Gravel rehabilitation/restoration

Issues

Many of Britain's chalkstreams have been subject to extensive reprofiling. Land drainage for agricultural 'improvement', major flood defence schemes and pre-emptive dredging to stop invading tanks during World War II were some of the main reasons for this work. Whatever the reasons, removal of significant amounts of hard substrate often resulted in an overdeep channel, with a paucity of gravel. Superimposed upon these physical changes are the generalised increases in the fine sediment loading of surface water run-off. Changes in agricultural practice, road drainage and general development pressures often mobilise large volumes of sediment that eventually enters watercourses, particularly during periods of high precipitation (*see*: **Influencing Land Management**).

The consequences of these changes are wide ranging. There is a general reduction in variation in habitat within the channel, in particular a loss of valuable gravel dominated spawning/juvenile shallow areas ('riffles'). Overdeep channels also have a tendency to accumulate fine sediment ('silt') over the whole bed. Silt deposited on shallow areas often becomes entrained within the interstices of any remaining gravel, resulting in a reduction in the survival of any trout eggs deposited.

As a result of these damaging changes, spawning success is often significantly reduced, with the development of a habitat 'bottleneck' at the spawning lifestage. Unless these issues are addressed through habitat rehabilitation, this bottleneck will continue to constrain the abundance of trout within the river.

Potential restoration options

Enhancement of existing gravel riffles

There are two main mechanisms by which trout spawning and the subsequent hatching success of deposited eggs are reduced, namely concretion and sediment entrainment. Concretion is a natural process in chalkstreams. The chemical composition of the bed is dominated by calcium compounds, particularly calcium carbonate. In contact with water, calcium carbonate can bind together an otherwise loose matrix of individual stones into a solid 'concreted' layer. Spawning trout have great difficulty in breaking up this layer in order to allow them to create a redd and deposit eggs.

Sediment entrainment is the process by which fine sediment carried in river water is drawn into and deposited within the interstices of a gravel spawning riffle. The rate and extent of entrainment is governed by a series of variables including sediment loading of the river water, flow, water velocity and gravel size. Any increase in the volume of entrained gravel can lead to a reduction in the percentage hatching of deposited trout eggs, with even moderate levels of silt potentially resulting in a total hatching failure.

There are a number of ways of enhancing poor quality gravel. They focus on breaking up any concreted areas, and removing entrained fine sediment.

Use of Large Woody Debris (LWD)

Large Woody Debris (i.e. naturally occurring timber limbs with a diameter in excess of 10cm) can be used to create scour in riffle zones. LWD already present on riffles can be trimmed, and then manoeuvred and pinned into a position where it creates scouring of impacted gravel. The most secure fixing of LWD is obtained when timber lies across the width of a stream,

