

Back Burn Hydromorphic Character and Restoration Opportunities

FINAL

June 2012



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Revision History


Revision Ref / Date Issued	Amendments	Issued to
Draft - 27 February 2012		Emile Wadsworth & Steering Group Pdf copy
Draft v2 - 2 May 2012	Inclusion of Task 2.2.4	Emile Wadsworth & Steering Group Pdf copy
Final - 28 June 2012	Adjustments after Steering Group comments	Emile Wadsworth & Steering Group Pdf copy

Contract

This report describes work commissioned by Emile Wadsworth, on behalf of Central Scotland Green Network, by a letter dated 16 May 2011. Caroline Anderton, George Heritage, Thomas Crow, Aleisha Keating and Kieran Sheehan of JBA Consulting carried out this work.

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Purpose

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Abbreviations

ID	Identifier
JBA	JBA Consulting – Engineers & Scientists
NGR	National Grid Reference
OS	Ordnance Survey
OS NGR	Ordnance Survey National Grid Reference
RBMP	River Basin Management Plan
SEPA	Scottish Environment Protection Agency
SNIFFER	Scottish & Northern Ireland Forum for Environmental Research

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1 Back Burn hydromorphology

1.1 Background to the study

The River Basin Management Plan for the Scotland River Basin District reports 56% of rivers as achieving 'good or better ecological' status / potential or better, with a target of increasing this to 63% by 2015. The task of improvement must be viewed in the context of a generally dynamic river network across Scotland where the geology, topography and climate has created a diversity of channel types. Many of these rivers remain sensitive to local alterations to the flow and sediment regime linked to climate change and human activity. Catchment practices including forestry, livestock management, power generation, water abstraction, effluent discharge and land drainage continue to invoke a response from impacted rivers, which varies according to river type. Similarly, direct intervention and alteration in the form of river training, flood defence works and bank protection has invariably created instability and system degradation.

This level of reactivity and responsiveness to local and catchment wide alterations presents significant challenges to river restoration, with physical change inevitable. Restoration feasibility and design must incorporate a detailed evaluation of linked local and catchment river functioning to ensure that appropriate morphologies are proposed to encourage morphological and ecological development linked to the anticipated flow and sediment regime. Failure to achieve this will result in extensive and relatively rapid destabilisation. The project to deliver multiple benefits through river basin management planning in the Forth sub-basin recognises the dynamic nature of the rivers in the Forth river basin and this report documents the hydromorphic assessment of the Back Burn, one of 4 watercourses targeted at the end of the first phase of the project for priority restoration.

1.2 River Basin Management Plan - Water Body Information Sheet

In 2010 the Kennoway Burn / Back Burn (water body ID: 6303) was classified as having an overall status of Moderate ecological potential with High confidence, with overall ecological status of Moderate and Physico-Chem status of Good. In 2008, SEPA set the overall environmental objectives for the first, second and third River Basin Management Planning (RBMP) cycles for this water body, these are detailed below in Table 1-1.

Table 1-1: Extract from complete classification of water body in 2008

Year	2008	2015	2021	2027
Status	Bad Ecological Potential	Bad	Bad	Good

The pressures on the water body are morphological alterations (multiple pressures), diffuse source pollution (mixed farming), flow regulation (water collection, purification and distribution), abstraction (arable farming) and morphological alterations (barriers to fish passage).

There is a total capacity of 28.86 % taken up by the morphological pressures on the Back Burn with 5.97 % of these being on this particular study reach.

An extract from the 2010 classification for this water body is shown below in Table 1-2.

Table 1-2: Extract from 2010 classification of water body

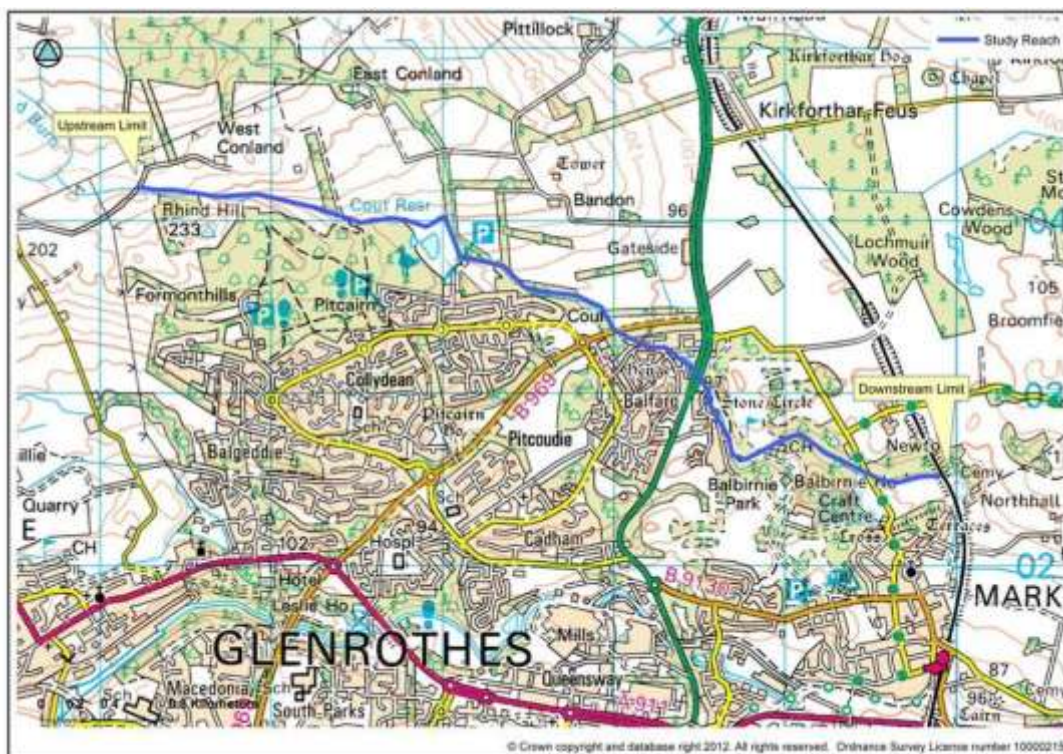
Parameter	2010 Status
Overall Status	Moderate
Pre-HMWB status	Moderate
Overall Ecology	Moderate
Hydromorphology	Good
Hydrology	High
Morphology	Good

In terms of the pressures being considered within this study (morphology, urban and diffuse pollution), this water body is failing due to both morphology and diffuse pollution.

1.3 General character of Back Burn

The Back Burn was subject to walkover survey in January 2011 from Rhing Hill in the west through to Newton in the east (Figure 1-1). The watercourse is known by several different names along this study reach. To the south of the West Conland Farm the watercourse is known as the Conland Burn, downstream of the Coul Reservoir the watercourse is then known as the Coul Burn. The watercourse then becomes the Balbirnie Burn as it enters the Balbirnie area. Immediately downstream of this study reach (and the railway line) the watercourse becomes the Back Burn. As the watercourse nears Windygates some 3.5km downstream of the railway line it becomes the Markinch Burn before reaching Kennoway where it joins the Kennoway Burn. The Kennoway Burn then flows south for 1.5km before joining the River Leven.

Figure 1-1: The Back Burn hydromorphology survey limits



The character of the river varied considerably along the length of the surveyed watercourse as did the surrounding land use. The upstream sections of the river are rural in character and, in spite of their high altitude, dominated by arable farming and the odd forestry plantation. Further downstream the burn begins to interact with the urban fringe of Glenrothes and has suffered from the effects of urban expansion and the requirements of utilities. This pressure over a couple of centuries has had an effect on the burn and its surroundings that are still evident to this day: indeed the pressures for recreation and new housing stock are still affecting the burn and its environs.

Eventually the Back Burn enters Glenrothes where it traverses a nineties housing estate before crossing parkland at Balbirnie. Here the burn has a more natural character but again it is impacted by recreational land uses, especially golf and infrastructure, in the form of railways, and these have again affected the character and land use of the burn.

The section of the burn that has been surveyed has been divided up into a number of reaches: these are described below working from upstream.

1.3.1 The upper burn between Conland Road and Hairyholes Plantation

This part of the watercourse is very rural and is at a high altitude (222m where the survey begins at the bridge on the road to West Conland Farm); the views across the outer Forth are spectacular and personify the very open landscape in this location. In this section of the reach land is privately owned farmland. The burn flows generally eastward from this location, in a

narrow channel with a margin of unimproved neutral grassland, dominated by false oat-grass *Arrhenatherum elatius*. The right bank is steep (rising to Rhind Hill) and covered in scrub, mostly gorse *Ulex europeaus*, whilst the left bank is more gently sloping and has been given over to arable production. In places there are drains between the fields and these drop into the burn and deposit small alluvial fans that are typically covered with Yorkshire fog *Holcus lanatus*.

The upper watercourse is characterised by a single thread pool - rapid channel dominated by boulder sized steps and rapids (Figure 1-2). The valley is quite confined and valley floor deposits are limited in lateral extent comprising of a mix of fluvial berms and stable valley side fan deposits that are slowly being reworked. Limited lateral activity is evident in the channel with dry stone walling collapsing into the channel in several places. Overall the hydromorphological character of the reach is natural and good. Some planting opportunities exist along the valley bottom and sides.

Figure 1-2: Slightly confined step - pool channel with restricted valley bottom deposits



Current farming practice in the area is generating significant mixed sediment (Figure 1-3) and this is being transferred to the channel through surface water flows and minor gullyng.

