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Grip Blocking Best Practice Guide

Extract from a University of Leeds report for Yorkshire Water.

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Grip-Blocking Best Practice Guide

Introduction

This grip blocking best practice guide was developed as part of a wider project undertaken by the University of Leeds on behalf of Yorkshire Water. The wider objectives of the project were:

A. To produce a grip blocking strategy for Yorkshire Water and;

B. To develop an understanding of the economics and benefits of grip-blocking and other land management activities on colour formation and transport.

The study combined three main data collection components in order to meet the objectives:

i. A UK-wide survey of grip-blocked sites.

ii. Intensive monitoring at two sites.

iii. Review and utilisation of existing grip-blocking data sets.

These three sets of data contributed to the formation of the grip blocking best practice guide set out in this report. The grip-blocking best practice guide aims to be a tool to help with the implementation of grip-blocking for the primary objective of reducing raw water colour. It may also be useful in designing effective grip blocking strategies for other objectives, such as raising the water table for biodiversity purposes.

Contents

This grip-blocking best practice guide is structured as follows:

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1. Site prioritisation

Where it is decided to implement a grip-blocking strategy then sites should be prioritised. We suggest that, for the primary objective of reducing colour in raw water, the catchments are prioritised by the factors outlined in Table 1, although SSSI status may also influence the decision. These factors are based on our extensive surveys, existing data collected by ourselves and others and the literature. They are in an arbitrary order as it is not possible to rank them given the variability in these factors between catchments: assessment should be made on a catchment-by-catchment basis.

Table 1 - Factors by which catchments should be prioritised for grip-blocking.

Factor	Rationale
Intakes with high or increasing colour	*Prevent or delay the need for a step-change in the treatment process.*
High proportion of catchment gripped	*The benefit of blocking will be more evident in catchments which have a greater proportion of grips.*
Soil type	*Catchments dominated by winter hill peat should be prioritised as winter hill peat has been associated with greater water discolouration in previous research (McDonald et al., 1991).*
Vegetation type	*Grip catchments dominated by heather should be blocked, then those with mixed vegetation (indicative of moorland in good condition) and then grass/sedge-dominated (excluding cotton grass) catchments.*
Grip condition	*In order of preference, actively eroding grips should be blocked, then stable and then naturally infilling. Water table response will be similar in stable and eroding grips but eroding grips will be a source of particulate organic C which may degrade in-stream and/or contribute to reservoir sedimentation. If there is no evidence that the water table is near the grip base (e.g. if there are no pools of water and/or is covered by vegetation which favours dry conditions) then blocking will have a limited impact.*
Grip morphometry	*Deeper grips should be prioritised over shallower grips (Gibson, 2006.)*
Slope	*Grips on steeper slopes should be prioritised as the areal extent of water table drawn down will be greater (Lane et al., 2003).*
Percentage of intake catchment gripped	*The impact will be greater for intakes with a high gripped to un-gripped area ratio.*
Grip network density	*Assuming equal slope, denser grip networks should be prioritised for blocking as the impact of gripping on the water table depth is more noteworthy within ~2 m (Boelter, 1972) of the grip.*

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2. Grip-blocking technique

A decision tree to identify the preferable grip-blocking method has been devised using evidence primarily from the UK-wide survey (Figure 2). This takes into account information from the three data components in the project, for block effectiveness in different conditions and circumstances, in terms of probability of success for firstly blocking water and sediment, and secondly for re-vegetation of the grip. Development of a decision tree necessitates hard boundaries to provide ‘yes’ or ‘no’ answers. However, given the interaction between various factors such definite decisions are not always applicable in the field. Consequently, this decision is provided as a guide and some degree of interpretation and adaptation in the field may be required. Notes to accompany the decision tree are given below.

The preferable blocking technique

If site characteristics are appropriate then the recommended blocking technique is peat turves. The key reasons for this are:

• It is the cheapest technique, even taking into account its slightly higher failure rate.

• Landowners/ managers prefer turves as this gives lambs and grouse a greater chance to get out of the grips if they fall in and grouse grit can be put on higher blocks.

• No foreign material is required; they are less obtrusive in the landscape and preferable for longer-term moorland management.

However, during the UK-wide survey there was a wide variation in peat turve blocking styles and variation in the ability of contractors to adequately install them. Therefore, it should be ensured that the contractors are competent and blocking undertaken in the most appropriate manner for each location.

