Sussex Flow Initiative
River Ouse

RESTORING WOOD IN WATERCOURSES FOR NATURAL FLOOD MANAGEMENT

The Wildlife Trusts Sussex Wildlife Trust

Woodland Trust

Environment Agency

INTRODUCTION

Natural Flood Management (NFM) provides simple, natural solutions to reducing flooding using a range of practical techniques. One NFM technique is the strategic placing of Large Woody Debris (LWD), or leaky dams in watercourses, to slow the flow during heavy rainfall events. In the right places leaky dams can provide a cheap and easy way to reducing flood risk, when applied at a landscape scale. There are thousands of hectares of woodland and other natural habitat where leaky dams can easily be used to facilitate the temporary storage of flood water, with no risk of increasing flooding to homes. This helps to increase the drought resilience of the countryside, as well as reducing the amount of flood water reaching houses downstream.

This guidance manual gives examples of the types of leaky dams at the more natural end of the spectrum. These more naturalistic structures can be absorbed into the countryside with minimal impact, as well as:

- Improving water quality and reducing sedimentation in streams
- Providing instream habitat and promoting new habitat formation
- Kick starting natural processes to restore more natural stream habitat
- Increasing drought resilience by holding back more water in the landscape

The advice in this manual is drawn from local experience, advice from leading NFM projects, and existing NFM resources/publications. Rather than duplicating this informative work (see 'FURTHER READING') this manual is a guide to the practical delivery of LWD in 'ordinary watercourses'[1]. NFM work on smaller watercourses and in rural areas away from human infrastructure is inherently less risky than placing leaky dam on main rivers, where the consequences of a structure 'blowing out' or causing additional flood risk are much greater. Leaky dams can be installed at a relatively high density in these smaller streams. They are easy to adjust or remove if needed, and enable us to slow and remove large volumes of water before it reaches larger rivers.

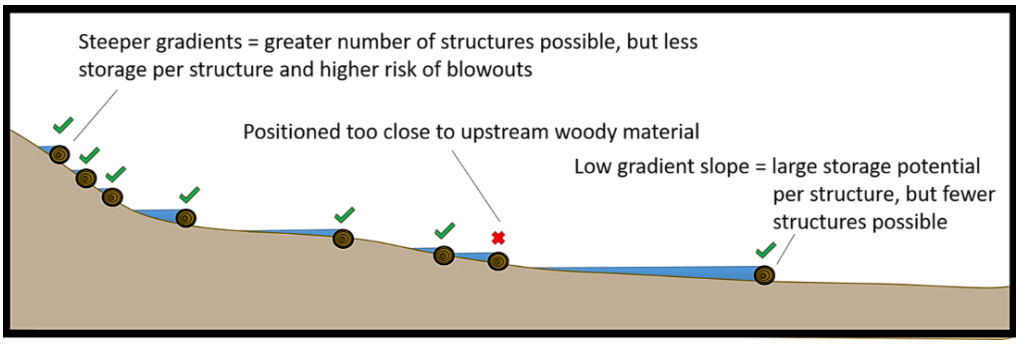
Large woody debris installed in a woodland stream in Gloucestershire as part of the Stroud Rural Sustainable Drainage project.

[1] Ordinary Watercourses may be on private land but are under the jurisdictions of Lead Local Flood Authorities, (usually local Councils) and consist of minor watercourses such as streams, ditches etc..
'Main River' is jurisdiction of the Environment Agency. www.gov.uk supplies 'main river' maps for the UK.

GENERAL GUIDELINES

Here are a few practical guidelines that you can follow to ensure that your leaky dams are a success:

