Natural England Commissioned Report NECR140

New Forest SSSI Geomorphological Survey Overview

Annex G: Roe Inclosure South Restoration Plan - SSSI Unit 117

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1 Roe Inclosure South Restoration Plan - SSSI Unit 117

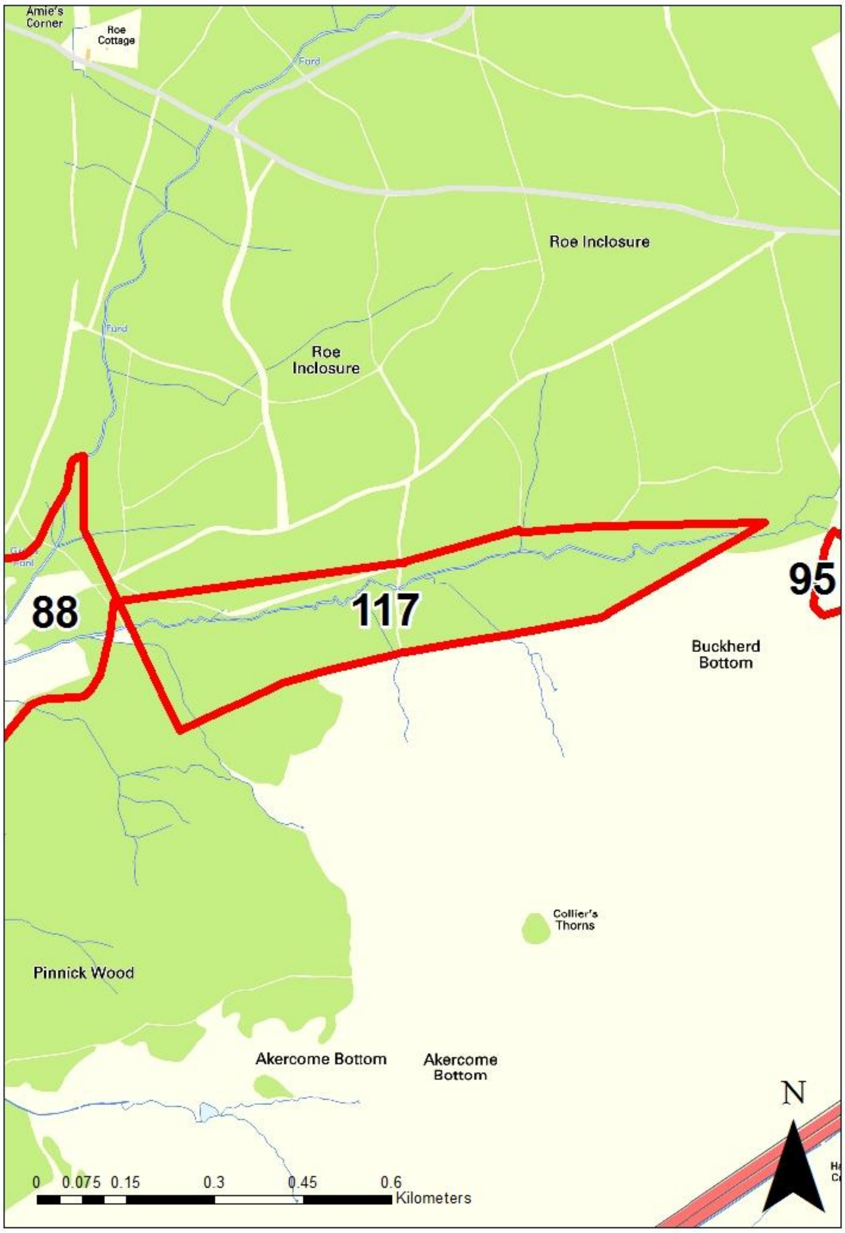
1.1 Introduction

Roe Inclosure South (Unit 117) is one of the tributaries feeding the Linford Beck in the downstream SSSI unit 88 (Figure 1-1). The SSSI unit is considered to be in an unfavourable recovering condition. It is approximately 15.78ha in size.

The unit consists predominantly of conifer plantation, with some semi-mature oaks.

It is essential that incision in the downstream 88 SSSI Unit (Linford Beck) is also mitigated as any works undertaken with Unit 117 risk being compromised in the future if this is not undertaken. It is also important that incision within this unit is managed to reduce the risk of continued upstream incision propagation impacting Unit 95 upstream.

Figure 1-1: SSSI Unit 117 location (flow direction is right to left)



1.2 Current hydromorphic conditions and issues

A summary of the hydromorphic conditions of Unit 117 is given below in Table 1-1.