For example, there should be no attempt to distribute the water across the peat surface at locations where erosion may result.

Figure 1. Poorly installed turf block which also caused extensive damaged to surrounding area.

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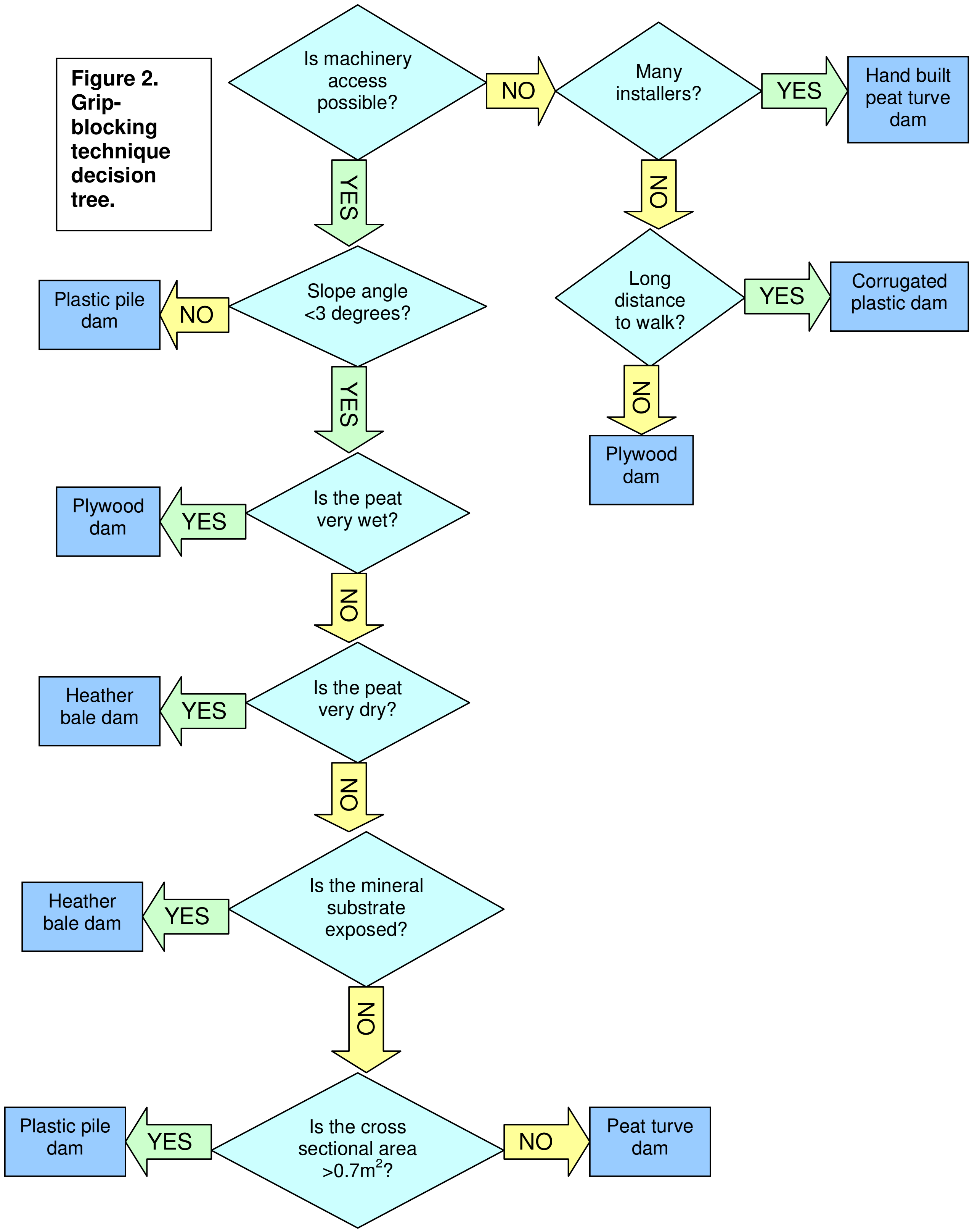
Figure 2. Grip-blocking technique decision tree.



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Machinery access possible?