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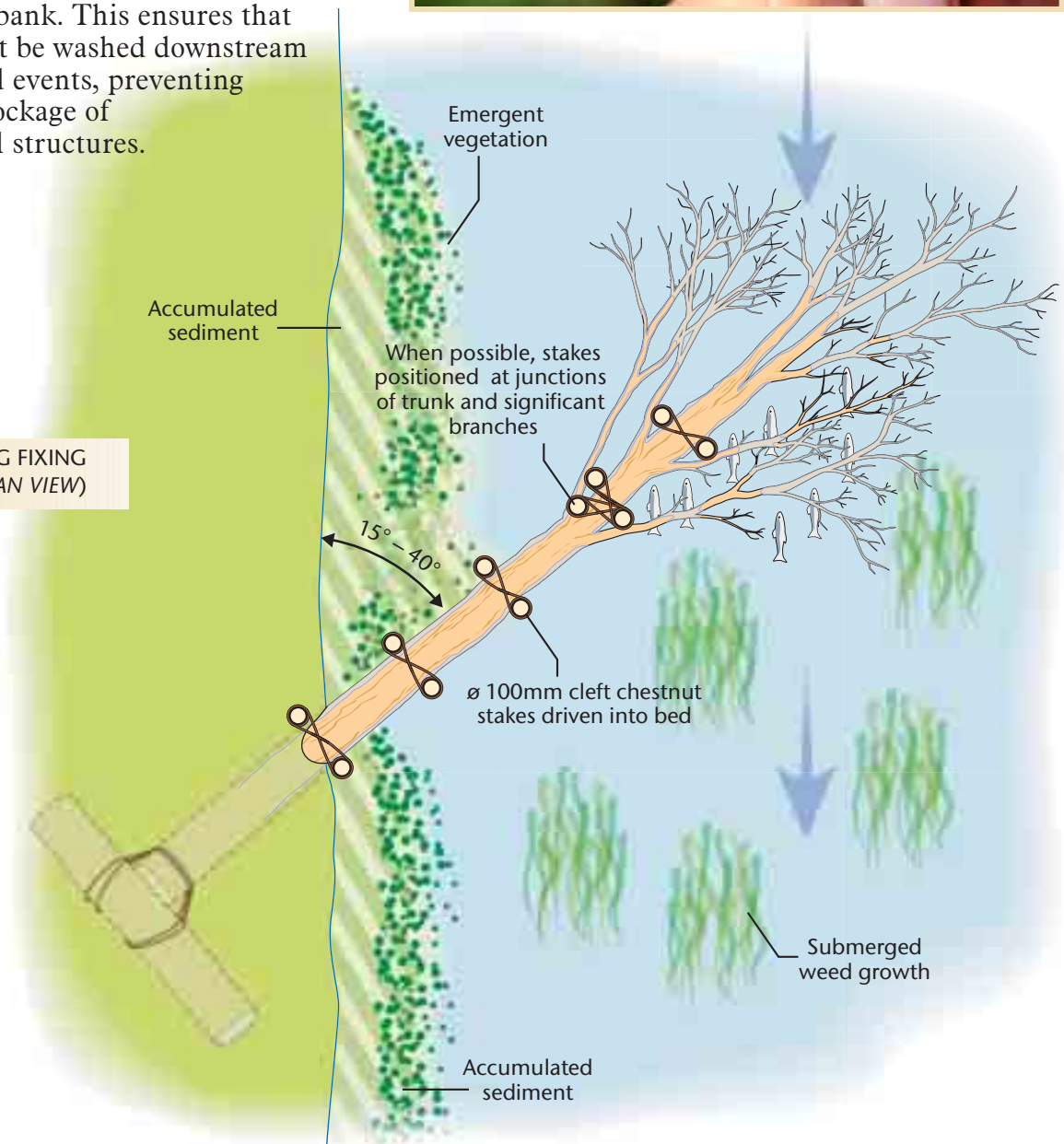
with its extremities lodged firmly between tree trunks or stumps on opposite banks. The longevity of LWD of this type can be in excess of 10 years, with additional accumulated material helping to form a large and semi-permanent structure.

Where limbs/trunks are not firmly fixed across the span of the channel, they should generally be aligned with their tops facing upstream at angle of between 15° and 40° to the bank. Cleft chestnut or similar 'untreated' posts can be driven into the bed at strategic locations to stabilise the LWD. High tensile steel wire can be used to attach the trunk to a ground anchor (*see diagram*) or another tree growing on the bank. This ensures that the LWD cannot be washed downstream in extreme flood events, preventing the potential blockage of bridges and mill structures.

LWD PROVIDES HABITAT FOR A VARIETY OF ANIMALS INCLUDING WHITE CLAWED CRAYFISH.



LWD SHOWING FIXING INTO BANK.(*PLAN VIEW*)

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The selective felling of riparian trees can be used to actively introduce LWD into a river. Not only does this provide a great source of additional LWD, but it can also have the secondary benefit of reducing shading of the channel, hence promoting the growth of instream and riparian vegetation. It is sometimes possible to partially cut through tree trunks and 'hinge' them into the river; not only does this allow the tree to continue to grow, but it also increases the stability of the LWD within the channel. It may be necessary to obtain a felling licence from the Forestry Commission prior to the felling of any trees. Care should also be taken to ensure no trees selected are subject to a Tree Preservation Order (*see*: **Tree Management** section).

Gravel cleaning

This technique utilises a range of machinery in order to loosen concreted gravels and release entrained fine sediment. In the most commonly employed technique, the outlet hose from a portable water pump (normally petrol powered) is reduced in diameter from 50mm to around 20mm using adaptors in order to produce a high pressure jet. This is then placed over the surface and within the interstices of the gravel spawning area, mobilising and removing sediment. Recently, field trials have shown back-pack leaf blowers to be very effective in cleaning gravel.