1. Be aware of your local stream conditions during both low, high and flood flows. Water levels can vary greatly in different seasons, and you may need to secure the LWD more than you think.
2. Leaky dams will have water pushing against them from upstream, and may also float upwards during a flood. Take into account both these water forces when planning how to fix your leaky dams in place.
3. Never create an impenetrable dam – all dams should allow low/normal flows to flow underneath. Non-permeable dams have a much higher risk of being blown out by floods, and can have negative impacts on local habitat and wildlife such as migrating fish.
4. Where possible, use locally harvested natural (woody) material, preferably from site. This is better for wildlife, is more sustainable, reduces the chance of introducing non-native invasive species or diseases, and significantly reduces cost and effort.
5. Always apply for Ordinary Watercourse Consent prior to your work, with your Lead Local Flood Authority. N.B. apply at least 12 weeks prior to the anticipated practical delivery, there will usually be a fee.
6. In general do not place LWD on watercourses with gradients of greater than 30° – the fast flow of these streams is likely to blow out your structures too easily during flood events.
7. Check if your site is a protected site, such as an ancient / ghyll woodland, Site of Special Scientific Interest, or it has sensitive archaeology. Liaise with appropriate organisation to gain legal consent if needed.
8. Avoid or limit the use of LWD within 30 m up and downstream of any bridge, footpath, culvert or road. This largely removes the risk of flooding or damage to these structures.
9. In gradients of less than 5-10°, be aware that water may back up for longer distances behind your leaky dams (which will affect the spacing of your dams i.e. you will need a lot less).
10. Look out for natural 'mini floodplains'. These are some of the best places to use leaky dams, to help kick water out of the channel and therefore store more water during a flood.
11. Make dams look as natural as possible, and as minimally hazardous as possible by removing excess wood such as the top of stakes.
12. Locally harvested birch or heather can also be turned into brash bundles and used in place of logs.



Influence of channel slope on the installation and positioning of large woody debris.

TYPES OF LEAKY DAM

Depending on whether you are putting wood into a river, stream, ditch, floodplain or seasonal surface water flow path, your leaky dams will vary in design and size. The following are examples of naturalistic leaky dams that can be used on a range of different watercourse types.

BANKTOP DIVERTERS

These are effectively a large log or piece of woody material, laid across the top of a stream/ditch from one banktop to the other. Banktop diverters allow normal and low flows to pass under them, and only become active after heavy rainfall/flood flows, when the water level reaches bankfull. Once the water flows out of channel, the banktop diverter will hold water back behind it, and kick it out onto minor floodplains.

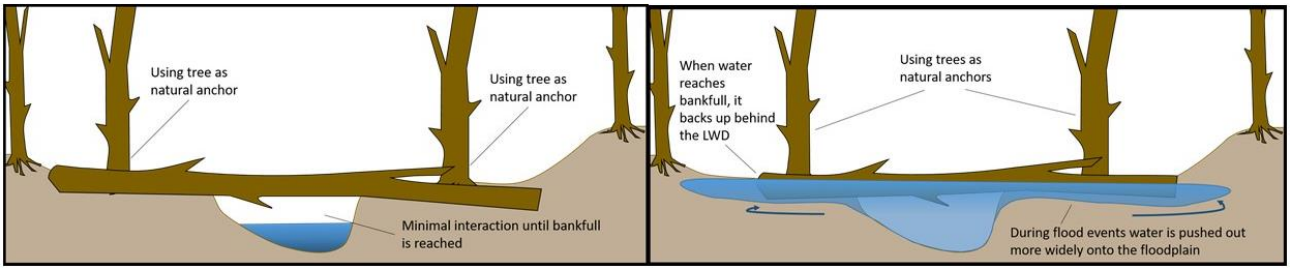


Figure 1: [Left] Looking downstream during baseflow conditions, a banktop diverter secured using standing trees. [Right] Looking downstream during flood conditions at a banktop diverter.

Specification

- Banktop diverters can be made from trees, logs or brash with a diameter of ><0.4m, and a length of at least 2x the channel width. Greater length and diameter are required for larger flows.
- Where possible, use living riparian trees as stakes, to hold the diverter in place on the downstream side (Figure 1).
- You can also use stakes made from local durable wood, such as alder or sweet chestnut. Stakes should be placed on the downstream side of the diverter. Locally harvested willow can be used as a living stakes.
- To prevent the diverter floating up and over the stakes, you can angle some stakes so that they point upstream and are hammered tight across the top of the diverter.

Figure 2: Rebar with a metal plate at one end, hammered through a log into the ground. A section has been removed from the log to ensure fixing is recessed (SFI).

- Alternatively hammer stakes in from both an up and downstream direction in a pyramid or cross shape across the top of the diverter. Where there are very large volumes of floodwater passing through the watercourse, metal rebar of >1.5m length can be hammered through a hole drilled in the log(s), a nut or plate welded on the top end of the rebar will secure the log (Figure 2).