Table 1-1: Hydromorphic conditions of unit 117

Geomorphological Assessment Area		Roe Inclosure South
Site Name		Roe Inclosure South
Size (ha)		15.8
SSSI Unit(s)		117
Channel Condition	River type (s)	Active single thread, mild wandering in some locations
	Responsiveness	Moderate - moderate gradient, straightening, strong gravel supply, tree clearance (historic), flow regime alteration (drains)
	Sediment delivery, type and mobility	Strong upstream local gravel supply, gravels in banks
	Main source of water	Upstream source (Bratley Plain) and drains
	Aquatic vegetation	No in-channel vegetation present
	Drainage damage	Drains over both banks incised, straight and embanked
	Morphology	Vegetated bars, limited gravel features due to incision, mid-channel bar upstream has caused local widening
	Incision	Yes - heavily incised throughout including drains, up to 3m upstream, reaction to straightening and embankments
	Engineering	Channel straightening. Dredging. Embankments. Bridges.
	Bank activity	Moderate with some lateral activity (maybe more sinuous than OS map suggests) a lot of bank collapse associated to incision
	Flow type (s)	Flows impacted by upstream and local drainage network. Flood peaks concentrated in channel due to level of incision
Floodplain Condition	Valley type	Wide floodplain
	Main source of water	Drains / overland flow, out of bank flows
	NVC communities	None (Plantation woodland)
	Key habitat types	Mixed plantation woodland, Coniferous plantation woodland
	Drainage	Embankments on bank edge of main channel and drains where previously dredged / straightened. Natural drainage impacted through artificial drainage network
	Scrub / tree encroachment damage	Plantation woodland, some felling has occurred
	Palaeo features	Difficult to identify on site due to accessibility
	Floodplain connectivity	Poor - incision has significantly reduced floodplain connectivity
	Poaching and grazing Pressures	Little
Generic restoration options		Re-meander if LIDAR identifies palaeo channels. Manage incision through debris jams, embankment removal on main channel and drains, consider filling in drains

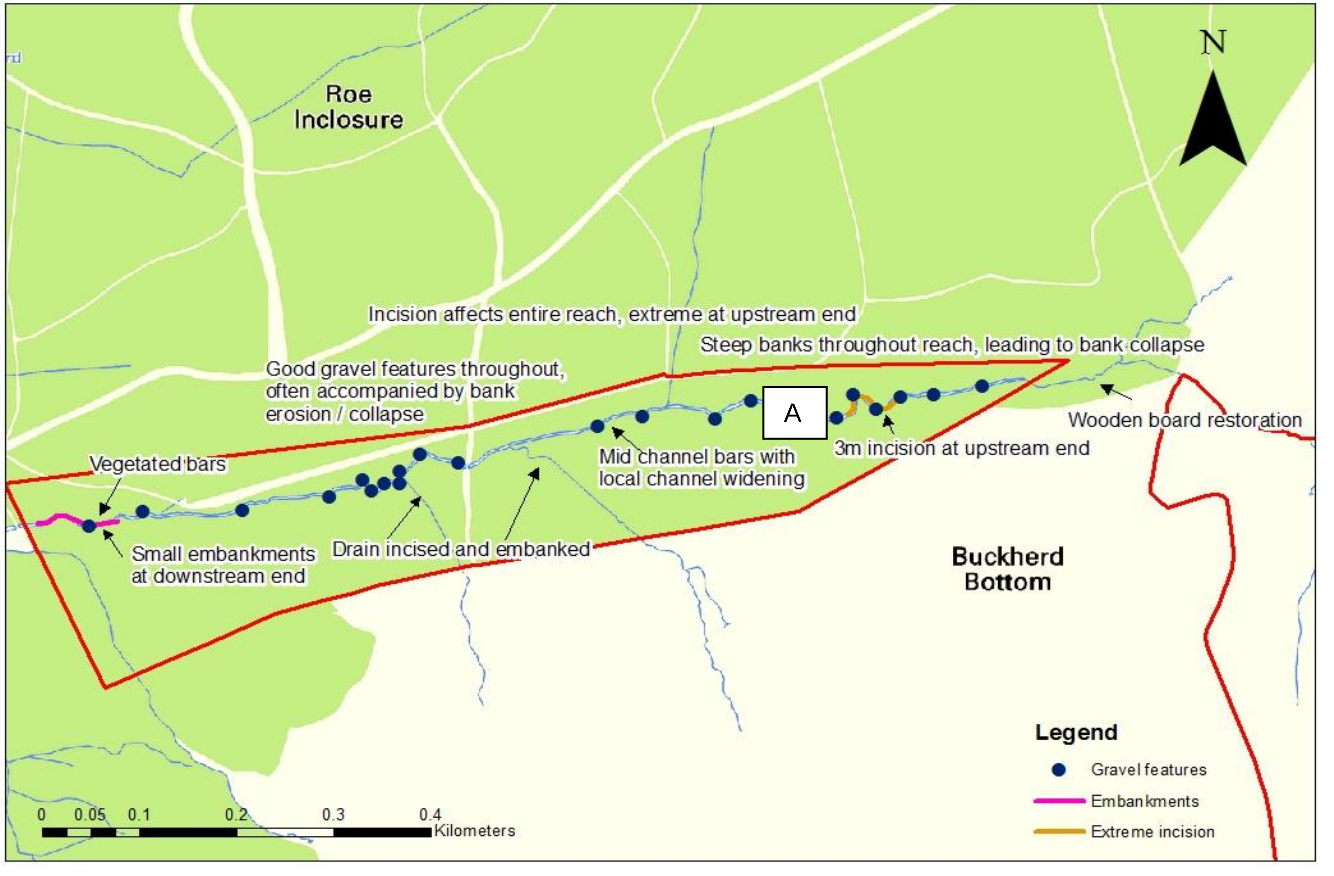
The stream within SSSI Unit 117 is an active single thread channel with strong gravel inputs (Figure 1-2). Some reaches are accumulating significant gravels shoals (Figure 1-3).

