to stream or ditch inflows.
- Don't add topsoil in or around the pond, as this will pollute the waterbody with nutrients.

2. Leave the pond to colonise naturally – don't stock it with plants, fish or other animals.

Planting up isn't necessary, as pond colonisation is usually rapid, particularly on floodplains and near existing wetlands. The early phases of pond creation are also particularly valuable for specialist 'new pond' species such as common darter dragonflies and stoneworts, so planting up may work against conservation objectives.

If planting up is essential (for example, as part of landscaping for an amenity afteruse scheme), then use native species of local provenance from a reliable source. This helps to prevent the establishment of problem alien invasive species such as New Zealand pigmyweed (*Crassula helmsii*).

Don't plant with common reed (*Phragmites australis*), unless you're trying to create a reedbed, because this vigorous plant will quickly colonise and dominate new sites, often resulting in quite species-poor ponds.

Without any planting, the Pinkhill Meadow pond complex in Oxfordshire supports over 20% of Britain's wetland plant and invertebrate species four years after its creation.

3. Make sure the pond will have few impacts during its lifetime: no frequent disturbance from dogs or duck feeding.

In principle, there is nothing wrong with grazing or trampling pressure at a new site, as long as large amounts of silt don't erode from the bank into the pond. However, if wildfowl, livestock or people are likely to use the site in considerable numbers, it may be worth protecting colonising vegetation by erecting temporary fencing around part, or all, of the pond.

Ponds that are designed to follow the recipe for a clean water pond will enjoy the benefits of a clean water source, such as high biodiversity value, a long lifespan, minimal management requirements and few long-term problems such as cloudy water or excessive algae or duckweed growth.

Integrating a pond scheme with quarry afteruses

When a pond scheme is part of a wider restoration plan, the scheme design should be considered alongside the afteruse and landscape objectives for the aggregate site in question.

Nature conservation afteruse will result in the very best outcomes for pond wildlife, because ponds on these sites are less likely to be impacted by intensive surrounding landuse. However, where a nature conservation scheme is not possible, wildlife ponds can be integrated into most other afteruse schemes, including public amenity, angling, watersports, agriculture and development, and will add biodiversity value to the site. Integrating wildlife ponds within these afteruses requires thought and planning; for information, see *Aggregates Toolkit Sheet A5*. For information on integrating ponds within other habitat types, see the *Supplementary Design Factsheets*.

3. Locating ponds

Good wildlife ponds can be very small and can be created almost anywhere (see Box: *Opportunities for pond creation on aggregate sites*). If a source of water is present, there are very few sites where it is *not* possible to make ponds.

Water source and water quality

A clean water source is the most critical factor for wildlife. So locate new ponds where they will have a clean water source (for example, groundwater or clean surface water run off), and where water pollution will be minimised:

- Do not link ponds to rivers, streams and ditches, because this will usually bring in water polluted by nutrients and silt, and in many areas, alien invasive species such as signal crayfish.
- Create groundwater fed ponds in sand and gravel substrates.
- Create surface water ponds fed by surface run off from semi-natural land (e.g. unimproved grassland, woodland) on clay substrate.
- Avoid drainage from intensive landuse such as arable farmland, and avoid creating ponds that take runoff from urban areas.
- At lake sites where over-grazing and trampling by waterfowl (e.g. large flocks of Canada geese) is likely to be a problem, locate ponds away from larger waterbodies, preferably near hedges or in areas surrounded by tall vegetation which are less likely to be impacted by birds.
- When creating ponds on a lowland river floodplain, don’t put ponds right next to a river where flooding from the river is likely to occur. Locate ponds a little further away where the ponds won’t be flooded every year (occasional flooding from a watercourse is acceptable).

If the site has more than one type of substrate (for example, sand, gravel, clay) with a clean water source, create ponds in as many different substrates as possible. Differences in underlying geology and hydrological regimes will increase the habitat variety on the site and provide conditions for different species (see *Pond complex creation at Eye Landfill, Peterborough*).

Opportunities for pond creation on aggregate extraction sites

- Ponds can be created in all the phases of aggregate extraction: (i) during quarrying (e.g. silt ponds), (ii) during restoration, and (iii) at already restored sites during the aftercare period and beyond.
- Ponds can be created at sites with all types of afteruse and still provide benefits for biodiversity, as long as a few key principles are applied.
- If nature conservation is the main afteruse, ponds and pond mosaics can be usefully created as part of larger terrestrial or wetland schemes to enhance the patchwork of habitats in the landscape. For example ponds can be created as part of reedbed, grassland, heathland or woodland.
- The lack of available land is often perceived as a barrier to pond creation, but the size and shape of the pond or pond complex can be adapted to fit site circumstances (see Figure 1).
- If there is only a small area of land available, it may be possible to create linear ditch-like ponds, or modify gravel pit margins to make pools. Small ponds just 1-5 m^2 will still be valuable for wildlife.