Some sites are considered too sensitive for machinery access, such as Forsinard Reserve in Scotland, other sites may not be accessible due to topography, or the site may be too boggy. This will have to be assessed on a site-by-site basis by the contractor and bodies such as Natural England as appropriate.

Many installers?

Only a limited number of hand built turve dams at Kielder and Scotland were assessed during the UK-wide survey. They were well constructed, effective, and did not require the addition of any foreign materials, compared with corrugated plastic and plywood dams. Consequently, if there are sufficient installers then the hand built turve dam method is preferable. However, this is unlikely, and perhaps only suitable for smaller sites.

Long distance to walk?

Plywood dams were found to perform better than corrugated plastic and therefore are recommended. However, plywood dams are more cumbersome and heavy to carry. Consequently, if the grips are a distance from the point at which vehicles can access the site, corrugated plastic may be preferable.

Slope <3 degrees?

The relationship between block failure and slope established from the UK-wide survey is potentially affected by other factors such as ground wetness, and consequently guidance can not be grounded on this data. However, slope angle and grip erosion or infilling suggests that on slopes greater than 4 degrees grips tend to erode, whereas on slopes less than 2 degrees grips tend to infill.

Therefore, it is recommended that grips on a slope greater than 3 degrees should be blocked using plastic piling. The rationale for this is that steeper slopes promote higher stream powers and therefore more likelihood of erosion: erosion can occur around the margins of peat turves, and through them in some cases, whereas this rarely happens with other blocking methods as they are inserted several centimetres into the peat. Also, grips on steeper slopes were sometimes orientated down slope as opposed to across slope, with several grips feeding into them. Therefore they transport greater volumes of water, increasing the likelihood of erosion. The 3 degree threshold is a generic recommendation. If the grips being blocked do not show signs of erosion, or do not transport much water then follow the decision tree as for gentle slopes.

Is the peat very wet?

The UK-wide survey established that blocks in areas where the ground was very soft (soft, bubble like appearance when you walk on it) were less effective. Therefore, it is suggested that plywood dams are used as they can be inserted further into the peat and are more successful than corrugated plastic and plastic piles.

Is the peat very dry?

Field observations during the UK-wide survey indicated that at some sites the peat was very dry and fragmented. In this case none of the blocking methods which aim to create a watertight seal are recommended as the chance of failure will be high.

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Therefore, heather bales are suggested in such circumstances as they do not aim to create a watertight seal, will trap sediment and do not introduce foreign material into the site.

Is the mineral substrate exposed?

Mineral substrate exposure has been linked to higher block failure rates (Worrall, personal communication). There were insufficient data for grips with exposed substrate in the UK-wide survey to investigate this, but field observations during the survey support this idea. Peat does not bind well with mineral substrate hence using peat turves in such locations would result in a high failure rate. Given the cohesive and often rocky nature of mineral substrate corrugated plastic would shatter and plywood and plastic piles are likely to break. Consequently, heather bales are the recommended blocking technique where the mineral substrate is exposed.

Is the cross-sectional area >0.7 m^2?

During the UK-wide survey some very large grips were successfully blocked with peat turves. However, large volumes of peat had to be sourced from the adjacent hill slope and the holes, whilst creating pool environments, were an eyesore. Consequently it is recommended that if the cross-sectional area is greater than 0.7m^2 that plastic piles should be used. Plastic piling is recommended in these cases rather than plywood dams and heather bales primarily because they are stronger: large grips are likely to be erosive. Also, plastic piles come in small sections so are easy to transport.

3. Where to block at the site and grip scale

Throughout the project attempts have been made to obtain cost estimates for grip blocking. However, this has proven problematic as

(1) Contractors are reluctant to pass on this information to an academic institution.

(2) Different costing structures are used (per block, per day, per length of grip) and may also be affected by the time and cost involved of transporting the necessary plant to the site.

Therefore, before commencing grip-blocking at a site it is recommended that estimates are requested from contractors specific to the site due to be blocked.

Consequently, it is not possible to establish whether it is more cost effective to block all grips on a site or select individual grips to block. Furthermore, there is not sufficient evidence from the UK-wide survey suggesting that grips can be categorised as more important to block, and this is also dependent on the goal of grip-blocking. However, some guidance can be drawn from existing studies:

i. Assuming that much of the peat in Yorkshire is well decomposed it is reasonable to assume that the hydraulic conductivity (ease with which the water flows through the peat) is relatively low. Therefore, it is likely that effects on the water table are more local to the grip on relatively gentle gradient slopes (Boelter, 1972). Therefore, it could be assumed that it is preferable to block every grip in these circumstances, but this is dependent on the goal of grip-blocking and individual site characteristics.