Figure 1-3: Significant farmland mixed sediment inputs



1.3.2 From Hairyholes Plantation through to Coul Reservoir

Hairyholes Plantation (owner unknown) is a significant feature of the landscape in and around the watercourse. The land surrounding the burn is privately owned farmland. Shown on the 1940s Ordnance Survey map the plantation is mature and composed of Sitka spruce *Picea sitchensis* that is now mature and beginning to suffer from wind throw in places. Here and there large trees have fallen across the burn and form woody debris dams. In general though the plantation has had negative effect on the ecology of the burn as needle fall and deep shade have led to the almost complete absence of any ground flora, which is still plentiful immediately upstream and downstream of the plantation.

Figure 1-4: Boulder / cobble channel with limited but well developed wooded floodplain



The plantation also marks a change in the land use on the left bank of the burn, instead of arable land, improved grassland is now the dominant land cover and the burn itself now begins to cut into its bed leaving steeper valley sides, especially on the right bank, that are being colonised by broadleaved trees, such as rowan *Sorbus aucuparia*.

In this location there is also a small bridge over the burn which is used by walkers to access Rhind Hill and there is a walkway on the left bank of the river. From here onwards the burn will see increasing amenity and industrial usage as it and its environs are exploited by the town and people of Glenrothes. This can clearly be seen a very short distance downstream where there is an old cast iron sluice that is now kept in bolted-open position (see Figure 1-5). This sluice directs water away from the old course of the burn and around and along the hillside in a raceway which eventually rejoins the burn well downstream. The raceway is shown in Figure 1-6 below and is suffering from an influx of silt which is preventing the colonisation of the stream by aquatic plants, although watercress *Rorippa nasturtium-aquaticum* has gained a foothold in this highly artificial watercourse situated beneath a steep, unstable slope.

Figure 1-5: Victorian cast iron sluice gate used to direct water out of the natural course of the burn and into a raceway



The old course of the burn is wooded and steep and is still in excellent ecological condition with birch *Betula spp.*, alder *Alnus glutinosa* and willow *Salix spp.* growing on the slopes and with large areas of wet woodland at the bottom of the valley where the trees become an extensive area of wet woodland with water backing-up from the Coul Reservoir. Here there are large stands of marginal and aquatic species, including branched burr-reed *Sparganium erectum*, reedmace *Typha latifolia* and common water starwort *Callitriche stagnalis*. There are also at least four species of willow here and it is highly likely that there are some unusual hybrids present.

The area is used by walkers and probably bird watchers and access across the wet woodland and fen is via a path with boardwalk sections.

Figure 1-6: Detail of the cobble lined raceway



The natural channel remains steep and confined with a well developed boulder / cobble pool - rapid in-channel morphology. Valley floor development continues to be limited (Figure 1-7 and Figure 1-8). This natural pattern is significantly disrupted at the weir structure controlling flow into Coul reservoir (Figure 1-9). Mixed sediment has accumulated behind the weir and is now passing over the structure and downstream (Figure 1-10).

Figure 1-7: Diverse bedrock / boulder / cobble pool - rapid - riffle sequence



Figure 1-8: Boulder / cobble channel with limited but well developed wooded floodplain



Figure 1-9: Weir structure controlling flow into Coul Reservoir



Figure 1-10: Mixed sediment deposition upstream of the weir controlling flow into Coul Reservoir



1.4 Coul Reservoir

The reservoir was originally constructed in 1890 for the Markinch and Wernyss Distillery (Figure 1-11) and a long lined raceway (Figure 1-12) transferred flows past the reservoir when it was full. The reservoir is now a redundant structure and is part of a Local Nature Reserve known as Coul Den. The land is privately owned.

This raceway is steep and uniform and has a lined bed free of stored coarse sediment. It is currently a major barrier to fish due to the weirs at the top and bottom end (Figure 1-14) and the uniform high velocity flow created along the engineered channel. The reservoir wall was breached in 1998 and water levels were lowered and the limited flow in the original channel has now created a semi-confined boulder pool - rapid channel (Figure 1-14) grading into a wet woodland anastomosed channel (Figure 1-15) across sediment accumulated in the reservoir.

This section of channel offers an excellent opportunity for restoration reducing the flow split into the raceway and creating a more natural confluence with the original channel through the gabion lined exit channel (Figure 1-13).

The main interest in the reservoir is birds, although on the day of the visit only black-headed gulls *Chroicocephalus ridibundus* and mallard *Anas platyrhynchos* were present. The main floristic interest is in Coul Den, the now abandoned channel that was once occupied by the Coul Burn, and the steep, wooded valley sides with the wet woodland fen carr on the upstream side of the open water (see Figure 1-15).

On the downstream side the overflow channel is lined with gabion baskets and it being invaded by willow saplings. This is quite a steep channel and at the time of the visit was virtually non-flowing. Once this leaves the reservoir it is met on the left bank by the redirected water which has flowed around the reservoir via the raceway and then downhill through a long stone-lined race that will only allow passage for eels *Anguilla anguilla*. Adjacent to this race is another plantation, this time composed mainly of English oak, *Quercus robur*. The further downhill you go, the more the oak thins out until, where it meets the now reconstituted burn, the ground flora is dominated by bracken *Pteridium aquilinum* with only a few isolated hawthorn *Crataegus monogyna* bushes present. Here, in the damper areas, less favoured by bracken, butterbur *Petasites hybridus* is common.

Figure 1-11: Overview of Coul Reservoir



Figure 1-12: The raceway around Coul Reservoir



Figure 1-13: Walled reach at the exit weir from the raceway and gabion lined reservoir outflow channel



Figure 1-14: Semi-confined boulder pool - rapid channel approaching Coul Reservoir



Figure 1-15: Anastomosed channel system at entrance to Coul Reservoir



1.4.1 Between Coul Reservoir and the B969 (Western Avenue)

Below Coul Reservoir the burn flows through a section of mixed farmland on the left bank with arable and improved grassland fields. The land surrounding the burn is privately owned farmland. On the left bank there is some horticulture but generally the bank is wooded and steep. In this reach an otter spraint was found on a prominent rock on the edge of the channel.

Further downstream again the burn enters a large area of woodland with houses on the steep right bank. For most of this woodland the burn occupies the far right hand side of the floodplain leaving the plantation woodland and the improved grassland fields beyond well away from the burn. The woodland itself has a poor ground flora because it is a secondary plantation, composed of 120 year old sycamore *Acer pseudoplatanus* trees planted in lines. In addition there are some older, larger beeches *Fagus sylvatica* trees and a good growth of suckering elm *Ulmus procera* with the occasional holly *Ilex europeaus* bush.

After the channel leaves the raceway and is joined by intermittent flows from Coul Reservoir (Figure 1-13) it flows through an area of farmland (arable & improved grassland) with opportunities for riparian planting. It then enters a well wooded confined reach displaying pool - rapid - riffle sequences (Figure 1-16). Some fine sediment was seen in the channel bed indicating an increase in diffuse inputs. Elsewhere the wooded riparian supplies ample material for debris jams (Figure 1-17) creating local hydromorphic diversity.

A low flood bank runs along the left bank close to the B969 protecting pasture. This could be removed to improve floodplain connectivity before the river flows into a flume and culvert under the road (Figure 1-18).

Figure 1-16: Mixed sediment pool - rapid - riffle reach



Figure 1-17: Woody Debris Dam across the channel



Figure 1-18: Flume entrance to B969 culvert



1.4.2 Balfarg (between the B969 and the A92(T))

Immediately after the B969 road flow exits from the culvert through a restricted pipe into an area of woodland with a small patch of improved grassland. The pipe (Figure 1-19) allows only a fraction of the flow to enter the channel with the rest being diverted underground around Balfarg to rejoin after the A92(T). The impact of flow loss on the channel has been significant and severe with extensive sedimentation in the original channel immediately downstream of the culvert exit (Figure 1-20).

After this the river is majorly modified through the housing estate with a narrowed section and numerous flow obstructions. It emerges periodically into shrubberies and small, wooden-lined channels on the roadside. This eventually widens out and flows under a stone bridge where the channel is situated within a stretch of amenity grassland and hawthorn scrub. Here a line of Leyland cypress *Chamaecyparis leylandii* has recently been felled opening up the channel which has been diverted around the property, leaving a dry, grass and leaf-filled channel a few metres to the south (Figure 1-22). The original channel course has been abandoned in several places in favour of ornamental reaches (Figure 1-21) through and adjacent to houses and gardens. This is most notable close to the A92(T) where restoration is possible (Figure 1-22).

Figure 1-19: Reduced flow piped exit after the B969



Figure 1-20: Strongly sedimented alluvial plane bed channel



Figure 1-21: Ornamental channel section through the Balfarg housing estate



Figure 1-22: Split channel with flow confined to the artificial section



1.4.3 The Dens, between the A92 (T) and the Balbirnie House Hotel

On the East side of the A92 the burn emerges from the culvert under the road. The burn flows through a residential area, with land immediately surrounding the channel owned by Fife Council. After emerging from the culvert, the channel flow levels are restored and the river flows through a moderately confined wooded reach as a pool - rapid - riffle channel (Figure 1-23). A number of piecemeal bank protection measures have been employed along the river through The Dens, much of which is superfluous or failing and a notched weir is causing flow to back up (Figure 1-24). These interventions should be considered for removal / modification. The burn runs within an area of broadleaved plantation with occasional patches of planted ornamental shrubs, especially dogwood *Cornus sanguinea*.

The woodland is planted and attains a semi-natural character but there are invasive species here and there, especially along the line of a water main where snowberry *Symphoricarpos albicans* is rampant and spreading. There are a few defunct weirs here and a few places where trees have fallen across the river. Overall the area has a pleasant, slightly run-down feel to it, which is good for biodiversity.