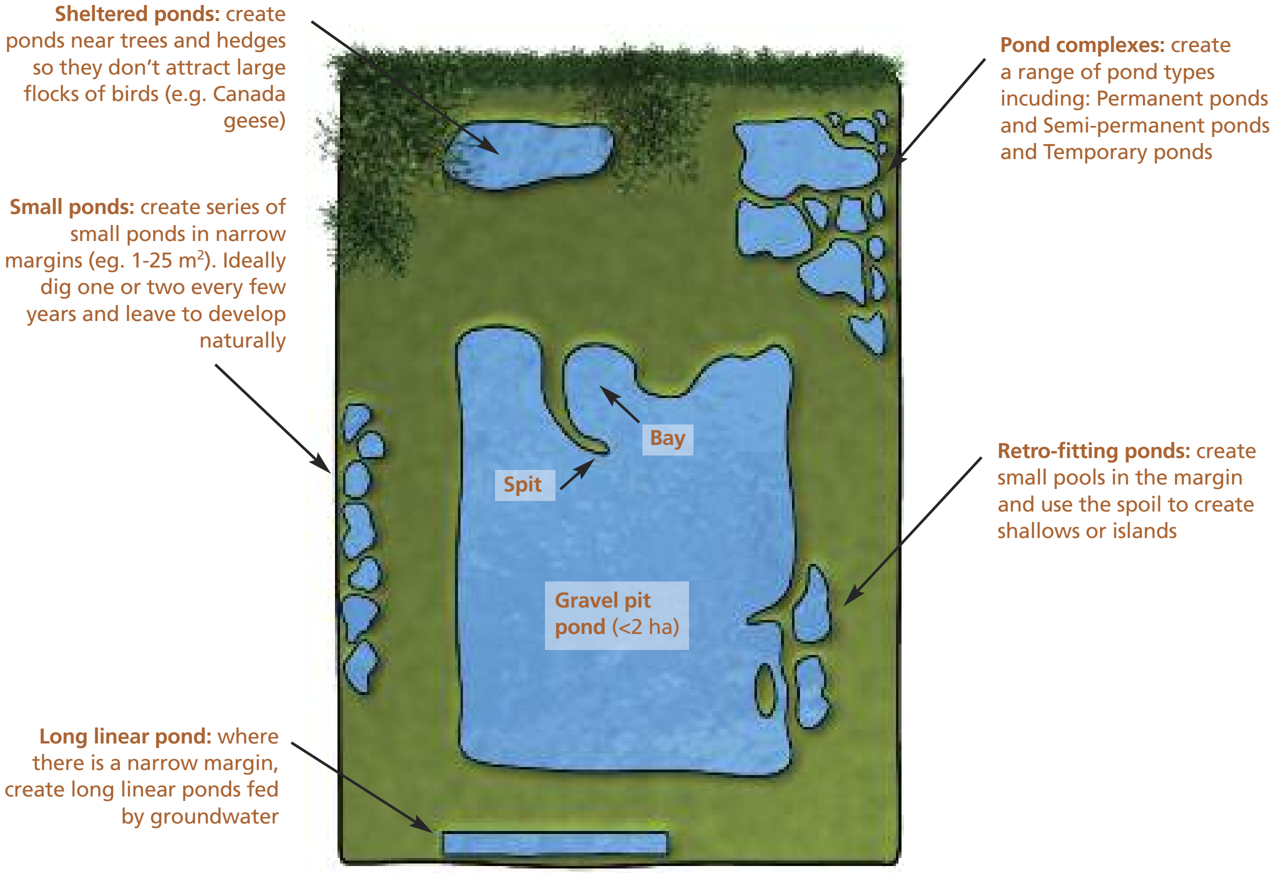


Figure 1. There are many opportunities for the creation of a variety of pond types on aggregate extraction sites.

Locating and creating ponds for target species

Use the *BAP Species Map* to find out what pond-associated Biodiversity Action Plan (BAP) species are in your area, because you can create ponds that may benefit these species. The Map also gives summary information about the habitat requirements of each pond-associated BAP species, to help you design new ponds targeted for those species. More detailed guidance on how to create ponds or pond complexes for particular species or species groups can be found in the *Million Ponds Project Species Dossiers.*

Ponds provide food and habitat for a wide range of Biodiversity Action Plan (BAP) species, for example water vole, common toad, coral-necklace and spangled water beetle.

4. Pond creation scheme design principles

There is no "right" design for a pond or pond complex. There are, however, some simple principles that are worth considering.

Pond complexes

If there is space, create a pond mosaic and wetland complex rather than a single large pond. Keep shallow and deep-water ponds separate so they provide distinct habitats. They can be as little as 1-2 metres apart but should not be permanently connected (except perhaps in winter high water conditions).

Include ponds of different maximum depths and ideally include permanent, semi-permanent, and temporary waterbodies. Tiny pools upwards of 0.5 m^2 in diameter can be valuable. The shallower pools may dry out occasionally, but that increases habitat diversity for wildlife. The greater variety of pond types you can create the better.

The mosaic of permanent, semi-permanent and seasonal ponds will encourage a far greater variety of plants, invertebrates, amphibians and mammals to use the site.

When creating a pond complex, aim to complement existing waterbodies on the site. For example, if the restoration already provides deep, permanent, groundwater-fed gravel pit lakes or ponds, focus on creating smaller, shallow, semi-permanent or temporary ponds.