Figure 1-2: Active single thread channel characteristics

Figure 1-3: Gravel shoal development in some locations

The stream provides an important source of gravels for downstream Unit 88 (Linford Beck). The source of the stream is SSSI Unit 95 at Bratley Plain. Figure 1-4 summarises the existing hydromorphology and pressure impacting unit 117.

Figure 1-4: Current hydromorphic conditions and pressures



The stream has a moderate gradient and has been subject to channel straightening in the past. Straightening of the watercourse has occurred and this has had a profound effect on the nature and functioning of the river. The length of watercourse will have been shortened leading to a steepening of the system and the associated dredging will have over-deepened the channel. This in combination will have increased flood shear stress levels promoting erosion (Figure 1-5).

Figure 1-5: Bank erosion common along reach

Where the channel banks are stronger (due to the presence of more resistant boulder clays rather than fluvio-glacial gravels or where riparian woody vegetation is dense enough to provide a coherent resistant root mat) erosive energy will have been concentrated into vertical incision into the bed leading to an over-deep channel. Where the banks are less resistant (due to tree clearance, presence of gravels etc.) lateral erosion will also have occurred. This is evident in the more wandering sections. Often in rivers with moderate to high energy, lateral erosion and widening is also associated with bar deposition concentrating flows around gravel shoals and promoting further lateral activity (Figure 1-6).

Figure 1-6: Bar growth with associated channel widening and some evidence of colonisation by vegetation

The initial impact of straightening would have been incision along significant lengths of the wooded watercourse (Figure 1-7) and channel widening across areas with erodible banks. This initial incision episode is likely to have caused the knick point development moving through the tributary / drain systems (Figure 1-8).

Figure 1-7: Upstream incision levels

The result of poor floodplain connectivity and the modified flow regime, in a responsive river type, has been vertical incision. Ditching of the upper catchment (Figure 1-4 - A) will have impacted on the flood flow regime of the watercourse creating a more responsive system where flood peaks are concentrated and increased and water enters the main channel more efficiently. The degree of artificial drain creation is shown in Appendix A and is impacting significantly on the flow regime. This effectively creates a higher energy system more capable of erosion and sediment transport.

More locally the incision will be followed by in-channel deposition as gravels are dropped in lower energy zones during flood recession. Significant shoals will then influence channel hydraulics upstream, reducing the water slope and promoting more deposition. This 'cut and fill' activity is evident along the stream with fill zones characterised by plane bed, shallow gravel reaches and more local gravel shoals and bars causing local lateral erosion. This pattern is often repeated over time as gravels are re-eroded and re-deposited along the system and this will in turn have generated successive knick-points along the tributary / drains.

There has been incision up to 3m (from bank top to stream bed level) in the upper reaches of this unit. Erosive energy is contained within the banks rather than spread across the floodplain at higher flows resulting in bed erosion. This creates oversteep banks that are prone to collapse through undercutting, as well as further reducing floodplain connectivity. This is exaggerated in some locations by the presence of embankments on the bank tops. As a result of incision in the stream, connecting drains are also incised in some locations, and in many cases incision within the drains is also impacted by embankments on the bank edge of the drains (Figure 1-8).

Figure 1-8: Some incision in left bank drain, with embankments

Groundwater levels have also been altered as a result of the incision, infilling and spoil dumping (embankment creation). Sections of the immediate floodplain have become drier than natural.