On the right bank of the stream beyond the trees at the top of the valley, the land use is residential whilst on the left bank the woodland area is flatter and the former open parkland has been turned into a golf course. In front of the golf clubhouse the stream is confined within artificial walls and crossed by a number of stone bridges (Figure 1-25).

The stream here is over-engineered and has the odd patch of water crowfoot *Ranunculus aquatilis* in the channel and very little else, barring some acrocarpous mosses on the channel linings.

Figure 1-23: Semi-confined cobble / gravel pool - riffle - rapid reach.



Figure 1-24: Redundant structure in the channel.



Figure 1-25: Heavily modified and engineered stream near Balbirnie House



1.4.4 From the Balbirnie House Hotel to the rail line at Newton Braes

Beyond the golf course the burn again flows through an extended area of policy woodlands, associated with the former Balbirnie Estate. This area is owned by Fife Council. The burn has been modified here but the surrounding woodlands are semi-natural immature with only the odd coniferous species in the mix. From here the burn emerges into an open field, which itself contained some new plantings. This field shows evidence of palaeochannels and the stream appears to have been straightened here. The grassland here is mixed with improved areas and areas of rushy pasture, associated with the former river channels.

Downstream of Stob Cross Road the land is privately owned and the channel and floodplain are similar to upstream. Here the burn extends in a straight line to the railway whilst on the north side of the burn a new forestry plantation has been planted whilst the south side is improved grassland grazed by cattle. This field has a large area of rushy pasture within which, an old palaeochannel winds its way to the railway embankment at the eastern end of the field. Here there is a small area of very wet pasture as the embankment impedes the drainage

eastwards. This area is poached and the banks of the burn are heavily damaged by the cattle accessing the watercourse in this location.

The river is extensively modified after the Balbirnie House Hotel with further weirs (Figure 1-26) and channel bank lining (particularly past the Balbirnie Park Golf Course). Gradient change linked to the weirs has led to the river forming plane-bed - riffle areas. All should be considered for removal / modification.

Figure 1-26: Ornamental weir structure.



The character of the channel changes again as it exits the confined wooded valley close to Stob Cross Road. Here the river has been straightened (Figure 1-27) having originally flowed in channels to the south and north of the current river. The channel route to the south, although older than the northern channel, is evident from line of rush (Figure 1-28) and offers a significant opportunity for restoration and wetland creation close to the railway crossing.

Figure 1-27: Straightened section of the Back Burn through Markinch.



Figure 1-28: Aerial view of the floodplain between Stub Cross Road and the railway line
(copyright Google Earth 2012, getmapping plc 2012)



1.4.5 Summary

The Back burn is a very heavily modified channel which displays good in-channel hydromorphology through the steep confined reaches, while outside of the confined reaches there are significantly degraded sections due to impoundment, channel diversion, channel straightening and flow splitting. Major restoration opportunities exist around Coul Reservoir, through Balfarg and across Markinch plantation after Stob Cross Road. Additionally a number of local restoration opportunities should be considered to improve channel functioning.

1.5 Back Burn restoration opportunities

The very poor in-channel morphology and significant fine sediment issues on the Back Burn make restoration difficult. However, a number of local opportunities for restoration have been identified. These are discussed below and summarised in Table 1-4 and C-1.

1.5.1 Hairyholes Plantation

In the first reach a key recommendation would be to remove the Sitka spruce from the extension of the Hairyholes Plantation from the banks of the burn. This should be for a distance of 20m on either side (more so on the left bank) of the burn to allow light to enter the stream and encourage the growth of a riparian margin.

1.5.2 Coul Reservoir

The most interesting restoration project for the burn would be at the Coul Reservoir. Here it is a recommendation that the existing cast-iron sluice gate at the start of the raceway be removed (or if protected, closed) to allow water to once again flow into the former channel occupied by the burn. This would dramatically improve the ecology of this steep valley and would increase the throughput of water into the reservoir and ensure that the outflow channel flows all year round.

In order to aid this, work will need to be undertaken on the outflow channel to increase its naturalness whilst at the same time ensuring that the residual amount of water in the loch is safely impounded, thus retaining the areas of fen carr at the back of the reservoir which support important bird populations that utilise the reservoir. This would have the advantage of effectively reconstituting the original course of watercourses and improve the connectivity of the burn with the valley sides as well as increasing the opportunities for migratory fish to

access the upper reaches of the burn. Any such work will also have a beneficial effect for mammal species that utilise river corridors, such as otter *Lutra lutra*.

1.5.3 Coul and Coul Mains

Further downstream in the woodlands near Maree Way, the residents whose properties back onto the burn should be educated about the importance of the riparian and woodland habitats and the need not to use the area for the dumping of garden waste and other rubbish. Not far from here the burn enters into a culvert under Western Avenue and promptly loses a large proportion of its flow, which has a deleterious effect on the burn downstream as it makes its way through the Coul Mains part of Glenrothes. This loss of flow should be investigated with the aim of restoring the flow through Coul Mains and reconnecting the burn to this part of its floodplain. In addition the burn should be restored to the dry channel in Coul Mains just before it disappears beneath the A92.

1.5.4 Balbirnie Estate

On the other side of the A92 the burn is once again in good health with its flow restored. Here there are a number of obstructions in the watercourse, such as weirs, culverts and a redundant gauging weir. These structures and the associated gabion baskets should be removed so that the stream can have a more natural relationship with the surrounding woodland. In one place defences are required due to the presence of a buried water main, which forms a bank with manholes parallel to the burn. This has become infested with snowberry, a non-native species, and this should be removed to restore the woodlands to a more natural state and promote the growth of ground flora.

Within this woodland there are also a series of large weirs that are now redundant (Figure 1-29), these are constructed of cobbles and show no useful purpose. In order to aid fish passage and create a more natural watercourse in harmony with its woodland banks, these should be removed.

Figure 1-29: Gabion baskets and cobble weir hindering fish passage and the development of a riparian margin



The next opportunity is near Balbirnie House. Here the burn is straight and confined within artificial walls. The bank protection should be removed where practicable and the river allowed to alter naturally. This will allow a greater variety of natural features to develop (with a corresponding increase in the numbers of ecological niches available) and the colonisation of the banks with a riparian flora.

Further weir removal should be undertaken downstream of Balbirnie House in the woodland along with the removal of any associated bank protection, such as walls and gabion baskets. This again will allow fish passage and the creation of a riparian margin.

1.5.5 Stob Cross Road area

Where the burn emerges into the grassland area, before passing under Stob Cross Road, a small wetland should be created in which an anastomosing channel can develop. There is evidence for palaeo-channels in this location and the floodplain is extensive offering opportunities to re-create this habitat and its associated ecological niches.

The final reach from Stob Cross Road to the railway embankment is again engineered straight although there is evidence both north and south of the man-made channel or older channels. It is a recommendation of this report that the burn be redirected in a sinuous, multi-threaded channel to the south of its present location, through the existing area of rushy pasture until it meets the railway embankment. Here a new wetland should be created to allow the water draining down the embankment somewhere to go before eventually flowing under the bridge to the east. This wetland would be fenced-off from the remainder of the field to prevent excessive poaching and should be grazed by cattle for a week or two in August or September, depending on ground conditions. This will prevent the colonisation of the area by trees and ensure that the herbage does not become too rank. This will benefit amphibians, flowering plants and wading birds such as snipe *Gallinago gallinago*.

The restoration options are summarised below in Table 1-4. Full details of each restoration option considered are detailed in Appendix C (Table C-1) with locations of the options are shown in Figure C-1. Each restoration measure has been given a unique ID and a corresponding consecutive number for each measure working from upstream to downstream, the code descriptions are listed below in Table 1-3). Estimated costs have also been calculated for each of the proposed options and are included in Appendix C (Table C-1). Details regarding how costs have been derived are outlined in Appendix D.

Table 1-3: Restoration opportunities codes

Category	Code
Abandon channel	ACh
Assess abstraction value	AV
Channel creation	ChC
Channel reconnection	ChRc
Channel restoration	ChR
Construction management	CM
Create transverse bar	TBC
Diffuse source control	DSC
Education - farm practice	EdFP
Education - riparian management	EdRM
Flood banks/ flood walls - remove / set back	FBRe
Flow restoration	FIR
Identify diffuse source	IDS
Introduce large woody debris	LWD
Invasive removal	InRe
Natural regeneration	NR
Plantation forestry removal	PFR
Point source control	PSC
Remove channel	ChRe
Remove channel infill	CIRe
Remove culvert	CR
Remove debris / material	DRe
Remove fence	FRe
Remove geotextile	GRe
Remove lined channel	LCRe
Remove pipe	PRe
Remove road	RdRe
Remove structure eg. Greybank, in-channel structures etc	StRe
Remove waste	WaRe
Replace structure - footbridge	BrRp
Riparian margin creation	RMC
Vegetation - planting	VP
Vegetation - removal and planting	VRP
Vegetation removal	VRe
Weir removal / modification	WRe
Wetland creation	WC

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A summary of the restoration options is shown in Table1-4.