Key design principles

- Pond complexes
- All shapes, sizes, permanence, depths
- Shallow edges
- Undulations and broad drawdown zone
- Leave ponds rough

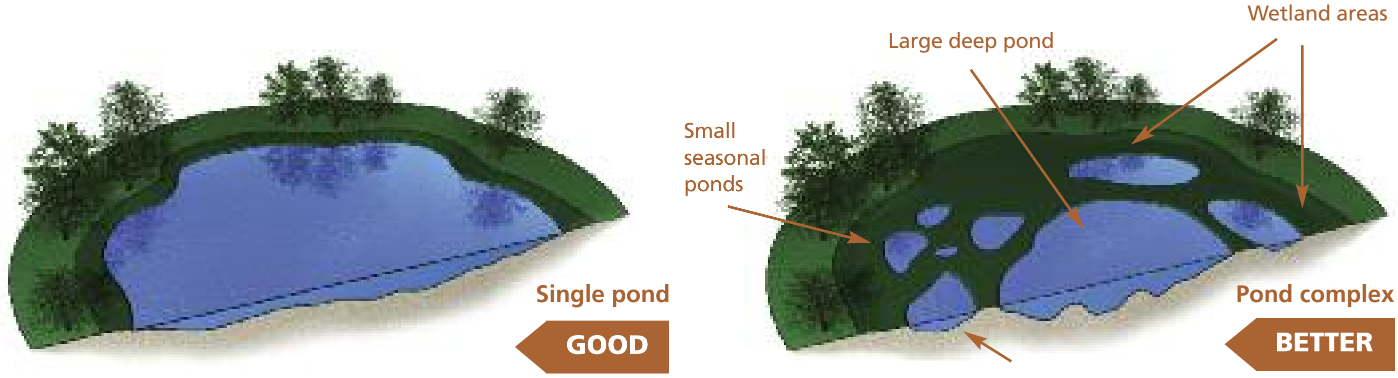
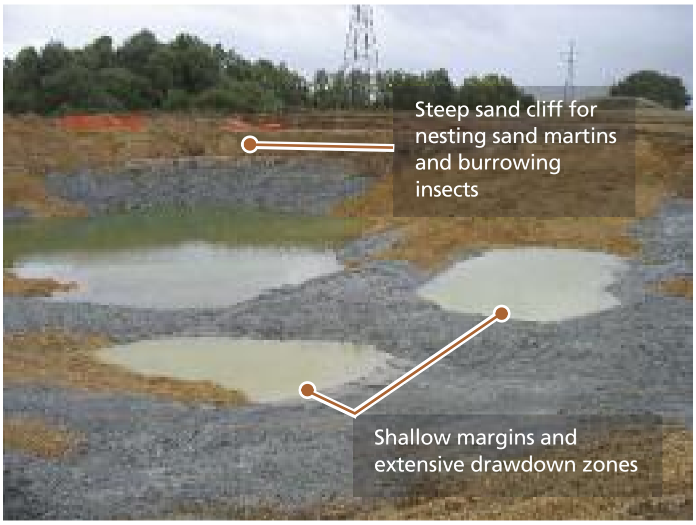


Figure 2. Create complexes of ponds with different depths and surface areas – this will increase the range of wildlife attracted to the site, and provide habitats in all climate conditions.

New pond complex at Eye Landfill

- The Eye Landfill site near Peterborough, operated by Biffa Waste Services Ltd, is located on old sand, gravel and clay workings. A pond complex of around **20** waterbodies of various sizes, depths and shapes was designed by Golder Associates and constructed in autumn 2008.
- A range of pond types (including groundwater fed ponds on sand and gravel, and surface water fed ponds perched on clay lenses), of various sizes and depths along a permanence gradient (from temporary to permanent) were created. The ponds have not been planted up – all have been left to colonise naturally.
- Monitoring of the site undertaken one year after pond creation has revealed that the new ponds are of county importance for stoneworts, a threatened group of plants which generally require both clean water and bare substrates to thrive. In addition, six Nationally Scarce species of aquatic invertebrates have colonised the pond complex in this short time.



Ponds were created with gently sloping margins and extensive drawdown zones, to benefit aquatic plants and invertebrates, and some ponds incorporated steep sand cliffs for sand martins and burrowing insects.

For more information, see the case study *Pond complex creation at Eye Landfill, Peterborough*.

Pond size, depth and shape

It's best to have a mixture of pond sizes and depths in order to provide suitable habitat for the widest range of freshwater wildlife. Tiny pools just a metre or so in diameter can be rich in wildlife – and will support different species to those in nearby larger ponds. Small pools are quick to make, and can be useful for adding variety to larger sites, since you can create many ponds in little space. Management by grazing will keep even tiny pools open in the long-term.

Many smaller ponds will support more species than one single large waterbody of the same surface area. However, there are situations where larger ponds are at a distinct advantage:

- In wooded landscapes larger ponds don't get completely overshaded.
- Large ponds give you scope to create complex individual waterbodies – it's possible to combine extensive undulating shallows, deep water and islands in a single pond.
- Large ponds often have wind-blown waves, which can be useful for keeping underwater bars free of sediment for submerged plants (see Figure 9).

Even small ponds (from 1 m^2 in surface area) can be good for wildlife (above). Small pools at the edges of gravel pit lakes add to site diversity (below).

Ponds don't have to be rectangular or oval in shape. Long linear features, which fit in small spaces alongside boundaries, can be very good if they have a clean water source (see Box: *Standlake Nature Reserve's linear pond*). In larger waterbodies, creating an undulating margin with long spits and bays or embayments will help to increase the diversity of habitats (see Figure 1).