Gravel supply (there are significant gravel sources within the river banks locally) is strong and this, combined with flow regime alterations through surrounding drains, as well as historic tree clearance, give responsive channel conditions.

The strong supply of gravels has resulted in significant gravel feature growth within the channel in the form of mid channel bars, lateral bars, transverse bars and point bars (Figure 1-3 and Figure 1-6). Some of the bar features have stabilised and vegetated in places (Figure 1-9). Poor connectivity with the floodplain means that the pattern of erosion and deposition is exaggerated (as a result of incision and embankments) meaning gravel feature growth has been enhanced locally in areas where widening can readily occur.

Figure 1-9: Bar vegetative colonisation

Natural woody debris features are also evident along the channel, which have often been created as a result of local bank erosion / collapse (Figure 1-10). These create short lengths of impounded watercourse that does improve floodplain connectivity significantly. These provide useful analogue features for the restoration plan.

Figure 1-10: Natural woody debris jams

In the upper reach of this unit, wooden boards have been installed in the channel (Figure 1-11), presumably to try and manage the incision to prevent it migrating upstream and impacting Unit 95 which is a mire. Some of these have failed (Figure 1-12) and others remain intact (Figure 1-13).

Figure 1-11: Wooden board incision management

Figure 1-12: Failed wooden boards

Figure 1-13: Pinned log and staked bail restoration

Significant palaeo channels have been identified in Figure 1-15 and show where reconnection could be possible through some of the proposed restoration measures in Table 1-2. These have been identified from the audit and supplied LIDAR. Reconnecting these whilst maintaining the existing channel will encourage anastomosed network development.

1.3 Probable channel development

The process of adjustment to the channel straightening, dredging, flow regime alteration and floodplain vegetation disruption is continuing despite the historic nature of many of the changes. As such the river remains highly responsive in nature.

The river can also be said to be recovering in the sense that it has now created a diverse hydromorphology consisting of locally sinuous channels through what were straightened single thread reaches with an associated mix of pool, riffle, plane bed, point bar, mid-channel bar, lateral bar, transverse bar, gravel morphology and significant woody debris induced features. The nature and distribution of these features is however likely to alter significantly over the next decades as the large scale erosion, transport and deposition patterns change.

Similarly, the impacted tributary / drain systems are responding to a series of knick points along their courses and themselves display multiple cut and fill sequences. Alterations to the stream will not impact on the current knick points.

The vertical incision risk to the upstream mire Unit 95 has been minimised through recent restoration measures including wooden boards, log pinning and staked bails.