Where to use banktop diverters - Where water levels regularly exceed bankfull during flood events, or where water can be backed up enough to do so. Otherwise the diverters will not influence water movement. Streams with intermittent or continuous small floodplains have the most benefits when using this method.

Figure 3: Multiple banktop diverters placed at intervals across the gradient of the floodplain to create continuous barriers, which slow flood water as it flows down the floodplain (Left: Stroud Rural Sustainable Drainage project (Stroud) and Right: SFI).

LEAKY DAMS

Leaky dams are similar to banktop diverters, with the addition of some wood within the channel. These dams help to create in-stream habitat and to encourage more diverse spatial patterns of flow and sediment. This style of leaky dam has minimal influence during low flows and allows fish passage underneath/through it.

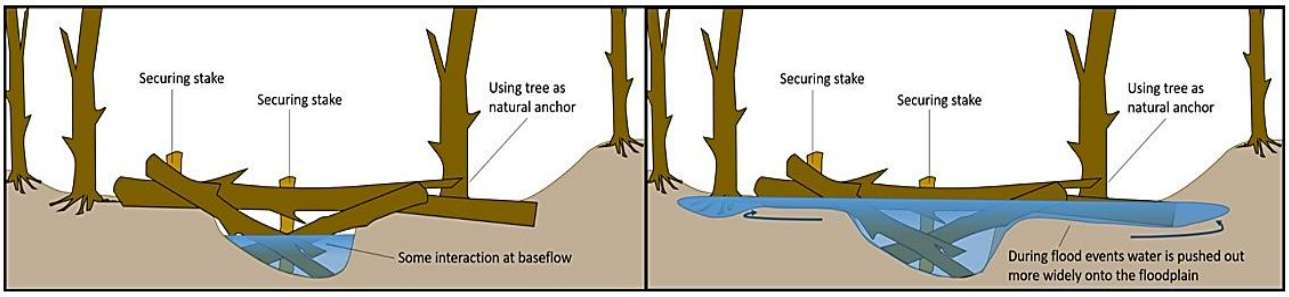


Figure 4: [Left] Looking downstream at a leaky dam during base flow conditions. [Right] Looking downstream at a leaky dam, during conditions which would not usually result in out of bank flow.

Specification

- Stake a log, brash bundle or other large woody material across the bank top (see banktop diverters for more information). Below this banktop log, create a cross-shape using at least two interlinked logs on upstream side of the banktop diverter.
- Drive logs at angles into the stream bank/bed to secure them into the channel. Creating a pointed end to the log will make them easier to drive into the earth, this works best into hard substrates.
- Stake the whole structure at either end, on the downstream side. Use living riparian trees as living stakes where possible. Generally, the higher the dam, the further upstream water will back up during a flood.
- If additional storage capacity is needed, raise the height of the dam by stacking and securing logs or brash bundles on top of each other.
- Drive in an additional stake in the middle of the channel, again on the downstream side. This supports the weight of the water held behind the structure during floods.

Where to use leaky dams - Particularly on minor watercourses that have been deepened or ditched. These dams encourage more water to be pushed up and out of the channel onto the floodplain, and encourage natural processes to kick start natural restoration of the channel.

Figure 5: [Left] Looking downstream at a banktop diverter with a cross-shape within the channel. Pinned using rebar and riparian trees. [Right] Looking upstream at the same leaky dam during high flow conditions (SFI).

Impacts on sensitive floral communities*: such as ghyll streams. Creating a leaky dam can result in areas becoming submerged more frequently, which although temporary, can have detrimental impacts on certain sensitive plant communities. If you decide to use woody material in ghylls, aim for it to be highly permeable, to use all natural materials harvested from the adjacent woodland, and not to create too many gaps in the canopy which would allow extra light into the woodland (thus reducing the natural humidity of these woodlands).*

TREE-HEAD DAMS

One of the most naturalistic ways of using wood for NFM, is to fell entire trees into the watercourse. In addition to slowing the movement of water by increasing in-channel roughness and catching other woody and leafy material, this technique will also help to increase habitat diversity, create more diverse flow patterns, and provide shelter for fish and invertebrates. Trees which are 'live hinged' can carry on growing, providing additional resistance to flood water, as well as a living structure.