Table 1-4: Restoration opportunities for the Back Burn

Issue	Unique ID	Action	Location Description	OS NGR	Pressure	Pros	Cons	Cost (£k)	Movement towards GES - Capacity released
ISSUE 1: Poor valley floor and valley side vegetation. Plantation forestry in one section.	Bac_VP_1, Bac_VP_2, Bac_VP_3, Bac_VRP_1	Plant low valley sides and terraces. Remove and replace plantation forestry.	Conland Road to Hairyholes Plantation	325234E 704173N to 326535E 704027N – Bac_VP_1, Bac_VP_2, Bac_VP_3 326291E 704068N to 326397E 704032N – Bac_VRP_1	Rural diffuse pollution	Address high levels of multiple benefits Increase floodplain biodiversity and create long term ecological benefits Potential to link to core paths downstream - increasing public access & health Improvements to a large section of the upper reaches of the catchment	Potential high cost of planting and removal	85.2	No info on diffuse pollution score
ISSUE 2: Poor farm practices including gullying adjacent to the channel.	Bac_EdFP_1	Education – farm practices.	Conland Road to Hairyholes Plantation	325234E 704173N to 326535E 704027N - Bac_EdFP_1	Rural diffuse pollution	Address high level of multiple benefits Potential to link to core paths downstream - increasing public access & health Improvements to a large section of the upper reaches of the catchment	Further assessment required to define specific options	-	No info on diffuse pollution score
ISSUE 3: Flow is split between engineered channel and channel to reservoir	Bac_FIR_1, Bac_ACh_1, Bac_StRe_1	Reinstate flow and channel to reservoir, abandon engineered channel. Excavate area adjacent to sluice gate to reinstate side weir. Remove sluice gate (if possible). Add boulder wrapping.	Upstream of Coul Reservoir	3265593E 704004N to 327041E 703791N	Morphological	Address medium level of multiple benefits Increase in-channel and floodplain biodiversity Existing paths - increasing public access & health	Further detailed assessment will be required. Access to may be difficult and require traffic management	10.0	0.77% (pressure not fully covered capacity dataset)
ISSUE 4: Poor valley floor and valley side vegetation	Bac_VP_4	Planting to improve riparian strip	Downstream of Coul Reservoir	327141E 703792N	Rural diffuse pollution	Address high level of multiple benefits Increase floodplain biodiversity and create long term ecological benefits Potential to link to core paths downstream - increasing public access & health		6.6	No info on diffuse pollution score
ISSUE 5: Plantation forestry surrounding channel; excessive fine sediment in the channel bed	Bac_VRP_2, Bac_VRP_3	Remove and replace plantation forestry.	Downstream of Coul Reservoir	327315E 703760N to 327625E 703555N	Rural diffuse pollution	Address medium level of multiple benefits Increase in-channel and floodplain biodiversity and create long term ecological benefits Extend existing core path, improving public access		15.0	No info on diffuse pollution score
ISSUE 6: Floodplain disconnection	Bac_FBRe_1, Bac_FBRe_2	Remove / set back floodbanks	Upstream of B969	327665E 703548N to 327958E 703424N	Morphological	Increase in-channel and floodplain biodiversity Extend existing core path, improving public access.	Address low level of multiple benefits Further detailed assessment will be required.	39.0	0.67% (pressure not fully covered capacity dataset)
ISSUE 7: Flow splitting as channel is culverted through the residential area. Bed sedimentation after flow diversion. Debris on banks of burn. Engineered channel at downstream end of reach	Bac_FIR_2, Bac_DRe_1, Bac_ACh_2	Restore original flow and reinstate channel. Remove debris. Abandon engineered channel.	Section through residential area at Balfarg, between B969 and A92	328048E 703294N to 328509E 703190N - Bac_FIR_2 328009E 703373N to 328082E 703283N - Bac_DRe_1	Morphological	Address medium level of multiple benefits Increase in-channel and floodplain biodiversity. Extend existing core path, improving public access	Further detailed assessment will be required. Works immediately adjacent to residential properties - would need to consider potential effects	10.6	1.08 % (pressure not fully covered capacity dataset)
ISSUE 8: Bank and in-channel	Bac_WRe_1,	Remove weirs	Through the Den	328692E 702687N –	Morphological	Increase in-channel	Address low level of	15.9	No capacity info

structures.	Bac_WRe_2		and Balbirne Park	Bac_WRe_1 328734E 702571N – Bac_WRe_2		biodiversity. Extend existing core path, improving public access.	multiple benefits Further detailed assessment will be required.		
ISSUE 9: Poor in-channel morphology.	Bac_ChR_1	Improve morphology / channel restoration by introducing gravel to create berms and bars.	Through Bilbirnie Park	328927E 702609N to 329048E 702761N	Morphological	Increase in-channel biodiversity. Extend existing core path, improving public access.	Address low level of multiple benefits Further detailed assessment will be required.	9.9	No capacity info
ISSUE 10: Poor channel morphology.	Bac_LWD_1	Introduce large woody debris to encourage naturalisation and sinuosity.	Through Bilbirnie Park	329132E 702740N to 329249E 702630N	Morphological	Increase in-channel biodiversity. Extend existing core path, improving public access.	Address Low level of multiple benefits	1.1	No capacity info
ISSUE 11: Modified channel – straightening, paleo channel evident.	Bac_ChR_2, Bac_WC_1	Improve in-channel morphology by creating two stage channel anastomosed wetland creation.	Newton Braes - downstream of Stob Cross Road	329702E 702485N to 329874E 702505N – Bac_ChR_2 329694E 702451N – Bac_WC_1	Morphological	Address high level of multiple benefits Increase in-channel and floodplain biodiversity. Create long term ecological benefits. Extend existing core path, improving public access.	Further detailed assessment will be required. High estimated cost	145	0.94 %

Full details of each restoration option are considered in Appendix C (Table C-1) with locations of the options shown in Figure C-1. Table C-1 includes a consideration of funding streams which could be used to deliver the restoration opportunities identified. Appendix D outlines how costs have been estimated.

1.6 Discussion of SEPA morphological pressures & JBA findings

Figure C-2 (Appendix C) shows the pressures identified within SEPA's pressures database and the capacity that is calculated as having been used up by each of these pressures. There is a total capacity of 28.86 % taken up by the morphological pressures on the Back Burn with 5.97 % of these being on this particular study reach. The pressures identified by SEPA are culverts, set back embankments, green bank protection, low impact channel realignment. No high impact channel realignment or grey bank protection has been identified.

JBA's audit has been documented in terms of the restoration opportunities present (Figure C-1). These do not always map on to the specific pressures as per SEPA's pressure database and this is reflected in the difficulty in determining accurate pressure capacity change related to proposed works (Table 1.4). For instance, the channel running around Coul Reservoir is only classed as low impact in the SEPA dataset whereas on the ground it was found to be a heavily engineered artificial channel. Flow abstraction issues and local morphological alteration through Balfarg have not been picked up in the high level SEPA database whereas the hydromorphological / ecological walkover audit noted significant pressures locally. It must be remembered that the restoration recommendations made here address the issues identified while undertaking the hydromorphological / ecological audit of the watercourse and not necessarily all of the high level pressures in the SEPA dataset.

1.7 Options assessment - multi-criteria analysis

Multi-criteria analysis was conducted to prioritise implementation of the various proposed options and is shown in Appendix F. The multi-criteria analysis was based on the three-level assessment scale described in 'Priority Catchment Restoration Scoping Studies - Phase 1: Overall Approach and Methods Report' (SNIFFER, 2011). The analysis considered a variety of different indicators including length of reach, flood risk reduction, capacity release, ecological and socio-economic benefits and cost of implementation. For each issue, each indicator was rated as positive, neutral or low benefits. Indicators highlighted at being most important in this study were weighted so that these indicators were favoured over other indicators. The weighting of different indicators is able to be adjusted easily to favour various indicators as necessary.

1.8 Recommendations

The restoration measures discussed within this report present a perfect opportunity to improve the environment to the north of Glenrothes and increase public walkway access and IHN connectivity. In the upper reaches large improvements to the watercourse and surrounding area can be achieved by improving education with respect to farm practices.

Based on the multi-criteria analysis it is recommended that the following options be prioritised for implementation:

- Issue 2 - Education - farm practices
- Issue 1 - Plant low valley sides and terraces, remove and replace plantation forestry
- Issue 4 - Improve riparian strip
- Issue 11 - Reconnect wetland, improve in-channel morphology