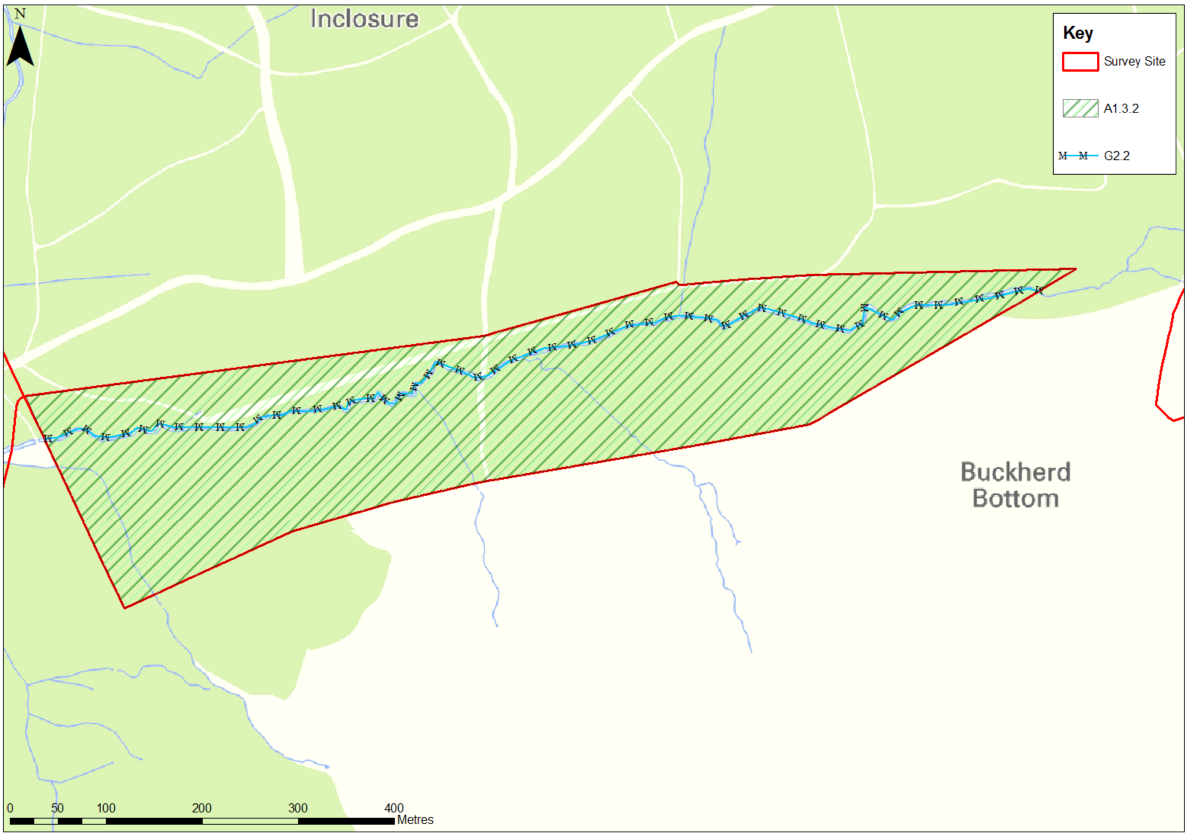
1.4 Current ecological conditions

The unit consists predominantly of conifer plantation (Corsican Pine *Pinus nigra maritima*, with extensive Norway Spruce *Picea abies* in the understorey), with some semi-mature Oak *Quercus robur*. The ground flora is species poor with frequent large stands of Bracken *Pteridium aquilinum*. Where the canopy is more open, adjacent to the stream, there are some small areas of wet, rushy heath, with Soft Rush *Juncus effusus* abundant.

At the time of the site walkover survey there was no aquatic vegetation present within the channel. Some patches of Rhododendron *Rhododendron ponticum* were recorded on, and adjacent to, the banks of the stream.

Figure 1-14 shows the Phase 1 Habitat Map for Unit 117.

Figure 1-14: Phase 1 Habitat Map



1.5 Restoration plan proposals

A summary of the current pressures, unmitigated impacts and restoration proposals is given in Table 1-2 and shown in Figure 1-15.

The key hydromorphological and ecological gains associated to the proposed restoration measures are:

- Palaeo channel reconnection, alongside embankment removal and incision management creating improved morphological features;
- Improved anastomosed channel network development will improve hydromorphological diversity;
- Better floodplain connection through water level raising and artificial drain restoration;
- Improved in-channel habitat and mire and heath restoration.

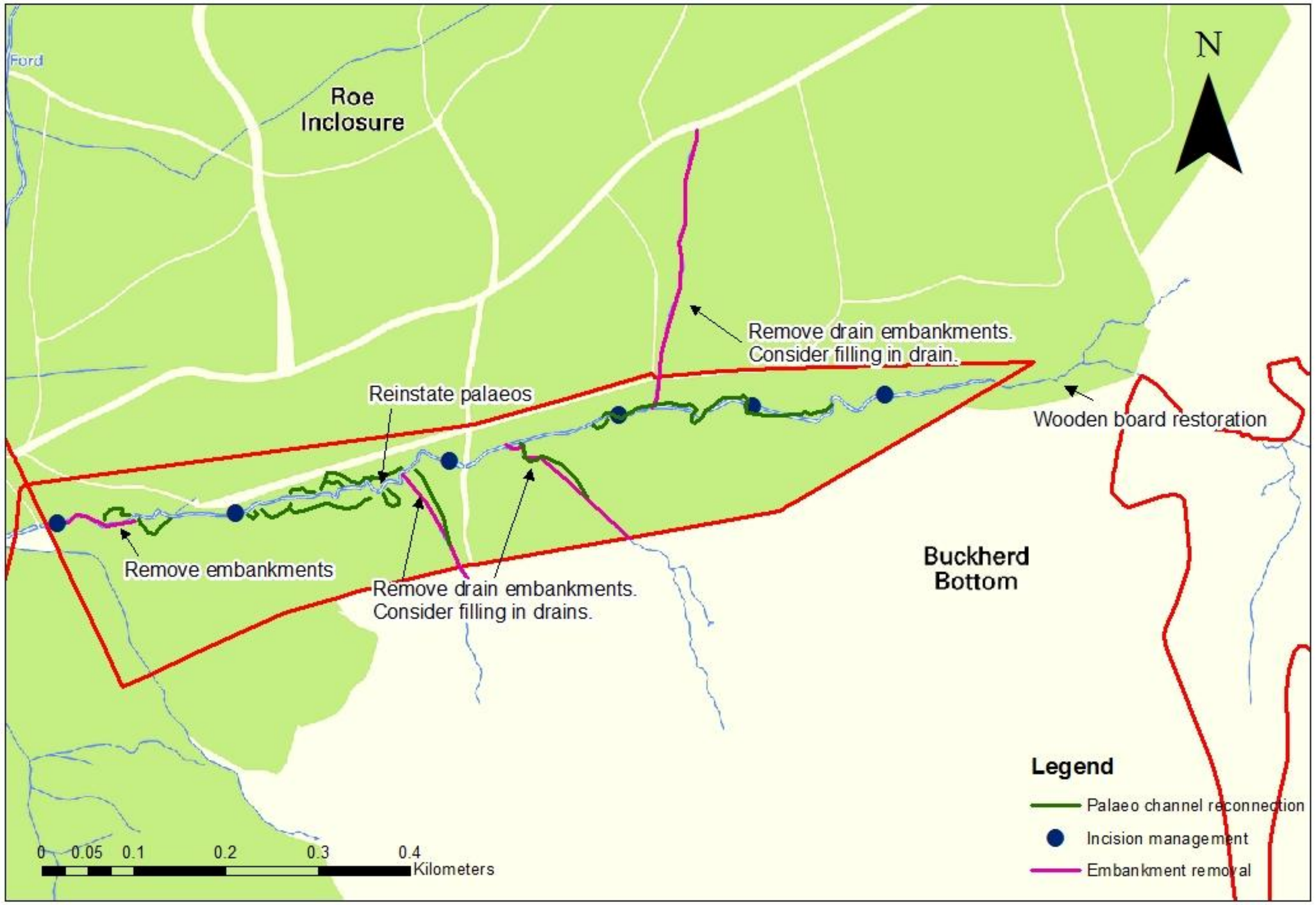
Table 1-2: SSSI Unit 117 proposed restoration measures