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ii. Where grips are on longer slopes, with some gradient to them, then grips that are near the top or half way up such slopes should be prioritised for blocking. This is because they will cause a larger area of slope down slope from the grip to receive less water (Holden *et al.,* 2006). This is backed up by findings of the intensive monitoring data gathered for this project.

iii. Shallower grips produce less colour (Gibson, 2006) and field observations suggest that the water table in some grips is below that of the grip base. Therefore, it is suggested that there is limited worth in blocked grips which shown no signs of having standing water in them. To assess this it is advised that the site is visited on wet days.

Block location and spacing at the grip scale are also site dependent. In terms of block location, points along the grip which would potentially feed water flowing out of the grip upstream from the block into a preferential pathway orientated down slope (i.e. path, track, depression) should be avoided as this may lead to erosion. In some locations it is possible to feed water flowing out of the grip into a depression creating a pool environment which is viewed as beneficial for biodiversity. Other considerations are related to vegetation and ground hardness. The UK-wide survey indicated that blocks were more likely to fail in very wet ground hence this should be avoided if possible. Also, field observations suggest that peat turves sourced from heather-dominated areas can produce fragmented blocks and consequently, if possible, should be avoided or care taken to ensure the block is well installed. Analysis of block class (i.e. how successful the blocks were) and block spacing data suggests that blocks should be no more than 10 m apart and on steeper slopes and in grips that transport larger volumes of water, blocks should be placed 5 m apart.

4. Critique of the variations of blocking methods

During the UK-wide survey it was evident that the same blocking technique was executed in different ways. Therefore the variations have been summarised and advantages and disadvantages given for each in Table 2. The suitability of some of these variations depends on site characteristics, for example redistribution of water from a block is not suitable if the local topography around the block is such that erosion will occur. The choice of other variations may depend on site characteristics, for example if the moor is used for grouse shooting some blocks may be elevated to provide a dry area for grouse grit. Therefore, these variations should be selected with reference to the site characteristics.

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Table 2 - Variations of the grip-blocking techniques and their advantages and disadvantages.

Block type	Variation	Comments
1. Peat turve	(a) Redistribution of water from a block	**Advantages:** Aims to stop water overflowing out the grip, round the block and back in the grip downstream of the block and associated erosion. Wets up a larger area of the peat mass to encourage sphagnum growth. **Disadvantages:** Enhanced overland flow will improve connectivity and increase microbial movement across the peat surface. Can lead to erosion of the hill slope. Causes wetting and drying of the peat. If water is not redistributed pool communities can develop. May increase evapotranspiration
	(b) Peat source	Peat commonly sourced from upstream of the block. **Preferable as:** Creates a pool environment.
	(i) From upstream or downstream	If is peat removed from downstream of block scars are more noticeable – upstream pools become filled with water. Produces pool environments. Slows water velocity before block and therefore decreases erosion.
	(ii) From one side of the grip or both	This appears to have limited impact, except if the water is being encouraged to redistribute and the pool is to one side of the grip it should be to the down slope side.
	(iii) Away from the grip	At Cut Thorn Hill, a site with wide, deep grips peat for the grips was taken from a few metres away from the grip and large pools were created. This maybe beneficial in promoting pool environments but had a high impact on the visual appearance of the landscape.
	(d) Pool size	Shallower, wider pools preferable as field observations and Russell (personal communication) suggest that vegetation, namely sphagnum species and common cotton grass, grow more readily in shallower water as light penetration is higher. However, peat material taken from nearer the surface tends to create less cohesive blocks than those made from peat taken from depth.
	(e) Block height	Some are built approximately 1 metre high so to act as dry areas on which to place grouse grit while others are high as a result of the machinery used to produce them. If they are not built slightly elevated (15 cm) in comparison with the surrounding land they are less effective.
	(f) Block width	Field observations also indicate that blocks should ideally be slightly wider than the grip (~15 cm). If not then the joint between the block and the grip edges is more likely to be exploited by erosion. Slightly wider blocks will also encourage redistribution of water, as opposed to water flowing round the block and back in the grip.