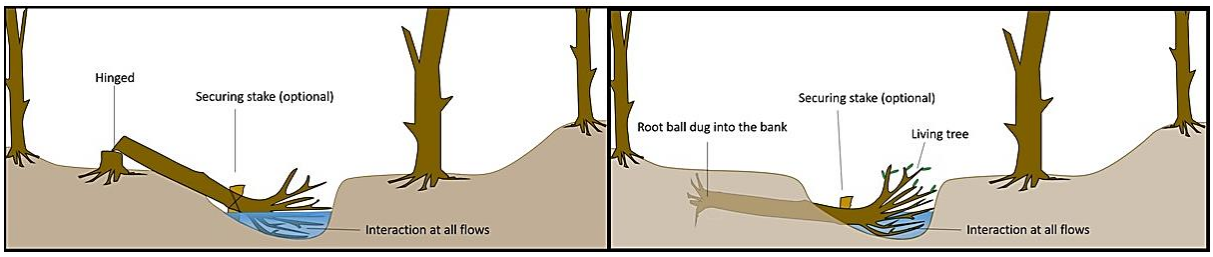


Figure 6: [Left] Looking downstream at a hinged tree with its head positioned in the channel. [Right] Looking downstream at a tree head dam, whose root ball has been excavated and buried in the steam bank.

Specification

- Fell and lever the entire tree partially or entirely into the watercourse from the riverbank, with the branches facing either upstream or downstream. Fell with :
    - no hinge so that the tree is detached from the stump (requires staking of the trunk), or
    - a hinge to enable the tree to carry on living, and to naturally secure it to the bank.
- Secure the head of the tree (main branches) and the trunk, with stakes made from local durable wood. For larger dams, use rebar as described previously.
- Stakes securing the tree should be on the downstream side, angled so the top of the stake is pointing upstream and >0.1m above the top of the felled tree.
- Large branches of willow and similar species can be hammered into banks to mimic this dam type on a smaller scale. Willow may root and grow, whilst other species will create dead wood dams.
- Where stream flows are unlikely to erode vulnerable banks, large logs or entire rooted trees/shrubs can be dug into the bank and pinned. Minimise bank disturbance. Where excavations are necessary they should be backfilled, consolidated and compacted to reduce bank erosion.

Where to use tree head dams - Tree head dams and tree hinging are some of the most secure forms of leaky dams, and can be used in many situations. Trees can be angled with the flow, against the flow, across stream banks, or to fully or partially block the watercourse. This type of LWD also helps to deflect/channel water into temporary storage areas (floodplains, ponds). In large flows, the stream is likely to erode around the tree-head dam, so consider carefully whether your site allows this to occur.

Impact on infrastructure: *Ensure that any large log material is well staked and secured to resist being mobilised during flooding. The damage which can be caused by a floating tree trunk is significant if it becomes a blockage of a bridge or culvert, and it can exacerbate flooding locally.*

GULLY STUFFING

Gully stuffing can be done in-channels with logs and brash or brash bundles. Wood is placed longitudinally with the flow, to slow the flow of water, and to trap sediment and other floating leaves and brash. The wood interacts with water in the channel from baseflow to bankfull (depending on the height to which the channel is 'stuffed'). Although gaps allow water to filter slowly through and around the dam, this happens slowly, so water is backed up behind the wood encouraging it more frequently out of channel/bank. Gully stuffing is best used in grips and ditches, and in straightened sections of minor streams where it helps to encourage greater sinuosity and channel diversity.

Figure 7: [Left] Gully stuffing in a flowing stream (SFI). [Middle] Brash bundles in a low lying woodland ditch (SFI). [Right] Gully stuffing in a steep, seasonally wet flow path (Stroud).

Specification

- Place logs, branches, brash or brash bundles into the channel, with their ends facing into the flow. Logs/brash length should be > 2x the channel width.
- Choose whether you need to secure gully stuffed material in the channel. The weight of logs and complexity of brash enmeshment can often be enough to withstand the forces of floodwater. However if needed, it can be pinned through the middle or from the sides with stakes, or secured with stakes at the downstream end.
- Trees can be felled and rolled longways into the channel as partial 'gully stuffs'.
- The gully stuffed wood needs to be dense enough and sit tight enough in the channel to resist the forces of floodwater in the stream without moving. Other in channel and bankside trees or a varied stream morphology (e.g. narrow valleys, tight meanders) downstream helps prevent any brash which floats loose during flood events from being carried too far downstream.