Pressure	Impact	Restoration proposal	Hydromorphic improvement	Ecological improvement	Constraints / issues
Straightening	Long term river response, cut and fill activity. Enhanced in-channel energy levels. Disconnected sub-channels. Loss of in-channel features.	Palaeo channel reconnection Infill. Restore in-channel morphology. Restore connectivity. Treat knick points.	Reinstate some channel length lost through straightening - helping to reduce incision. Encourages anastomosing channel development. Reduces fine sediment inputs. Slows gravel movement. Stabilises in-channel features.	Promotes a greater diversity of features within the channel. Restores connectivity with floodplain and promotes the re-occupation of former channels recreating M29 Soakways. Promotes seral communities on revegetating bar features	Incision rate has meant reinstating the palaeo channels requires significant bed raising. Cultural objections.
Historic dredging Straightening	Long term river response, cut and fill activity. Enhanced in-channel energy levels. Disconnected sub-channels. Loss of in-channel features.	Incision management - debris jams, morphological restoration, floodplain works. Infill. Restore connectivity. Treat knick points.	Reconnecting the floodplain will improve in-channel hydromorphic condition and will reduce incision. Debris jams naturally occur along the reach, use local materials. Morphological enhancement to raise bed and water levels will help improve floodplain connectivity. Local floodplain works may be necessary to give sufficient connectivity. Encourages anastomosing channel development.	Improve diversity of in-channel and floodplain habitats. Opportunities to increase and/or provide new areas of wet heath. May require some felling of trees to allow light into the watercourse and along the margins. Prevent damage to mires upstream of the unit and raise water table on riparian strip, promoting colonisation by *Molinia* M25a mire.	Incision is severe in some locations, particularly the upstream end meaning significant works / features would be required to reconnect the floodplain. Debris jams may form a barrier to fish, however, their ephemeral nature mean that fish passes are unnecessary. Large amounts of material are likely to be required. Cultural objections

Pressure	Impact	Restoration proposal	Hydromorphic improvement	Ecological improvement	Constraints / issues
			Reduces fine sediment inputs. Slows gravel movement. Stabilises in-channel features.		
Embanking	Enhanced in-channel energy levels. Disconnected sub-channels.	Embankment removal - main channel and drains	Reconnect the floodplain, reducing incision rates and improving in-channel hydromorphic conditions. Drain embankment material could be used to infill drains. Slows gravel movement. Stabilises in-channel features.	Improve diversity of in-channel and floodplain habitats. Opportunities to increase and/or provide new areas of mire development in former mire areas. May require some felling of trees which will allow light entry and release	Drains may also require infilling to restore natural flow regime and reduce incision. Cultural objections Cost
Artificial drainage	High flows impacted. Water table lowered locally.	Drain infilling	Restore a natural flow regime, reducing incision in the drain and channel network. Reduces flood peaks. Reduces fine sediment inputs. Slows gravel movement. Stabilises in-channel features.	Improve diversity of habitats in and alongside the channel, including vegetating bars, riparian woodland and Soakways development.	May require import of material. Cost Cultural objections
Woody invasive species	Alters floodplain species assemblage. Impacts bank stability.	Non-native species control (Rhododendron and conifer species). Exterminate and allow natural regeneration / plant alder & willow.	Removal of conifer plantations would improve low flow hydrology and reinstate a natural drainage pattern. Creates riparian	Increased floristic diversity of ground flora on floodplain by allowing increased light onto the riparian zone. Restoration of wetland	Large-scale removal of conifer species is unlikely to be feasible or economically viable