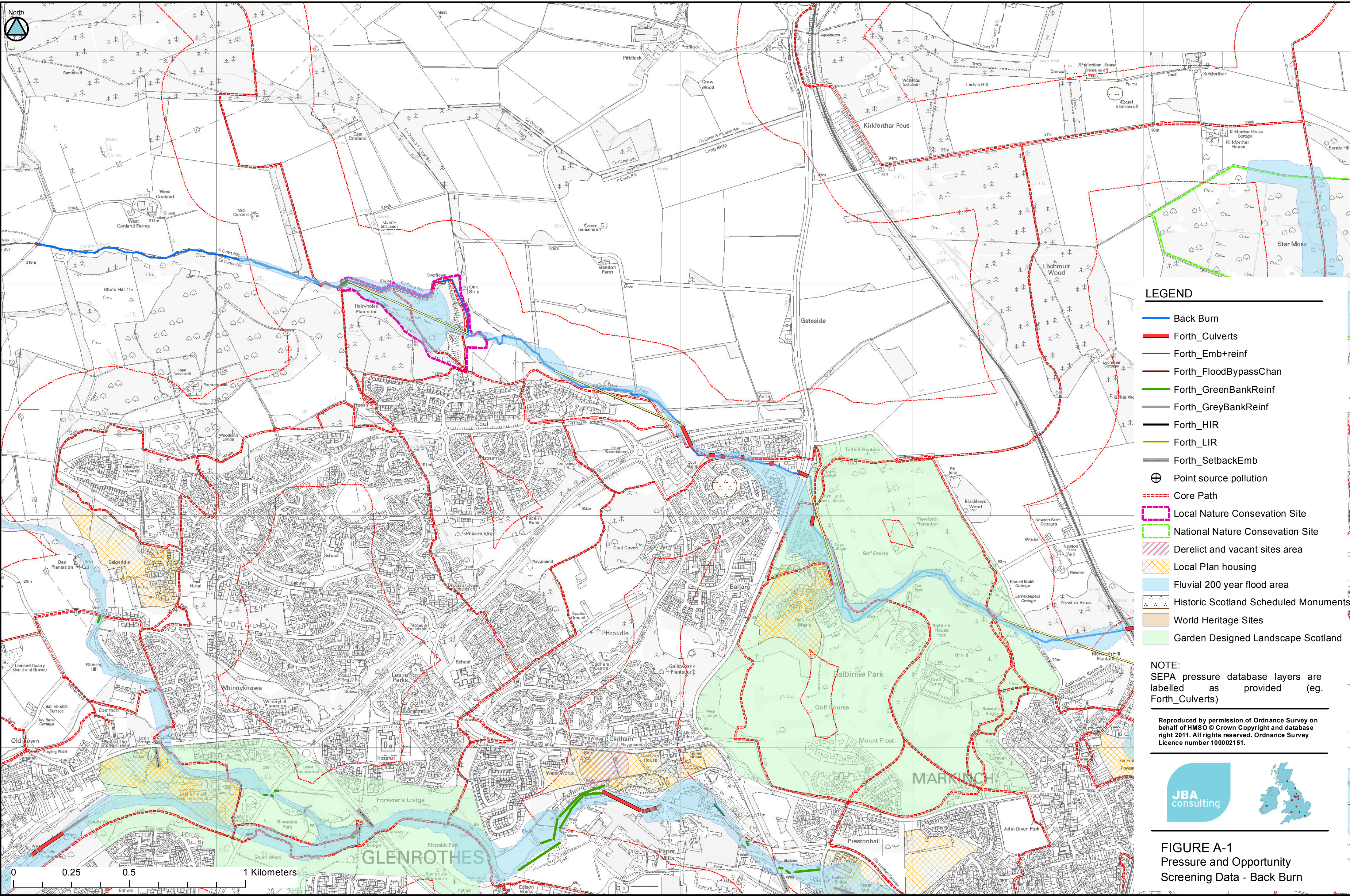
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Appendices

A Phase 1 screening features

Figure A- 1: Pressure and Opportunity Screening Data - Back Burn

Figure A- 2: Pressure / IHN Opportunity Areas - Back Burn



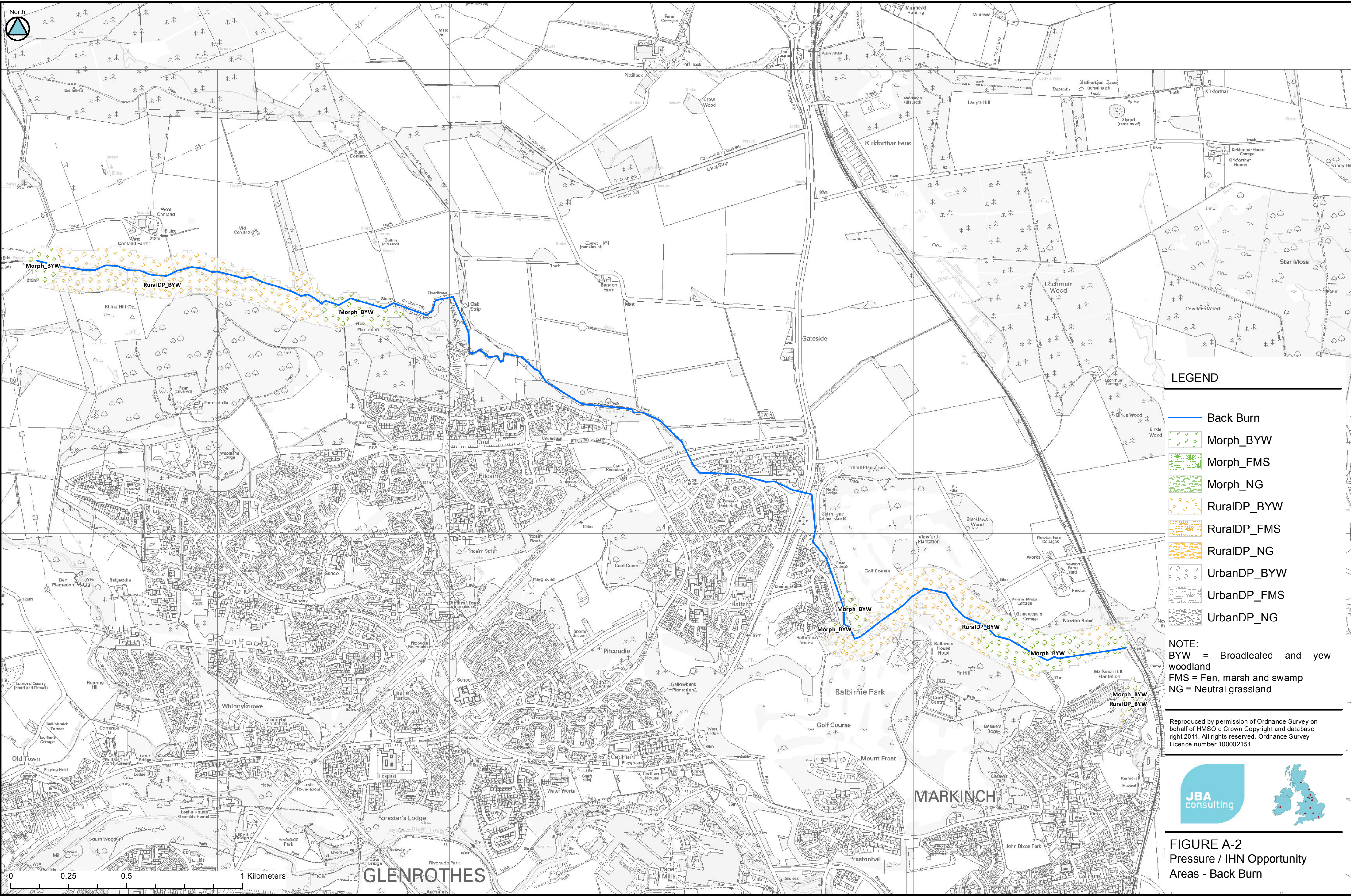
- LEGEND**
- Back Burn
 - Forth_Culverts
 - Forth_Emb+reinf
 - Forth_FloodBypassChan
 - Forth_GreenBankReinf
 - Forth_GreyBankReinf
 - Forth_HIR
 - Forth_LIR
 - Forth_SetbackEmb
 - Point source pollution
 - Core Path
 - Local Nature Conservation Site
 - National Nature Conservation Site
 - Derelict and vacant sites area
 - Local Plan housing
 - Fluvial 200 year flood area
 - Historic Scotland Scheduled Monuments
 - World Heritage Sites
 - Garden Designed Landscape Scotland

NOTE:
SEPA pressure database layers are labelled as provided (eg. Forth_Culverts)

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FIGURE A-1
Pressure and Opportunity
Screening Data - Back Burn



LEGEND

- Back Burn
- Morph_BYW
- Morph_FMS
- Morph_NG
- RuralIDP_BYW
- RuralIDP_FMS
- RuralIDP_NG
- UrbanDP_BYW
- UrbanDP_FMS
- UrbanDP_NG

NOTE:
BYW = Broadleaved and yew woodland
FMS = Fen, marsh and swamp
NG = Neutral grassland

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FIGURE A-2
Pressure / IHN Opportunity
Areas - Back Burn


B Photo record of the hydromorphic audit




Series of photographs taken along the reach and displayed from upstream to downstream (see Figure C-1 for photo locations).

	<p>Location : 1</p> <p>Description: Confined boulder / cobble pool – rapid channel</p> <p>OS NGR: 32528 70416</p> <p>Notes:</p>
	<p>Location : 2</p> <p>Description: Low berm development and valley fan deposits along the upper reaches</p> <p>OS NGR: 32532 70414</p> <p>Notes:</p>



	<p>Location : 3</p> <p>Description: Gullying over farmland adjacent to the channel</p> <p>OS NGR: 32549 70414</p> <p>Notes:</p>
	<p>Location : 4</p> <p>Description: Gorse development on valley margins</p> <p>OS NGR: 32555 70415</p> <p>Notes:</p>
	<p>Location : 5</p> <p>Description: Berm deposits and boulder dominated pool – rapid sequence</p> <p>OS NGR: 32568 70413</p> <p>Notes:</p>




	<p>Location : 6</p> <p>Description: In channel deposition leading to island development and flow bifurcation</p> <p>OS NGR: 32576 70411</p> <p>Notes:</p>
	<p>Location : 7</p> <p>Description: Boulder step</p> <p>OS NGR: 32592 70415</p> <p>Notes: Constructed?</p>
	<p>Location : 8</p> <p>Description: Valley side sediment sources</p> <p>OS NGR: 32615 70410</p> <p>Notes:</p>




	<p>Location : 9</p> <p>Description: Weir exit into raceway at Coul Reservoir</p> <p>OS NGR: 32656 70401</p> <p>Notes:</p>
	<p>Location : 9</p> <p>Description: Old sluice gates controlling reservoir / raceway flow split</p> <p>OS NGR: 32656 70401</p> <p>Notes:</p>
	<p>Location : 9</p> <p>Description: Mixed gravels accumulated above the raceway weir</p> <p>OS NGR: 32656 70401</p> <p>Notes:</p>