Deeper water is valuable for certain animal species, including water voles and common toads (see the *Million Ponds Project Species Dossiers*). However, it isn't generally necessary for species richness to dig deep ponds, as most pond wildlife lives in the shallows 0-10 cm deep. Many animal species are only found here living amongst the low submerged grasses and wetland herbs at the water's edge.

Provided that the water source is clean and unpolluted, deep water can also be useful for submerged plant communities such as native pondweeds and stoneworts, many of which are now uncommon and declining. On aggregate extraction sites it is common to create deep ponds and lakes, either to extract sand or gravel, or because the availability of restoration material or inert fill imposes a minimum depth or size on waterbodies. As long as deep water ponds and lakes are clean and unpolluted, they can provide a great opportunity to benefit threatened submerged plant communities. For example, the Cotswold Water Park gravel pit lakes are of particular importance for rare species such as starry stonewort (*Nitellopsis obtusa*). To design the deep water areas of ponds and lakes to help stoneworts thrive, see Figure 9 and the species dossier *Creating ponds and lakes for stoneworts*.

Deeper water areas can also be useful from a practical point of view:

- Where vegetation is not grazed down by livestock, deep water can be used to stop marginal emergent plants dominating all ponds.
- Deeper ponds will take longer to fill in with sediment, so the permanent water phase of the pond will last for longer.

Standlake Nature Reserve’s linear pond

Standlake Common Nature Reserve, a former gravel pit in West Oxfordshire, was recently restored to nature conservation. Three small ponds (c. 50, 150 and 250 m^2) were created as part of the restoration process, as well as a large gravel pit lake (c. 16 ha). Collectively, these four waterbodies are very rich – they support 116 species of macroinvertebrate (not including true flies). In total, 40% of the species found were only recorded from the ponds, showing how even small ponds can add value to a site. One of the small ponds, a linear ditch-like pond originally constructed to monitor groundwater levels at the site, supports 61 species of macroinvertebrate, almost as many as the 16 ha lake, which supports 70 species! The linear pond is located next to a hedgerow, which has meant that it doesn’t get negatively impacted by the large flocks of birds that use the lake. The pond was constructed with near vertical steep sides, and this has probably had the effect of maintaining clean, unpolluted groundwater flow through the pond, maintaining water quality (see Figure 6).

Figure 3. **Small ponds created as part of the restoration of Standlake Common Nature Reserve gravel pit lake, including the linear pond, add considerably to the diversity of the site.**

Pond profile

Design of the shallow water area

Shallow edged ponds are often best for wildlife, as most pond animal species live in very shallow areas, right against the pond bank, often in water only 1-10 cm deep. To create such shallow areas, ponds need to slope very gently at the edge, at less than 1:5 (12°) and preferably less than 1:20 (3°). Figure 4 shows the difference between steep banks and gently sloping banks (slopes of 1 in 10 or less). Figure 5 shows a gently sloping and undulating pond profile of a new clean water pond created on a previously restored gravel pit complex to complement the existing deep water habitat of the gravel pit lakes.

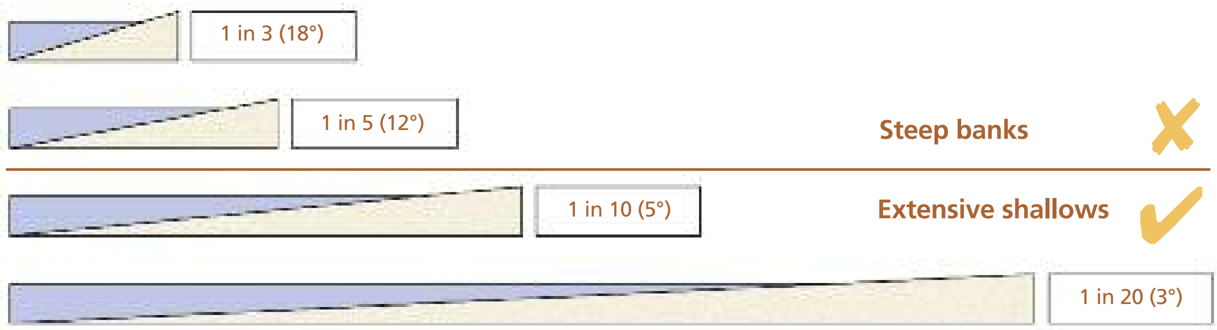


Figure 4. **Bank angles: slopes less than 1:10 are preferable for the water's edge (though the terrestrial bank above can be much steeper). The aim is to create broad areas of very shallow water. Even with a 1:10 slope the shallow water zone (<10 cm deep) is only 1 m wide.**

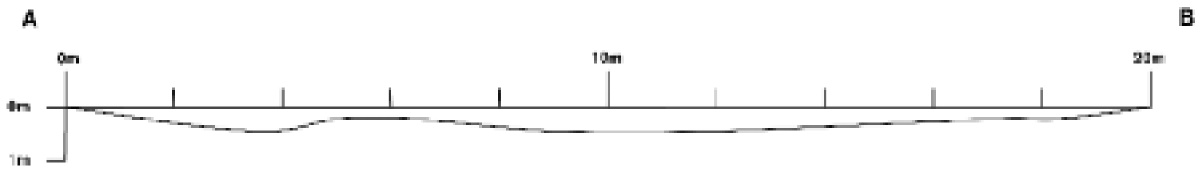


Figure 5. **Cross section of a new pond with gently sloping profile at a former gravel pit.**

To create deeper ponds (with depths over 0.5 m) and broad areas of shallow water – you need larger ponds. If necessary go for an asymmetric shape with some very shallow water, and a steeper far bank to gain water depth.