Pressure	Impact	Restoration proposal	Hydromorphic improvement	Ecological improvement	Constraints / issues
			hydromorphic diversity.	habitats.	
Riparian vegetation removal	Loss of bank stability. Loss of shading. Loss of organic inputs to the watercourse.	Reduced tree clearance at bank edge. Selective felling of undesirable species Half-felling Ring-barking Replanting of native species	Will help to stabilise banks in the wandering sections and alongside bed restoration to minimise incision, could improve floodplain connectivity Creates riparian hydromorphic diversity. Acts as fine sediment trap. Allows woody debris accumulation.	Increased floristic diversity of ground flora on floodplain Increased light onto the riparian zone Creation of standing dead wood and other CWD including in-stream Restoration of wetland habitats.	Tree clearance is a necessity and desirable in some locations. Cultural objections Cost
Forestry	Significant impact on low flow regime. Flow quantity, quality, variability. Increases water temperature. Fine sediment dynamics Water table impacts.	Phased removal	Reduced risk of drying, improved hydromorphic diversity, lowered risk of in-channel fine sediment accumulation	Increased floristic diversity of ground flora on floodplain. Restoration of wetland habitats, especially riparian strip and associated mire habitats.	Large-scale removal of conifer species is unlikely to be feasible or economically viable Cultural objections

Figure 1-15: Proposed restoration measures for SSSI Unit 117



1.6 Design considerations

The channel is unlikely to completely stabilise as a result of re-routing the watercourse back through a palaeo channel that was once occupied, probably at a time when channel and catchment processes and pressures would have been very different from today. However, retaining the dynamism of the channel should be an objective of the restoration plan.

Palaeo-channel entrance and exit elevations must be carefully considered to avoid instigating uncontrolled instability.

The major straightened / modified drainage channels are identified in Figure 1-15. Other minor modifications could be considered for infilling and Appendix A should be used for reference.

Consideration should be given to undertaking incision mitigation works within this unit prior to or at the same time as works in the downstream Unit 88. Managing the stream energy with Unit 117 will alter the flow regime and hydraulics within unit 88 and any works in Unit 88 may be compromised if works are not undertaken in unit 117. Similarly, incision should be managed within Unit 117 to prevent further risk to the upstream Unit 95.