	(g) Building technique	Block building technique is also variable and will impact the success of the block. At some of the Scottish sites blocks were installed by hand as the areas were deemed too sensitive to use large machinery. The hand built dams seem very effective; perhaps a result of the increased amount of time and care used to install them. Other techniques, using machinery involved simply pushing down the sides of the grip using an excavator bucket or using an excavator bucket to scoop material out and place it in the grip. With all of these methods it is important to get a complete, firm contact between wet peat to create a seal. Then, ideally, a piece of turf should be laid on top of the bare peat to prevent it drying out, increase stability and improve aesthetics.
	(h) Re-profiling	At some sites, in addition to blocking, the grip edges were re-profiled; the edges were reshaped from approximately 90° to 45°. This was done on larger grips and the sides were always left covered with vegetation. This technique was evident at Cut Thorn Hill. Theoretically the approach seems sound and advisable at highly eroded sites, typically with steeper sides, as the vegetation will trap sediment, decrease flow rates and decrease erosion.
2. Plastic piling	(a) Number of layers	The plastic piling may be installed in a single or double layer. Double layer plastic piling is stronger and should be installed in grips with wider cross-sections or where stream power is high.
	(b) Angle of installation	Installing the pile at an angle (i.e. not perpendicular) to the grip will discourage water, when the grip reaches capacity, from flowing round the pile and back into the grip.
	(c) Notch	Some plastic piling has a notch in the centre to stop water flowing over bank. This is not a recommended strategy as the purpose of blocking is to prevent water flow. However, it may be appropriate in situations were surface flow would be detrimental, i.e. if the grip was adjacent to a farmers track. However, field observations show that, as a result of channelling the flow through the notch, it can lead to increased erosion.
3. Wooden dams	(a) Construction type	There are two types of wooden dam: (1) sheet plywood dams, and (2) plank dams. Wooden plank dams are constructed using a series of upright supporting timbers inserted into the peat with planks attached either horizontally or vertically. When installed wooden plank dams are made watertight. However, often the wood splits, bows or distorts, thus the dams are no longer watertight. Furthermore, given the size of timber used to create wooden plank dams they seem slightly more prone to badly fitting; several were not sealed at the edges.
	(b) Angle of installation	Installing the dam at an angle (i.e. not perpendicular) to the grip will discourage water, when the grip reaches capacity, from flowing round the pile and back into the grip.

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	(c) Notch	Some dams have a notch in the centre to stop water flowing over bank. This is not a recommended strategy as the purpose of blocking is to prevent water flow. However, it may be appropriate in situations were surface flow would be detrimental, i.e. if the grip was adjacent to a farmers track. However, field observations show that, as a result of channelling the flow through the notch, it can lead to increased erosion.
	(d) Plastic sheeting	At one site the dams were lined with plastic but for these to be water tight the plastic would have to be dug into the peat and a seal ensured.
4. Perspex dams	(a) Basic structure	Corrugated plastic was inserted into the peat. Some had wooden supports across the top to stabilise them. The Perspex dams are similar to plywood board dams and plastic piling dams, but are less strong. Some had been washed out, and some were no longer water tight (but many had been *in situ* for over ten years).
	(b) Angle of installation	Installing the Perspex at an angle (i.e. not perpendicular) to the grip will discourage water, when the grip reaches capacity, from flowing round the pile and back into the grip.
	(c) Notch	Some dams have a notch in the centre to stop water flowing over bank. This is not a recommended strategy as the purpose of blocking is to prevent water flow. However, it may be appropriate in situations were surface flow would be detrimental, i.e. if the grip was adjacent to a farmers track. However, field observations show that, as a result of channelling the flow through the notch, it can lead to increased erosion.
5. Heather bales	(a) Density of bales	Heather bales are used to 'plug' grips and are installed with the aim of gradually trapping sediment. At some sites, bales are wedged in the grip to produce a 'dam'. At other sites the length of the grip is filled with heather bales. Grips blocked solely using heather bales were blocked recently and little difference in success between the two techniques was evident.
6. Straw bales		Straw bales were used as blocks in some grips (none surveyed in this study). However, they are not widely used as they rotted quickly and there were concerns regarding introducing materials from other ecosystems.
7. Sheep's wool		Sheep's wool in Hessian bags has been used to block some grips. However, this is not widespread. It was used more often to block gullies but the water industry was concerned that tannin may be released from the wool and pollute the water.