Although potentially very effective, gravel washing can be relatively slow, with only relatively small areas covered in a day. Treatment of larger areas can be effected using harrows or cultivators towed by tractors, or by employing a mechanical excavator to 'lift and sift' the gravel bed.

GRAVEL WASHING USING A HIGH PRESSURE WATER PUMP .

BACKPACK LEAF BLOWER BEING USED TO CLEAN SPAWNING GRAVEL.

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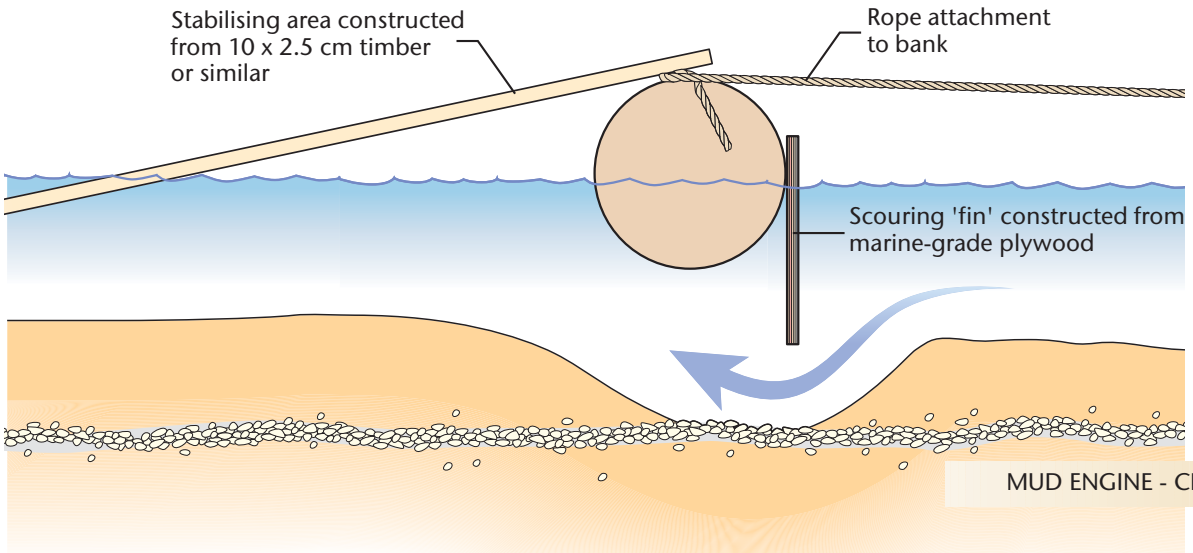
MUD ENGINE. NOTE ANCHOR ROPES

'Mud' engines

Mud engines are simple and easy to construct. In essence, they utilise a floating boom with attached timber 'vanes' in order to concentrate flow vertically and create scouring of the bed. Moved downstream along a section of riffle at regular intervals, they can be a very effective, labour efficient and cheap method of grading gravel and removing entrained sediment from spawning riffles.



MUD ENGINE - CROSS-SECTION

Creation of new gravel features

Raising of the bed elevation can be used to reduce the cross sectional area of a river. This speeds up flow velocity and increases habitat diversity. Bed raising can be undertaken by the introduction of stone, cobbles, or other suitable locally derived substrates, topped off by a layer of mixed sized gravel, in order to create the shallow, fast flowing areas often referred to as riffles.

It is important however to realise that these are not riffles in the true sense. Riffles are specific geomorphological features that occur in conjunction with pools in rivers with a gravel substrate and a moderate slope. Riffles are characterised by their locally steep/shallow profile, generally symmetrical in cross section. They are generally located at cross-over points in meanders, or are spaced between 3-10 river widths apart. Their substrate is characterised by mixed gravels, with a coarser, tightly packed armoured layer. Over time silt gets entrained within the gravel riffle, with the balance between silt and gravel fluctuating in this inherently dynamic system.

Despite the strict geomorphological definition, it is convenient to continue to refer to the output of bed-raising as riffles.

Before embarking on any riffle construction, it is very important to assess where these features could be most usefully sited. It is very unlikely that adequate funds will be available to construct riffles at a naturally occurring density along the whole of the fishery: a 30m long riffle on a 5m wide river may cost upwards of £3,500 to install.