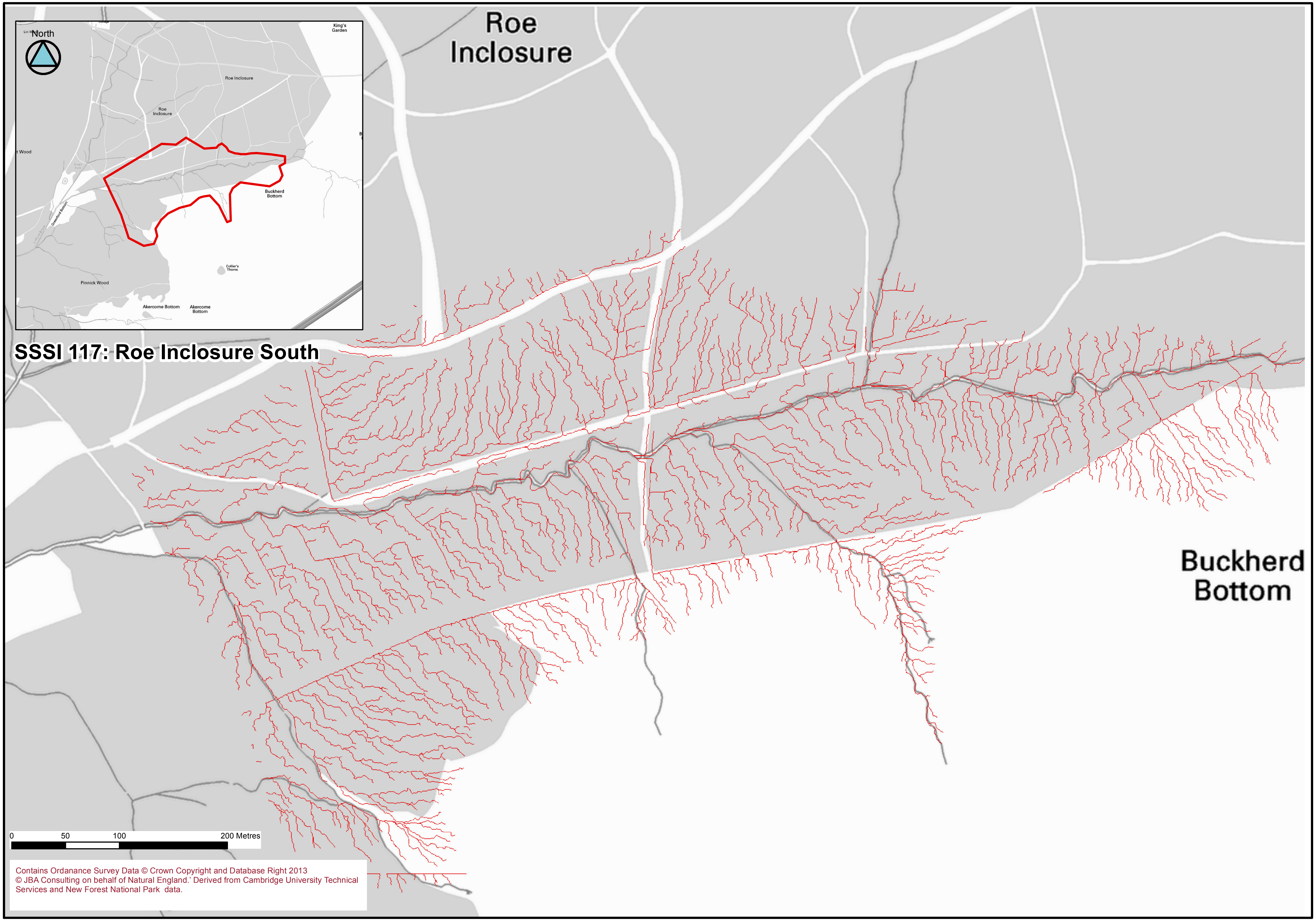
1.7 Restored channel and monitoring requirements

It is anticipated that the proposed restoration works will create a dynamic, sinuous channel with some anastomosed sections and improved floodplain connectivity, with frequent overbank flooding and a heightened potential for local channel switching in response to natural debris blocking. This pattern of development is difficult to document accurately due to the complex nature of the river network and the difficult surveying conditions. As such a qualitative monitoring approach is recommended with automated time lapse photography employed at key restoration points to record daily images of flow types, morphology and vegetation character. This could be undertaken alongside two-yearly reconnaissance audits to determine hydromorphological change over the entire reach, which fixed point photography will not cover. The daily photographic records should be analysed to estimate and record the parameters detailed in Table 1-3.

Table 1-3: Monitoring parameters, frequency and suggested approaches for the Unit 117.

<table>
<tr><th>Parameter</th><th>Approach</th><th>Frequency</th><th>Approximate cost</th></tr>
<tr><td>Morphologic unit change</td><td>Time lapse camera / audit</td><td>Daily (Annual statistical summary)</td><td rowspan="4">Capital 3 x £200
Half yearly downloading £200
Annual summary £300
Two - yearly reconnaissance audit £500</td></tr>
<tr><td>Flow change</td><td>Time lapse camera / audit</td><td>Daily (Annual statistical summary)</td></tr>
<tr><td>Sedimentology</td><td>Time lapse camera / audit</td><td>Daily (Annual statistical summary)</td></tr>
<tr><td rowspan="3">Vegetation change</td><td>Fixed point camera survey</td><td>Biennially</td></tr>
<tr><td>Fixed point quadrat survey</td><td rowspan="2">Biennially</td><td rowspan="2">Survey £350
Analysis £500</td></tr>
<tr><td>Fixed point aquatic macrophyte survey</td></tr>
<tr><td colspan="4">NB. Costs assume downloading and site visits as part of wider field campaign.</td></tr>
</table>

Appendix A - Artificial flow lines and drain lines SSSI Unit 117


Roe
Inclosure
Buckherd
Bottom
North
King's
Garden
Roe Inclosure
Roe
Inclosure
Ford
Green
Ford
Greenford Bottom
Linford Brook
Buckherd
Bottom
Collier's
Thorns
Pinnick Wood
Akercome Bottom
Akercome
Bottom
SSSI 117: Roe Inclosure South
0
50
100
200 Metres