Although most wildlife will benefit from gently sloping banks and shallow water areas, steep banks can also be useful for some species. In clean groundwater-fed ponds on sand and gravel extraction sites, having some near vertical banks can help maintain groundwater flow, as sediment will not accumulate at the edges and seal the pond (see Figure 6).

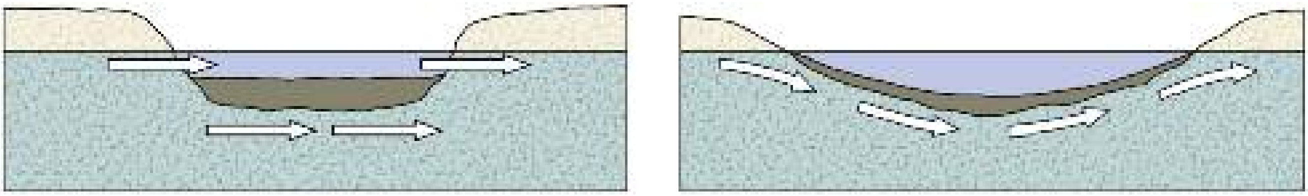


Figure 6. Steep banks can sometimes be useful in groundwater fed ponds.

Steep or stepped banks in a soft substrate such as clay or silt can also be incorporated as burrowing habitat for water voles (see *Creating ponds for water voles*), and steep cliffs in sandy substrates can provide habitat for nesting sand martins, kingfishers and burrowing insects (see *Pond complex creation at Eye Landfill, Peterborough*).

The drawdown zone

The drawdown zone is the "damp" area which is wet in winter and dry in summer. It is one of the most valuable habitats for pond plants and animals, when it's wet *and* when it's dry. Include *very* shallow undulating margins with broad drawdown zones, which are excellent for wildlife. Slopes of about 1:20 give a wide zone with fluctuating water levels which is very important for many wetland plants and animals. Create 'hummocks and hollows' in the drawdown zone to maximise the hydrological diversity of this rich area (see Figure 7). The creation of very fine topographical changes can be helped by asking digger drivers not to level the ground after the main excavations have taken place, i.e. leave the area rough and messy.

Wide drawdown zones with a variety of bumps, hollows and pools are valuable when created on the margins of large gravel pit lakes, benefitting wading birds and providing small-scale habitat diversity for plants and invertebrates.

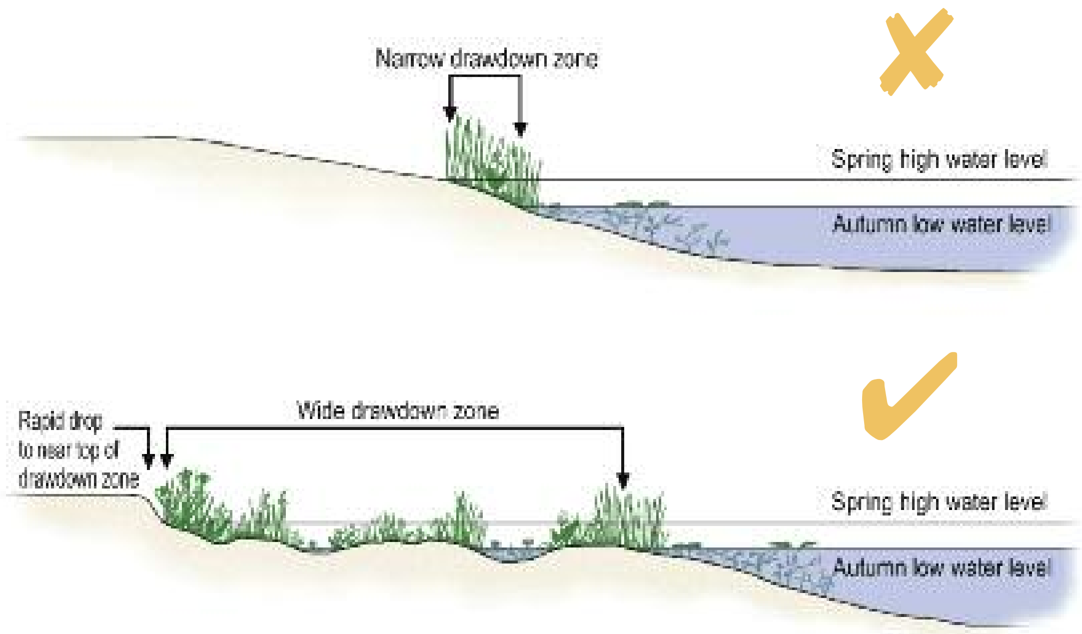
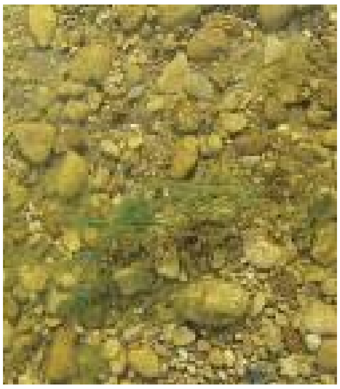


Figure 7. Create broad undulating drawdown zones – they are one of the most valuable areas for wildlife.