Where to use gully stuffing **-** Gully stuffing is best used in watercourses or channels which are low flow, stillwater, or dry for the much of the year. Ditches and grip drains in heathlands and woodlands are great locations for gully stuffing.

Impact on migratory fish. Gully stuffing creates at least a seasonal barrier to fish movement if placed in flowing streams. Also take care when working in areas with **sensitive floral communities**, for example in ghyll streams. If LWD is used in these locations, it should aim to be highly permeable. Be aware **water will often erode or scour** under the gully stuffing – this may not be desirable in some locations. Do not gully stuff any ditch or drain which you know is essential for surface water or flood drainage.

FLOW PATH INTERCEPTORS

We often think of slowing the flow only where we can see water permanently flowing. However, there are myriad locations in the landscape where flow pathways are activated across the land surface every time it rains. Using brash bundles or logs positioned perpendicular to overland flow pathways is a quick and easy way of slowing the delivery of this water to nearby streams, and spreading it across the land surface. Flow pathways can often be identified even during dry weather by looking for areas where leaf litter has been disturbed by running water, or where patterns in the surface of the soil show evidence of water flow or erosion. These structures are active only occasionally, when they intercept surface water run-off during heavy rainfall.

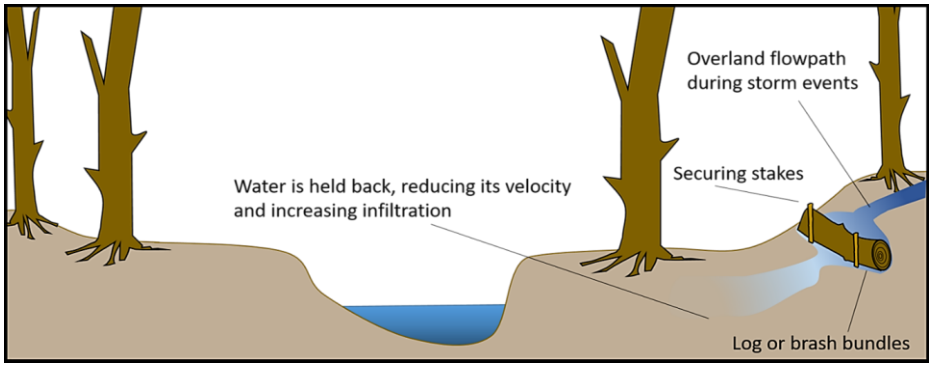


Figure 8: A flow path interceptor slowing the movement of overland water flow and increasing infiltration.

Specification

- Find a flow path, and secure a natural woody barrier directly across the flow pathway. This splits and slows the flow, spreading water through and around the leaky dam.
- The interceptor can be a log and/or brash bundle used as a (leaky) barrier. It should be secured in position - unless the weight of the log is sufficient to resist the flow of water.
- The interceptor should be at least twice the width of the flow path.
- Multiple barriers can be placed along one flow path, particularly in steeper gradients.

Figure 9: [Left] Log placed across flow path – note how water pools and spreads behind it (Stroud), [Middle] brash bundles across an overland flow path in woodland (SFI). [Right] brash bundle pinned across an overland flow path in pasture (SFI).

Where to use flow path interceptors **-** Particularly useful in woodlands. They can also help to reduce erosion and the formation of gullies on footpaths and tracks. Flow path interceptors can be used anywhere that there are signs of overland water movement. Partially buried log or plank deflectors can also be used to channel water across tracks/paths into adjacent woodland/vegetation.

CONSENT

Within England, the installation of LWD requires permission from the relevant authority.

For 'Ordinary Watercourses', consent should be sought from the Lead Local Flood Authority for permanent works, it maybe possibility to gain a single consent for multiple leaky dams for a single site.

For 'Main River watercourses' the Environment Agency must be contacted and permission sought from the local Flood & Coastal Risk Management Officers, in your regional Partnerships & Strategic Overview team.