PARTIALLY CONSTRUCTED RIFFLE. NOTE UNDERLAYER OF LARGER STONE, STILL TO BE TOPPED WITH GRAVEL.

Located with its downstream end leading into a well-vegetated meander, a riffle can encourage controlled erosion, leading to the creation of an undercut bank, valuable as cover for adult trout which may subsequently spawn on the riffle.

Each riffle should ideally be no less than 20m in length, with longer lengths increasing the feature's value as a spawning and nursery zone. The riffle should comprise of a depth of at least 30cm of spawning gravel (mixed 15-40mm diameter gravel) with a sub-layer of larger reject flints. The weight (tonnes) of stone/gravel required to complete a riffle can be calculated using the formula:

T = **L** x **W** x **D** x **1.8**

Where:

T = Total weight of material required in Tonnes

L = The length of the riffle in metres

W = The wetted width of the river at the site of the riffle in metres

D = The depth of gravel required to achieve a finished summer water depth of approximately 0.25m over the riffle

The riffle should have a slope of approximately 1:100 between its upstream and downstream limits.

Construction of riffles will require the assistance of a specialist contractor and hydraulic excavator.

It may be possible to obtain the gravel and stone required for riffles from on-site excavation. There may for instance be piles of gravel rich spoil deposited along the banks from previous dredging operations. These can be screened to remove fine material, with the larger gravel re-introduced into the channel. Other potential sources of material include digging flight ponds, wader scrapes and other wetland features within the floodplain if the geology of the area is suitable to yield good volumes of stone or gravel. With imagination and careful planning, it may be possible to not only install riffles in the river, but also to significantly enhance the ecology of the floodplain.

In the event that no materials are available on site, it will be necessary to import them. Subject to suitability and price, the aim should always be to procure stone from the nearest quarry to the site. Transport of materials from remote locations increases the carbon footprint of any project considerably.

There may also be a need for a basic flood assessment or even hydraulic modelling as part of the Land Drainage consenting process. For these reasons and the general complexity of riffle installation, it is recommended that assistance be sought from the WTT, Environment Agency or a reputable fisheries consultant at the planning stage.

TROUT REDDS ON CLEANED GRAVEL.

Costs

Mud engines and LWD can be installed on a 'labour only' basis. Expect to pay around £300–400/day for a qualified tree surgeon and assistant. They should be able to fell/trim a substantial volume of timber in a single day, for future installation into the river by volunteer labour. Gravel washing using powered pumps can be undertaken by a contractor at a cost of between £300–400/day including all equipment.

Alternatively, it may be possible to borrow equipment from the Environment Agency (contact your local office) or to purchase a set for around £400–500. Back-pack leaf blowers can be purchased for around £300–400.

The installation of riffles is an expensive operation. Costs for the installation of a 30m riffle on a 5m wide river may exceed £3,500. Installation of multiple riffles may reduce the unit cost for each riffle.

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Summary

Technique	Advantages	Disadvantages
Installation of LWD	Cheap. No import of materials to site.	Needs thought to anchor wel and prevent wash out.
Mechanical cleaning	Can treat large area rapidly.	Utilises heavy plant. Expensive. Can mobilise significant volumes of sediment carried downstream in short time frame
Mud Engine	Cheap. Easily moved along riffles. Cleans and sorts gravel very efficiently. Very slow release of sediment. No major labour input required.	Very slow treatment of small areas.
Gravel washing	Portable. Can be undertaken by volunteer labour. Easily controlled. Relatively cheap.	Requires purchase/hire of plant. Labour intensive. Relatively slow. Significant mobilisation of sediment affecting downstream.
Construction of riffles	The only practical method of rehabilitation of severely damaged habitat. Can increase trout recruitment dramatically. Offers significant habitat opportunities for a range of other species.	Relatively expensive. Requires specialist planning and installation. May not be possible in areas with high flood risk sensitivity.

Working Examples

River Glaven

A community based scheme on a small North Norfolk chalkstream, the River Glaven, incorporated both the introduction of LWD and the construction of riffles. Initial visual observations suggest that both elements have been successful, with brown trout seen on the riffles, and significant areas of substrate sorting having taken place downstream of the introduced LWD.