◄ **(left) Undulating pond margins and wide drawdown zone at Pinkhill Meadow, a pond complex with over 40 waterbodies in a 5 ha area (Oxon).**

◄ **(right) Clustered stonewort *Tolypella glomerata*, a Nationally Scarce stonewort species, grows in the shallow pools and drawdown zone at a gravel pit in Oxfordshire restored to nature conservation.**

Where a number of pools are being created close together, a good option is to remove the overburden (the material lying above the high water table mark) across the whole area to near the upper drawdown level (see Figure 8). This creates rich natural wetland areas between the ponds. This technique has a further advantage in that it lowers the fertility of the substrate across the pond creation area, which will mean a slower rate of vegetation succession of the site, and will defer and reduce the need for future management of the site.

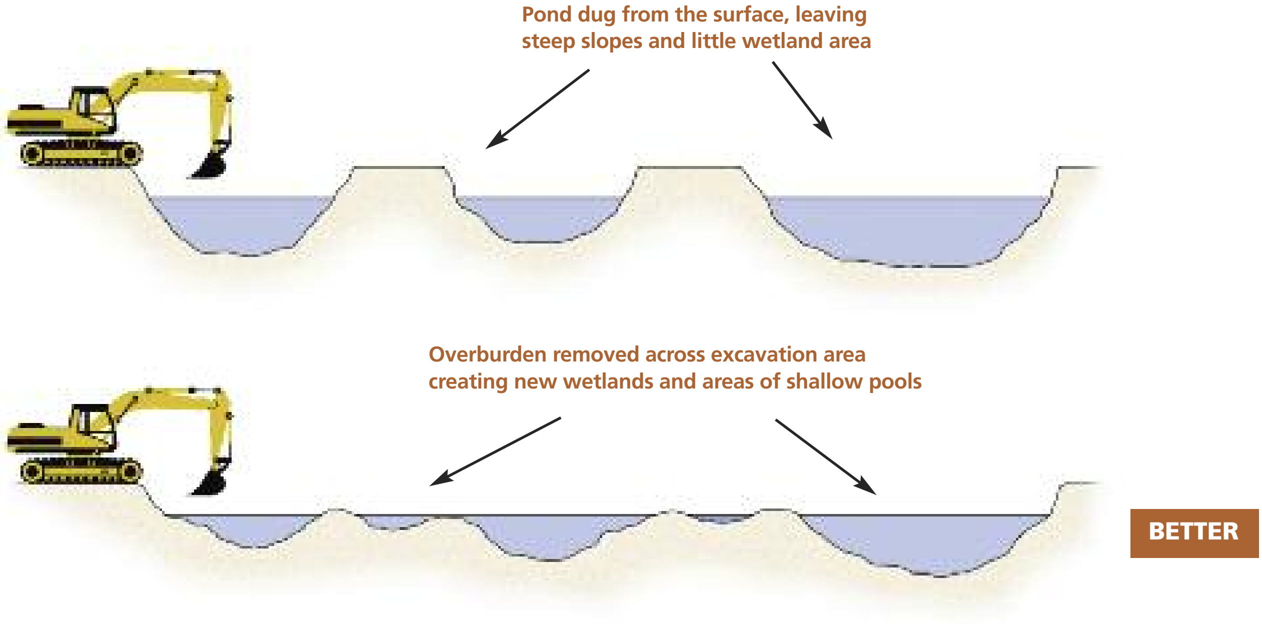


Figure 8. **Rather than excavating all ponds from the surface (above), strip off overburden across the whole area and create pools and wetland areas between ponds.**

Underwater topography

Amongst the particular target plants for deep clean water ponds are submerged stonewort and pondweed species, many of which are now rare in the UK.

Many of our rarest submerged plants need mineral soils to root into – they are happy in the bare clay or sand at the bottom of new ponds and lakes, but not in the dark organic-rich silts that build up as ponds age. You can keep mineral substrates exposed on the pond bottom for longer by creating underwater hummocks and bars. Organic sediments slip off the top of the bars, filling up the low troughs in-between, and keeping the mineral substrate exposed for plants to root into (see Figure 9).

The main draw back with this design is safety – rapid changes in underwater slopes can be treacherous for people wading in the pond, so this is not an ideal design for sites with public access.

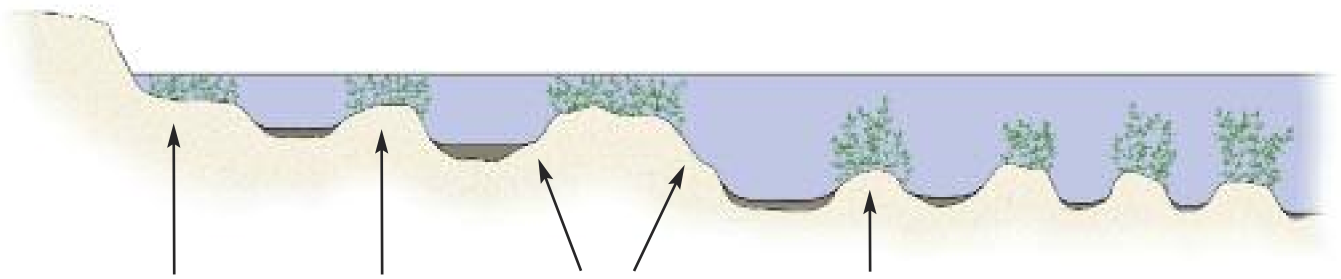


Figure 9. Organic sediments don't accumulate on top of submerged shoals and bars – so uncommon submerged stonewort and pondweed species can thrive.