Type of woody structure	Consent required?
Banktop diverter	✓
Leaky dam	✓
Tree-Head Dams	✓
Gully stuffing	✓
Flow path interceptor	✗

USEFUL TOOLS & MATERIALS

Taking the right tool and the minimum amount of kit needed is particularly important, as leaky dam locations can be difficult to access and generally remote. The following are useful tools and materials:-

- Camera (for before and after pictures) and GPS locator (for recording the Grid references of leaky dams).
- Bilhooks and sharpening stone for putting points on stakes and trimming trees/branches.
- Loppers and bowsaws for coppicing/felling material for leaky dam.
- Lump hammer and/or Mel for driving in large and small stakes
- Crowbar, or alternatively hand harvest a wooden pole on site to help lever wood into place.
- Timber tongs and felling lever for lifting and moving timber into place.
- Mattock and/or spade, if you want to dig dams into the bank.
- Hand drill, or for larger logs, petrol drill, and drill bits.
- Stakes and logs (if not possible to make from wood onsite). Brash bundles (pre-made and delivered to site). Local woodland groups can make both stakes and brash bundles. Ensure they are made with biodegradable natural cordage, and are sustainably / locally sourced.
- First aid kits and PPE, such as hard hats, protective gloves and spill kit.

Figure 10: Volunteers undertaking leaky dam work, ensure you have plenty cake (SFI).

FINDING CONTRACTORS

It can help to recruit contractors to carry out leaky dam work, particularly where project staff have limited time for delivery. There are myriad opportunities to install LWD in the wider countryside. Leaky dams work best at a 'landscape saturation' level – a greater number of leaky dams across the landscape have greater cumulative benefit, with less flood water is delivered to our streams and rivers.

The installation of woody material in rivers can be a relatively straightforward process. However, project managers should ensure that contractors are supervised during installation, or have a detailed specification including photographs and diagrams of the leaky dam types required. We recommend running training days to train up local contractors and landowners to deliver this work.

Figure 11: Contractors undertaking leaky dam work, utilising riparian trees as material for the leaky dams and as living stakes (Wild Sussex).

What to look for in contractors?

Essential:

- Chainsaw tickets (minimum of NPTC 201/202/203: Chainsaw Maintenance, Cross-cutting and Felling Small Trees).
- Appropriate level of insurance cover.
- Experience of delivering LWD work (ask to see examples of the kind of woody debris they have installed) or willingness to be trained.
- Able to create secure, LWD structures which look naturalistic and not highly engineered.

Desirable:

- Experience of working on conservation projects or an appreciation of the importance of minimising undesirable disturbance.
- A good understanding of land drainage, flooding and water movement.
- Awareness of wildlife considerations and laws.

FURTHER READING

CREW. The effect of natural flood management in-stream wood placements on fish movement in Scotland.
Available: https://www.nfm.scot/sites/default/files/NFM_fish%20movement%20v2.pdf

Forest Research. Slowing the Flow at Pickering
Available: https://www.forestresearch.gov.uk/research/slowing-the-flow-at-pickering/

Robinwood. Evaluation of Large Woody Debris in Watercourses
Available: http://www.robin-wood.eu/uploads/robinwood_flood.pdf

SEPA. Natural Flood Management Handbook
Available: https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf

Stroud District Council. Natural Flood Management
Available: https://www.stroud.gov.uk/environment/flooding-and-drainage/stroud-rural-sustainable-drainage-rsuds-project/natural-flood-management

The Woodland Trust. (2014). Holding back the waters – woodland creation and flood mitigation. Search Holding back the water at www.woodlandtrust.org.uk

The Woodland Trust. (2014). Stemming the flow – the role of trees and woodland in flood protection. Search Stemming the flow at www.woodlandtrust.org.uk

The Woodland Trust. (2016). Keeping Rivers Cool – creating riparian shade for climate change adaptation. Search Keeping Rivers Cool at www.woodlandtrust.org.uk

Thomas, H. and Nisbet, T.R. (2012). Modelling the hydraulic impact of reintroducing large woody debris into watercourses. Journal of Flood Risk Management 5 (2): 164 – 174.

Welton, P and Quinn, P. (2011). Runoff Attenuation Features: A guide for those working in catchment Management. Belford Catchment Solutions Project.

Wildlife Trust. Managing woody debris in rivers, streams and floodplains.
Available: https://www.therrc.co.uk/MOT/References/WT_Managing_woody_debris.pdf

Wild Trout Trust. Use of large woody debris. The Chalkstream Habitat Handbook.
Available: https://www.wildtrout.org/assets/files/library/Large_Woody_Debris.pdf

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For further information, help or advice please contact us at

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