	<p>Location : 10</p> <p>Description: Artificial uniform raceway on lower gradient</p> <p>OS NGR: 32682 70397</p> <p>Notes: Some marginal berm development</p>
	<p>Location : 11</p> <p>Description: Anastomosed sub-channel</p> <p>OS NGR: 32685 70387</p> <p>Notes: One of several sedimenting sub-channels</p>
	<p>Location : 12</p> <p>Description: End of former natural channel influenced by reservoir levels</p> <p>OS NGR: 32688 70388</p> <p>Notes:</p>

	<p>Location : 13</p> <p>Description: Willow carr</p> <p>OS NGR: 32688 70385</p> <p>Notes:</p>
	<p>Location : 14</p> <p>Description: Overview of Coul Reservoir</p> <p>OS NGR: 32696 70382</p> <p>Notes:</p>
	<p>Location : 15</p> <p>Description: Raceway</p> <p>OS NGR: 32694 70400</p> <p>Notes:</p>

	<p>Location : 16</p> <p>Description: Cobble lined raceway</p> <p>OS NGR: 32698 70401</p> <p>Notes:</p>
	<p>Location : 17</p> <p>Description: Weir at raceway exit</p> <p>OS NGR: 32705 70392</p> <p>Notes: reservoir outflow channel on right bank (gabion lined)</p>
	<p>Location : 18</p> <p>Description: Walled exit to raceway</p> <p>OS NGR: 32708 70379</p> <p>Notes:</p>

	<p>Location : 19</p> <p>Description: Lined raceway</p> <p>OS NGR: 32708 70378</p> <p>Notes:</p>
	<p>Location : 20</p> <p>Description: Gravel / cobble plane-bed riffle – rapid channel</p> <p>OS NGR: 32714 70378</p> <p>Notes:</p>
	<p>Location : 21</p> <p>Description: Woody debris dam</p> <p>OS NGR: 32748 70360</p> <p>Notes:</p>

	<p>Location : 22</p> <p>Description: Excessive fine sediment on the channel bed</p> <p>OS NGR: 32760 70355</p> <p>Notes:</p>
	<p>Location : 23</p> <p>Description: Flume entrance to road culvert</p> <p>OS NGR: 32802 70335</p> <p>Notes:</p>
	<p>Location : 24</p> <p>Description: Piped exit to road culvert</p> <p>OS NGR: 32805 70328</p> <p>Notes: Significant flow reduction exiting through pipe</p>

	<p>Location : 25</p> <p>Description: Strongly sedimented bed after flow diversion</p> <p>OS NGR: 32806 70327</p> <p>Notes:</p>
	<p>Location : 26</p> <p>Description: Strongly sedimented bed after flow diversion</p> <p>OS NGR: 32808 70326</p> <p>Notes:</p>
	<p>Location : 27</p> <p>Description: Ornamental channel through housing estate</p> <p>OS NGR: 32821 70325</p> <p>Notes:</p>

	<p>Location : 28</p> <p>Description: Ornamental channel through housing estate</p> <p>OS NGR: 32823 70325</p> <p>Notes:</p>
	<p>Location : 29</p> <p>Description: Ornamental channel through housing estate</p> <p>OS NGR: 32825 70325</p> <p>Notes:</p>
	<p>Location : 30</p> <p>Description: Ornamental channel through housing estate</p> <p>OS NGR: 32827 70325</p> <p>Notes:</p>

	<p>Location : 31</p> <p>Description: Naturalising channel after housing estate</p> <p>OS NGR: 32834 70322</p> <p>Notes:</p>
	<p>Location : 32</p> <p>Description: Former river course now dry following construction of engineered channel</p> <p>OS NGR: 32850 70318</p> <p>Notes:</p>
	<p>Location : 33</p> <p>Description: Semi-confined channel</p> <p>OS NGR: 32855 70316</p> <p>Notes:</p>



Location : 34

Description: Piped culvert

OS NGR: 32857 70300

Notes:

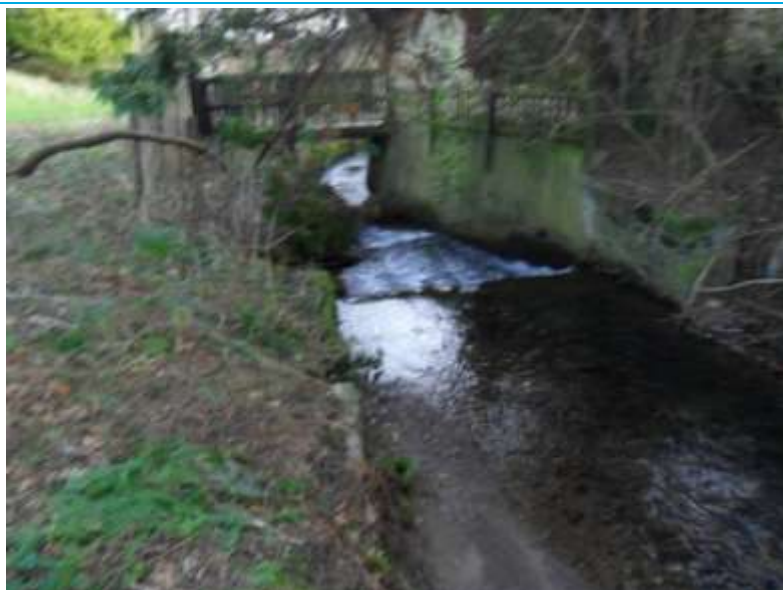


Location : 35

Description: Boulder
blockstone bank
protection

OS NGR: 32857 70294

Notes:






Location : 36

Description: Small weir,
bridge and lined channel
banks

OS NGR: 32861 70289

Notes:

	<p>Location : 37</p> <p>Description: Lined channel banks</p> <p>OS NGR: 32864 70285</p> <p>Notes:</p>
	<p>Location : 38</p> <p>Description: Boulder weir structure</p> <p>OS NGR: 32869 70268</p> <p>Notes: Extend boulder area downstream if removal not possible</p>
	<p>Location : 39</p> <p>Description: Redundant notched weir</p> <p>OS NGR: 32873 70256</p> <p>Notes:</p>



Location : 40

Description: Lined channel section through golf course

OS NGR: 32890 70265

Notes: Good in-channel hydromorphology



Location : 41

Description: Small weir backing up water for the golf course

OS NGR: 32899 70272

Notes:



Location : 42

Description: Boulder weir and lined channel

OS NGR: 32910 70275

Notes:

	<p>Location : 43</p> <p>Description: Palaeo-feature on floodplain</p> <p>OS NGR: 32968 70244</p> <p>Notes:</p>
	<p>Location : 44</p> <p>Description: Straightened channel reach</p> <p>OS NGR: 32972 70248</p> <p>Notes:</p>
	<p>Location : 45</p> <p>Description: Wet woodland formed next to the railway embankment splitting the floodplain</p> <p>OS NGR: 32989 70250</p> <p>Notes:</p>

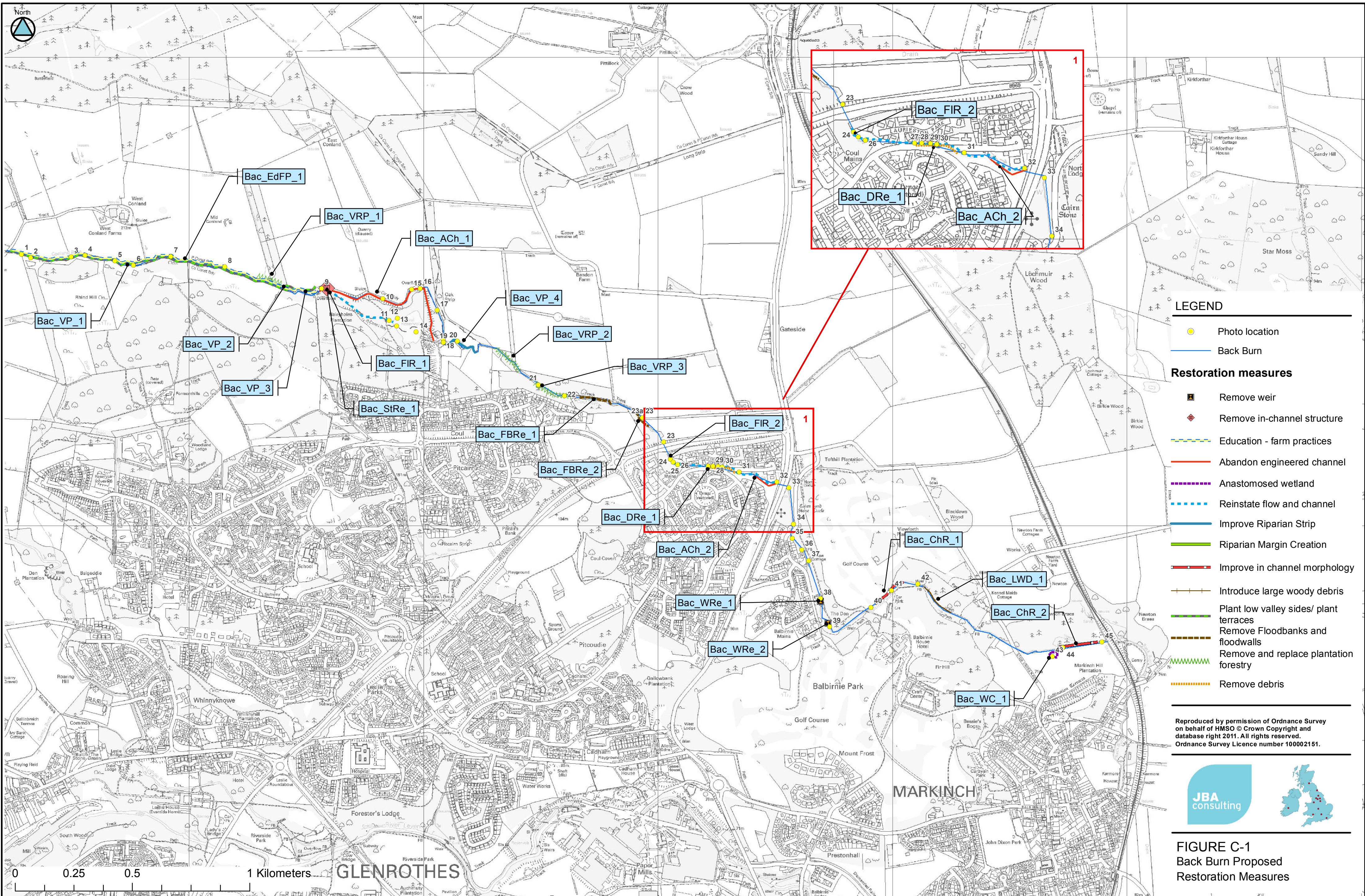
C Restoration opportunity maps and tables