Wind, fetch and bank erosion

On larger ponds (and lakes), strong winds will whip up waves. The longer the fetch (length of water across which the wind blows), the bigger the waves. As waves hit the far bank, they can erode small sharp-edged cliffs. The prevailing wind direction in Britain is broadly from the south-west. So, in a large pond (or lake), the opposite (north-east) banks will be the most eroded. Even moderate-sized 20-30 m diameter ponds can be affected by wave-wash, especially if the pond is located in an exposed landscape with few trees or hedges.

Wave wash is often seen as a bad thing, and certainly steep eroded banks can be inhospitable to wildlife. But, like many natural processes, waves can be a creative force. They are particularly useful in two contrasting ways (see Figure 10):

1. **Keeping bare sediments for submerged plants:** clean water ponds are good habitats for submerged plants like stoneworts which grow on bare sands or clays. Wave wash can help keep areas free of organic sediment and suitable for these plants by: (i) continually eroding sand and clay bank materials, and depositing them in the water (ii) keeping the pond base free of organic silt by washing organic silts into deeper water areas (see Figure 9), or;
2. **Creating wildlife rich backwaters:** a useful effect of the wind is that it blows seeds, spores, animal eggs and plant fragments across a pond and concentrates them along the wind-blown margin. If the right conditions are created, and these seeds germinate, the wave-washed margin can develop into a particularly rich habitat. The key is to slacken the wind and wave energy before it reaches the bank and erodes it. This can be done by creating islands or deep embayments along eastern margins. Very narrow-necked pools work particularly well, especially if their entrance is off-set so that they don't face the prevailing wind. Islands can be similarly protected from waves by creating submerged bars along their front edge.