RIFFLE – APRIL 2007

LWD– APRIL 2007

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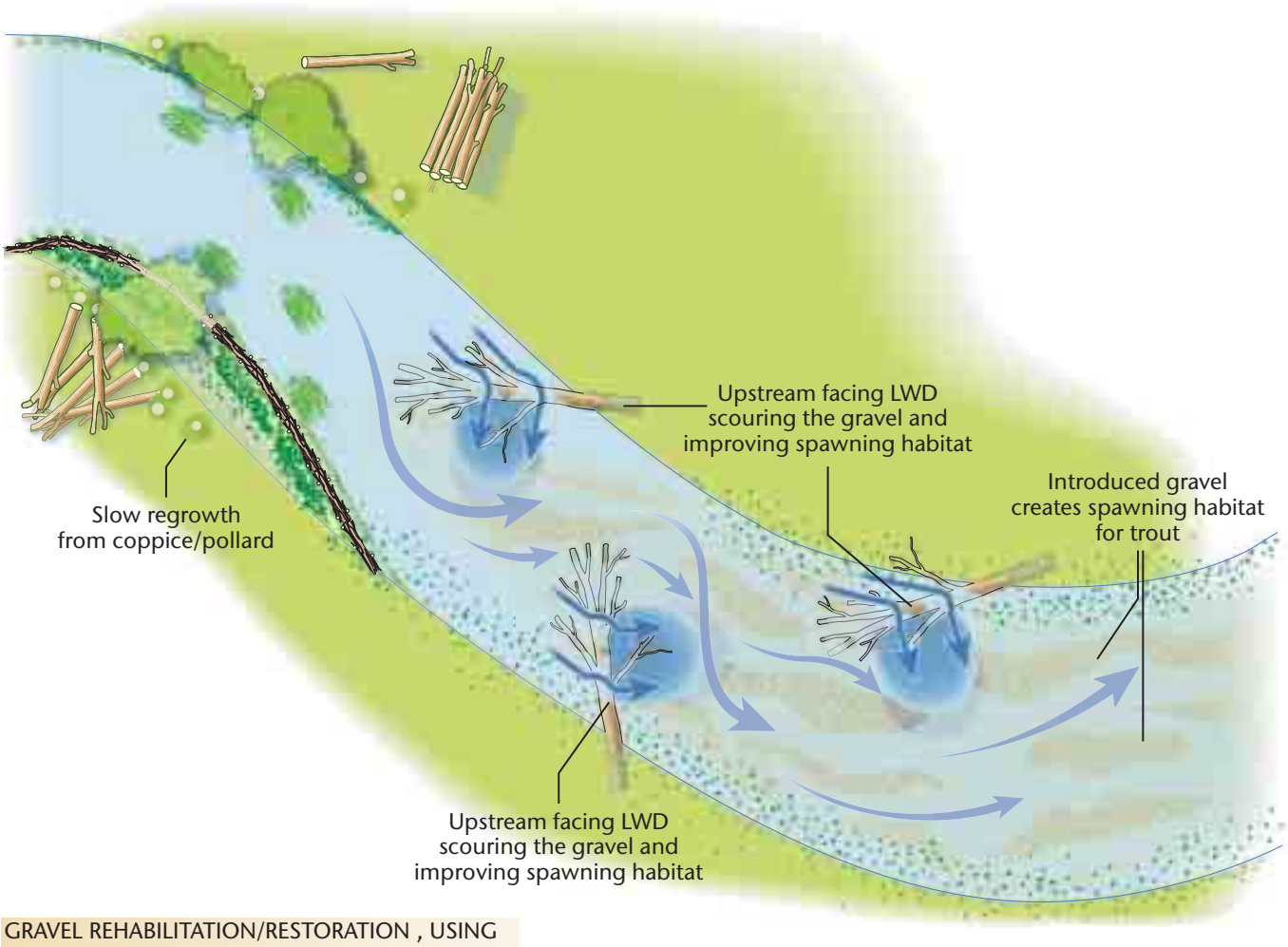

GRAVEL REHABILITATION/RESTORATION , USING INTRODUCED GRAVEL AND LWD TO IMPROVE SPAWNING HABITAT FOR TROUT.