Figure C- 1: Back Burn Proposed Restoration Measures

Figure C- 2: Capacity used by individual pressures on Back Burn

Figure C- 3: Property Ownership surrounding the Back Burn (100m)

Table C- 1: Restoration Measure Assessment Tables



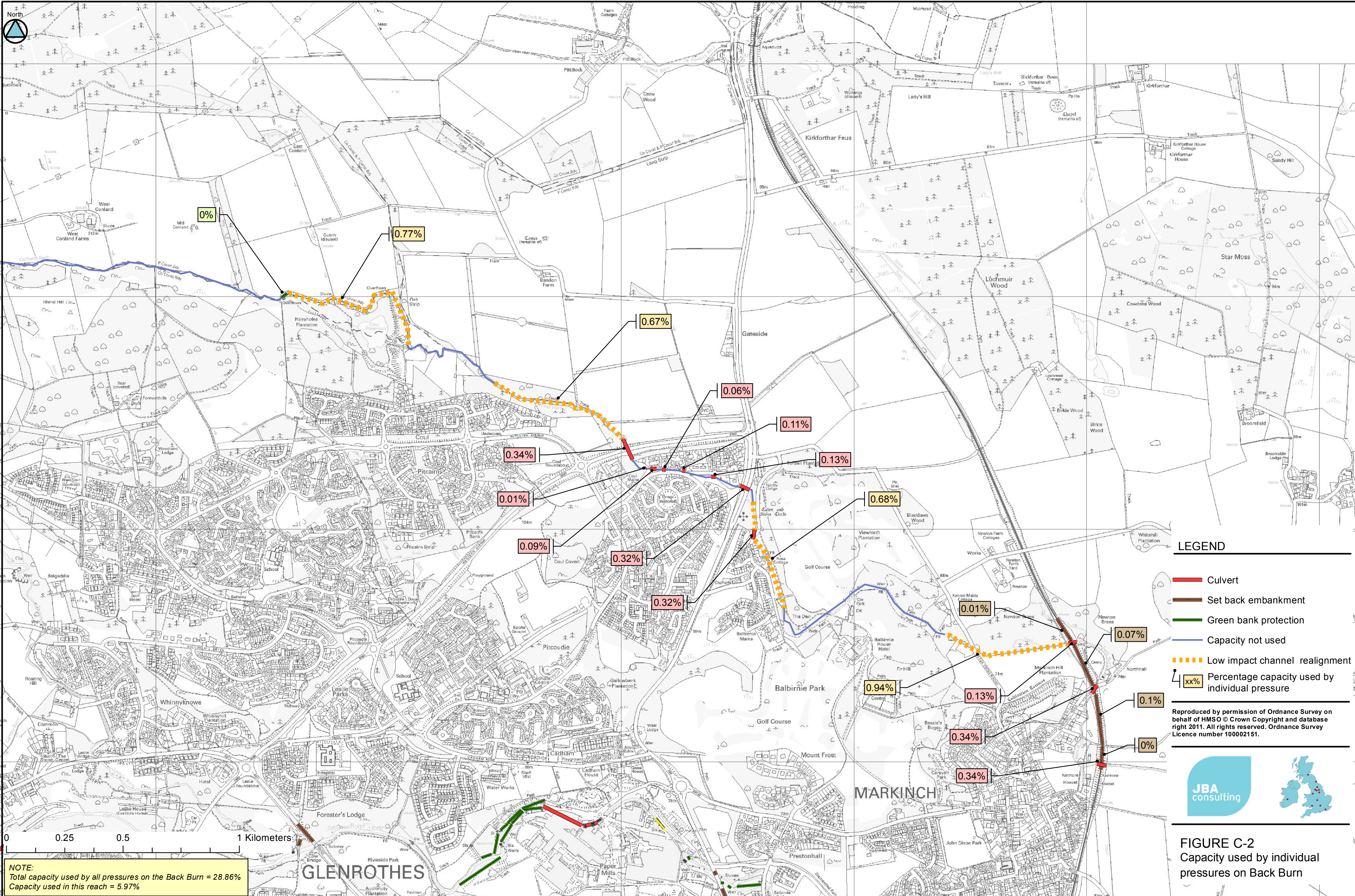
LEGEND

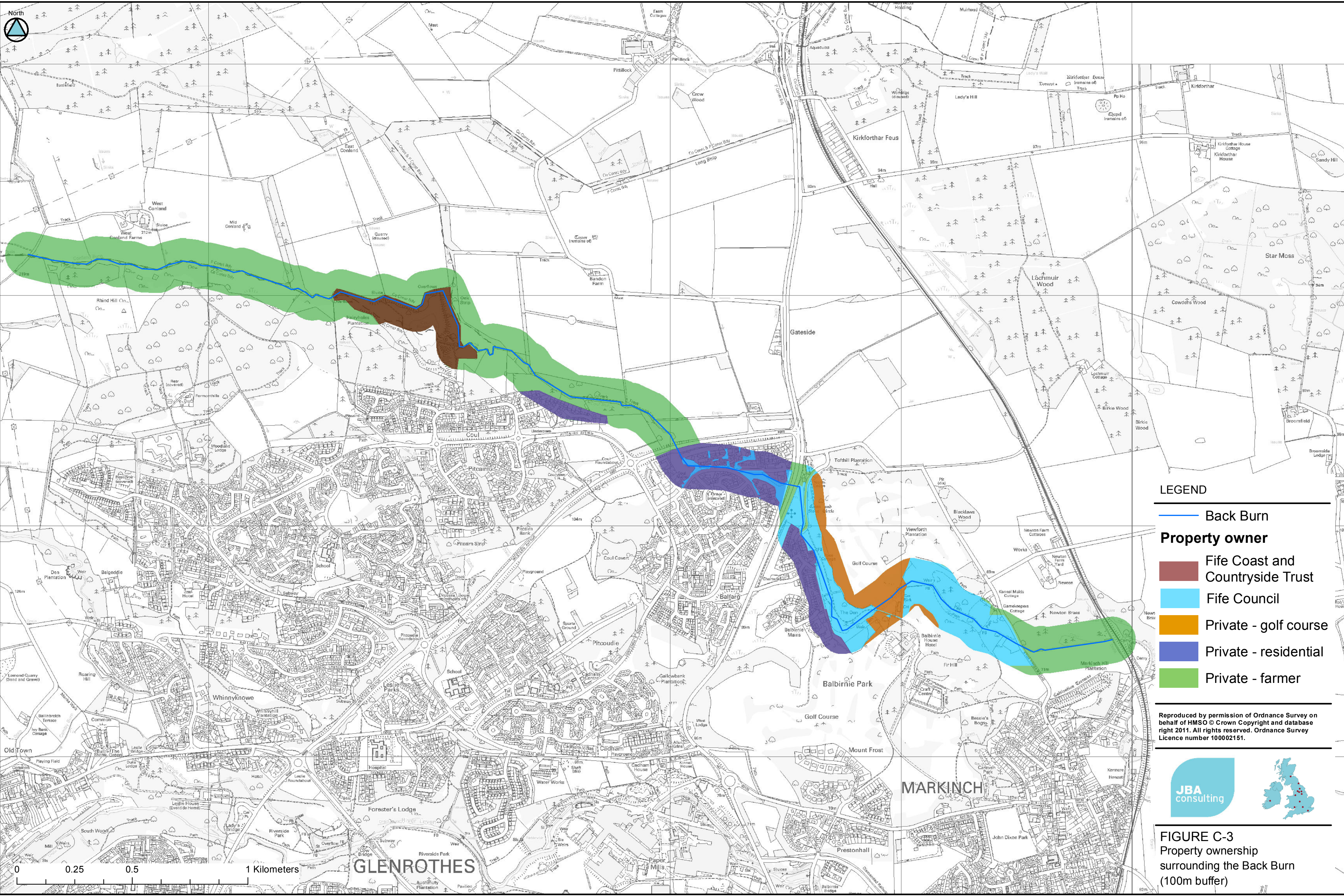
- Photo location
- Back Burn
- Restoration measures
 - Remove weir
 - Remove in-channel structure
 - Education - farm practices
 - Abandon engineered channel
 - Anastomosed wetland
 - Reinstatement flow and channel
 - Improve Riparian Strip
 - Riparian Margin Creation
 - Improve in channel morphology
 - Introduce large woody debris
 - Plant low valley sides/ plant terraces
 - Remove Floodbanks and floodwalls
 - Remove and replace plantation forestry
 - Remove debris