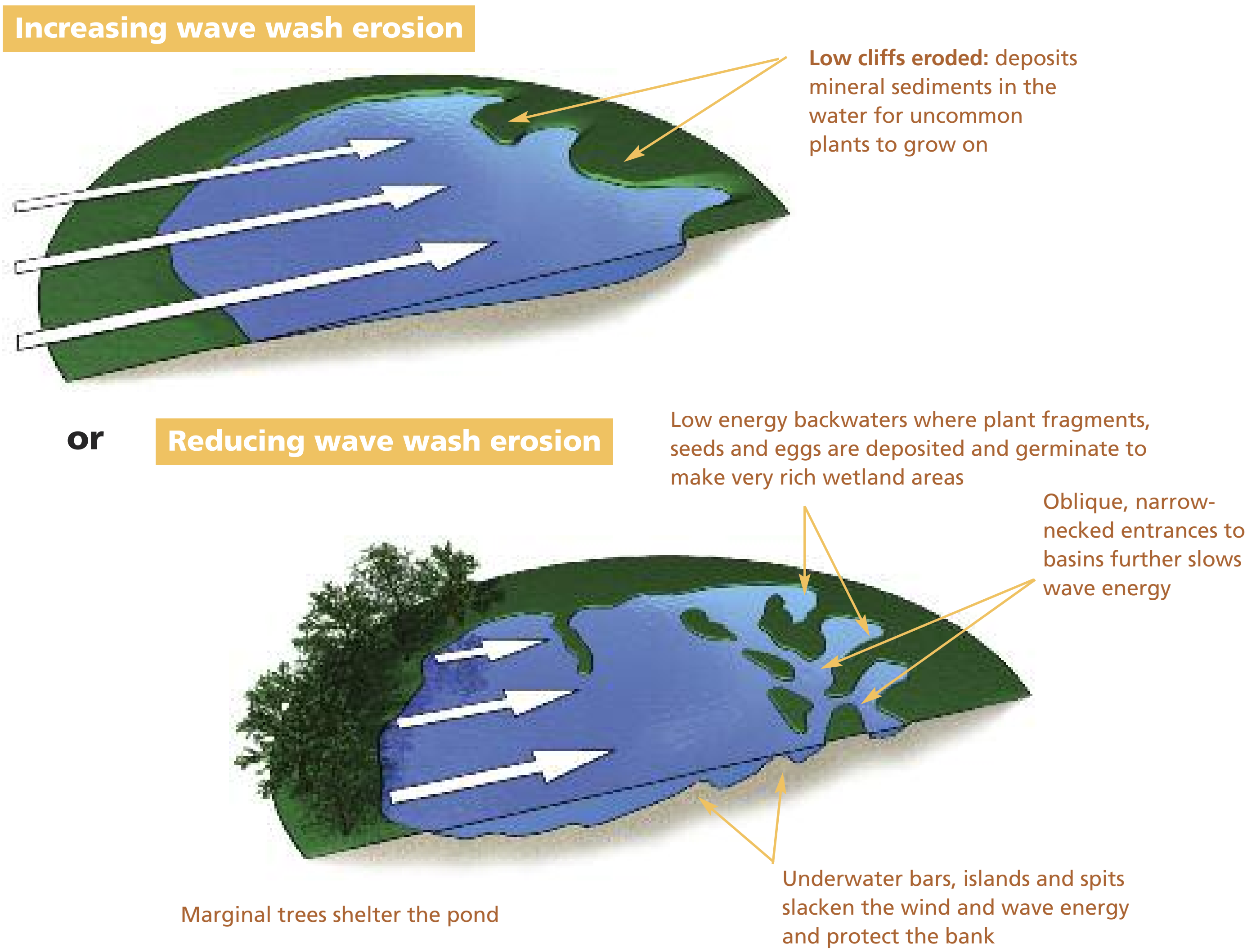


Figure 10. Two options for using design to influence wave wash effects.

Islands

Islands can provide safe areas for waterfowl and wading birds. The main problem with islands is that it can be difficult to get their height just right. Often they are created too high, and quickly become wooded, blocking views and, in some cases, providing perching places for crows on the look out for wading bird chicks. If islands are too low this is much less of a problem; they just become submerged bars – useful for aquatic plants to root in.

To minimise the need for management, aim to create islands so that they are submerged in winter and early spring, which will kill off tree and shrub species, but become progressively exposed in summer to provide feeding and roosting areas.

Islands, just like pond margins, can be varied habitats; depending on their height and exposure they can create either a marshy wetland or, if lower, off-shore mud banks for feeding waders. They can also be used in many ways to create shelter and seclusion to adjacent bank areas.

Where possible, locate islands at least 4-5 m away from the bank and maintain at least 0.5 m depth of water in summer, to provide birds with some protection from predators.

Taller islands, that do not flood in the winter, can be useful for water voles, but plan in time and easy access to allow for periodic management to remove woody vegetation.

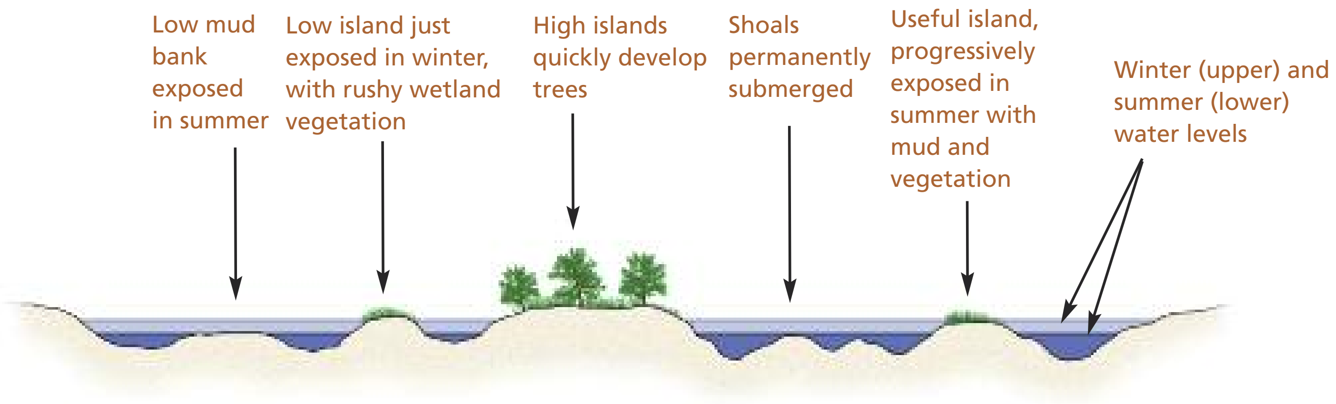


Figure 11. **Design islands to minimise the need for management – ideally keep them low.**

5. Design ponds according to landuse and long-term site management

Consider what the long-term management of the site will be and design the pond scheme accordingly.

For example, grazing is particularly useful to maintain waterbodies with open aspects and disturbed poached margins, which are valuable for many species. In such landscapes, subtle damp and wet undulations created during restoration can be retained in the long term.

If sites will not be managed by grazing, mowing, or clearance, most will eventually develop into scrub and woodland. Wooded ponds will fill with leaves, shallow undulating wetland areas become wet woodland, and lake margins will become overhung by trees. These wooded habitats are valuable in their own right (wet woodland is a UK Biodiversity Action Plan habitat), but with good design they can become more so.

For information on integrating ponds within other existing or created landscape types (such as woodland, grassland and heathland), see the *Supplementary Design Factsheets*.

Supplementary Design Factsheets

- Designing wildlife ponds in woodland
- Designing wildlife ponds in grassland
- Designing wildlife ponds in heathland
- Designing wildlife ponds in wetlands and reedbeds
- Designing wildlife ponds in river floodplains
- Pond designs to minimise the risk of bird strike
- Designing priority ponds in areas of public access

www.freshwaterhabitats.org.uk/projects/million-ponds/pond-creation-toolkit

For further information about the Million Ponds Project and to consult the other Factsheets from the Aggregates Toolkit, please visit *www.freshwaterhabitats.org.uk/projects/million-ponds* or email *info@freshwaterhabitats.org.uk*