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8. Combination methods	(a) Bales and plastic piles/ wooden dams	Bales of either Molina or heather were combined with plastic piles and dams to decrease erosion by slowing flows and trapping sediment. At Black Pitts, Exmoor, Molina bales were placed downstream of wooden dams to prevent plunge pools from developing. At other sites, especially those in Scotland there was evidence of plunge pool erosion downstream from blocks (many of the blocks in Scotland had v-notches cut out of them which would concentrate flow and increase the risk of erosion in comparison to blocks which, when flows were high, distributed water across the hill slope or down grip across the width of the block). Therefore, if water is not encouraged to distribute across the slope, and/ or is concentrated by the block form it is recommended that bales be placed immediately downstream of the block.
	(b) Heather bales and peat mats	Peat mats were placed over bales to increase stability or to promote peat growth on top of the bales. However, limited grips have been blocked with bales and as a result it is not possible to judge if the addition of peat mats is beneficial.
	(c) Peat turves and plastic piles	Peat turves were placed between plastic pile blocks at one site. There is no apparent rationale for this.

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5. Additional blocking considerations

During the UK-wide survey other considerations that should be made when blocking grips were noted. These are given in Table 3 and should be taken into account in order to ensure the blocking is successful as possible.

Table 3 - Additional considerations to be taken into account when blocking.

Issue to Consider	Rationale
Minimise site disturbance	Sensitive environments, some with rare vegetation species.
Avoid blocking during very wet periods (inc melting snow)	There is more disturbance and up-turned peat if the ground is very wet.
Block just prior to the growth season	Vegetation will grow and stabilise the block. Disturbed vegetation will recover quicker.
Do not expose mineral soil	Exposing mineral soil can lead to the establishment of vegetation communities (i.e. reed beds) which are not associated with moorlands and reversal can be difficult.
Do not leave bare peat surfaces through disturbance or on blocks	Bare peat can dry out and desiccate. If this occurs it is likely that it will remain bare: spoil from grip installation is still bare at some sites.
Trim overhanging vegetation, commonly heather	Overhanging vegetation prevents or slows vegetation growth in the grip (Holden et al., 2007a).
Engage with landowners & users to limit resistance	**Positive views:** • Increase the area of standing water for grouse to drink from. • Increase the area of wet ground for insects to inhabit that grouse feed on. • Provide ‘bridges’ across grips for young grouse and livestock, thus reducing death rates. • Turves and bales could make it easier for lambs or grouse to climb out of grips. **Negative views:** • Increase land wetness leading to a reduction in heather & therefore grouse numbers. • Concerns that lambs will become trapped in grips, especially given the smooth vertical faces of plastic piles and wooden dams.

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6. Summary of conclusions

- For water quality objectives, gripped areas should be prioritised for blocking based on colour levels, percentage of catchment gripped, soil type, vegetation type, slope and grip condition, morphology and density (as per Table 1).
- The grip blocking technique decision tree should be used, along with the additional guidance notes in Table 2, to plan grip-by-grip blocking during an on site survey.
- Where circumstances are appropriate (according to Table 2) peat turves are the recommended block type.
- Blocking should be carried out at 10 metre intervals, except on steep slopes or grips that carry a large volume of water, where the interval should be reduced to 5 metres.
- Where grips are located on longer slopes with some gradient, those upper most should be prioritised for blocking as these will affect the whole down slope area.
- There is no need to block shallow grips that show no evidence that the water table is above the base of the grip (this should be tested on a wet day).
- Capability of contractors should be considered when planning grip blocking.
- Site specific issues, including timing, working practices and the needs of land managers or tenants, must also be taken into account to ensure any grip blocking strategy is successful.

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Appendix – Photos from UK wide survey

Example of peat turve dam, with redistribution of water to form a pool next to grip

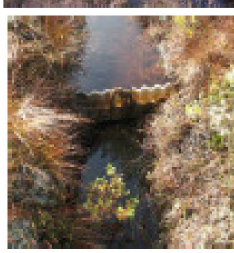
Peat turve dam constructed above height of surrounding land

Example of plastic piling dam

Example of plastic piling dams on steeper slope

Example of plastic piling dam with notch

Example of wooden dam with plastic sheeting



Example of corrugated plastic Perspex dam

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