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FIGURE C-1
Back Burn Proposed
Restoration Measures





LEGEND

Back Burn

Property owner

Fife Coast and Countryside Trust

Fife Council

Private - golf course

Private - residential

Private - farmer

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FIGURE C-3
Property ownership
surrounding the Back Burn
(100m buffer)

Table C-1: Restoration Measure Assessment Tables

ISSUE 1: <div><div>- Poor valley floor and valley side vegetation</div><div>- Plantation forestry in one section</div></div>		ACTIONS: <div><div>- Plant low valley sides and terraces</div><div>- Remove and replace plantation forestry</div></div>		Unique ID: Bac_VP_1, Bac_VP_2, Bac_VP_3, Bac_VRP_1						
Site information	Description	Conland Road to Hairyholes Plantation		Cost estimate	Estimate (£k) – valley planting		80	Width (m)	50	
	OS NGR	325234E 704173N to 326535E to 704027N – Bac_VP_1, Bac_VP_2, Bac_VP_3 326291F 704068N to 326397F 704032N – Bac_VRP_1			Estimate (£k) – plantation forestry		5.2		20	
	Photo reference	Appendix B: photos 1 to 8			Assumptions	Valley planting on both sides of waterway (1250m) and a further 89m on one side only. Plantation removal and planting on one side of waterway. Estimate includes fencing, plants, labour costs and disposal of some material.				
	Access	Access to the upstream extent of the reach via farm track (Conland Road)								
	Reach length (m)	1339 (valley planting), 112 (plantation forestry)								
Pressure	Pressures to be addressed through regulatory means	<div><div></div><div>Rural diffuse pollution</div><div></div><div>Morphological</div></div>		Further considerations	Funding mechanism / opportunities	Fund name		Applicability		
	IHN	Broadleaved and yew woodland				Scotland Rural Development Fund	Challenge Funds		✓	
	IHN opportunity area (JBA ID)	<div><div></div><div>236_6303_Morph_BYW_326604_703959</div><div></div><div>237_6303_Morph_BYW_325250_704159</div><div></div><div>238_6303_RuralDP_BYW_327655_703302</div></div>					Rural Development Contracts – Land Manager Options		✓	
							Rural Priorities – Forth Area		✓	
Associated data sources	<div><div></div><div>Partially within fluvial 200 yr</div><div></div><div>Adjacent to local nature conservation site (downstream)</div><div></div><div>Core paths from the north, south and east intersect the downstream section of the reach</div></div>		Scottish Natural Heritage			Natural Project Grants		✓		
						Community Grants		✓		
						Central Scotland Green Network		✓		
Habitat	Type of existing habitat	Arable fields with small unimproved grass riparian margins on the left bank. The right bank is steeper with a dry stone dyke separating the unimproved/rushy burn margin from a mosaic of gorse scrub and unimproved acid grassland.				SEPA Scottish restoration fund	✓			
	Extent of existing habitat	Typically 5 metres on either side of the burn but wider in places.					Land developer (ie. of surrounding area)	✗		
	Quality of existing habitat	Riparian margin is of good quality in this area and acts as effective buffer strip except in forestry section.						Other: <div><div></div><div>The Naturesave Trust</div></div>	✓	
	Sensitivity of existing habitat to land use / habitat change	High if planted with trees (especially coniferous species) or allowed to naturally regenerate with tree cover, i.e. left unmown/ungrazed. Low if existing forestry cover is removed and light allowed to reach watercourse.								
	Indicative species mix for restoration	Grey Sallow, Alder streamsid es. Ash, Wych Elm on the higher slopes with Sessile Oak, Silver Birch on the braes, if planting extends this far.								
	Establishment techniques required	Bare root plants and mounding								
Benefits	Barrier to restoration?	✗		Other surveys required	Survey Type		Required			
	Capacity released – contribution to obtaining GES	None – no information on capacity released through improving floodplain vegetation			Ecological habitat survey		✗			
	Flood risk benefit?	✓	Planting will increase floodplain roughness and reduce flood flow velocities		Hydrological survey		✗			
	Public access (existing or can connect to?)	✓	Potential to link into core paths downstream of the area		Ground investigation		✗			
	Multiple WFD benefits	Potential benefit			Applicability		Topographical survey		✗	
		Opportunity to expand green/ecological network			✓		Water quality monitoring		✗	
		Help achieve good ecological status		✓		Construction / restoration costs	Methods	Access required	✓	Through farmland / track
		Contribute to addressing flood risk		✓				Machinery required	✓	To remove plantation trees
		Reduce invasive non-native species		✗				Mitigation measures	✗	
		Climate change adaptation		✓			Timing	Avoid nesting time		
	Raise awareness of the benefits of healthy water environments		✓		Logistics	Ideally planting to be done between November and February – avoiding snow and frost where possible				
	Wider environmental benefits		Increase in floodplain biodiversity; contribute to improving IHN		CAR licensing required	N/A				
Ownership	Suggested action owner		Landowner							
	Land owner		Private – farmer (West Conland Farm)							

ISSUE 2: Poor farm practices including gullying adjacent to the channel						ACTIONS: Education – farm practices				Unique ID: Bac_EdFP_1				
Site information	Description		Conland Road to Hairyholes Plantation			Cost estimate	Estimate (£k)		Requires further assessment. Education will require liaison with farmer and review of current practices. Then appropriate control measures / changes in practices would need to be designed and implemented.					
	OS NGR		325234E 704173N to 326535E 704027N - Bac_EdFP_1				Assumptions		SEPA to action					
	Photo reference		Appendix B: photos 1 to 8			Further considerations	Funding mechanism / opportunities	Fund name			Applicability			
	Access		Access to the upstream extent of the reach via farm track (Conland Road)					Scotland Rural Development Fund	Challenge Funds		✘			
	Reach length (m)		1380						Rural Development Contracts – Land Manager Options		✓			
					Rural Priorities – Forth Area				✓					
Pressure	Pressures to be addressed through regulatory means		<ul style="list-style-type: none">Rural diffuse pollutionMorphological					Scottish Natural Heritage	Natural Project Grants		✘			
	IHN		Broadleaved and yew woodland						Community Grants		✓			
	IHN opportunity area (JBA ID)		<ul style="list-style-type: none">236_6303_Morph_BYW_326604_703959237_6303_Morph_BYW_325250_704159238_6303_RuralDP_BYW_327655_703302						Central Scotland Green Network		✓			
	Associated data sources		<ul style="list-style-type: none">Partially within fluvial 200 yrAdjacent to local nature conservation site (downstream)Core paths from the north, south and east intersect the downstream section of the reach											
Habitat	Type of existing habitat		Arable fields and adjacent riparian margins					Further considerations	Funding mechanism / opportunities	SEPA Scottish restoration fund			✘	
	Extent of existing habitat		Entire reach of watercourse on left bank							Land developer (ie. of surrounding area)			✘	
	Quality of existing habitat		Arable fields are a poor habitat although the riparian strip, although narrow, is a good quality habitat			Other: <ul style="list-style-type: none">The Naturesave TrustThe Ibrahim FoundationThe Steel Charitable Trust				✓ ✓ ✓				
	Sensitivity of existing habitat to land use / habitat change		Arable fields – low; riparian margin – high											
	Indicative species mix for restoration		Not applicable											
	Establishment techniques required		Contour ploughing rather than slope-directional ploughing; minimum tillage											
Benefits	Barrier to restoration?		✘			Other surveys required	Survey Type			Required				
	Capacity released – contribution to obtaining GES		None – no information on capacity released through improving diffuse pollution				Ecological habitat survey			✘				
	Flood risk benefit?		✓		Potential measures will reduce rate of runoff from farmland		Hydrological survey			✘				
	Public access (existing or can connect to?)		✓		Potential to link into core paths downstream of the area		Ground investigation			✘				
							Topographical survey			✘				
							Water quality monitoring			✘				
							Construction / restoration costs	Methods	Access required		N/A			
						Machinery required			N/A					
						Mitigation measures			N/A					
	Multiple WFD benefits		Potential benefit			Applicability		Timing		N/A				
			Opportunity to expand green/ecological network			✓		Logistics		N/A				
			Help achieve good ecological status			✓								
		Contribute to addressing flood risk			✓									
		Reduce invasive non-native species			✘									
		Climate change adaptation			✘									
		Raise awareness of the benefits of healthy water environments			✓									
Ownership	Wider environmental benefits		Improve farming practices			CAR licensing required			N/A					
	Suggested action owner		SEPA and landowner											
	Land owner		Private – farmer (West Conland Farm)											

ISSUE 3: Flow is split between engineered channel and channel to reservoir				ACTION: Reinstate flow and channel to reservoir, abandon engineered channel. Excavate area adjacent to sluice gate to reinstate side weir. Remove sluice gate (if possible). Add boulder wrapping.							Unique ID: Bac_FIR_1, Bac_ACh_1, Bac_StRe_1							
Site information	Description		Upstream of Coul Reservoir			Cost estimate	Estimate (£k)	10	Dimensions		3m width x 1m depth							
	OS NGR		3265593E 704004N to 327041E 703791N				Assumptions	Assume that sluice gate is able to be removed/disabled (would need to check if it an historic structure). All material to be disposed of off-site. Includes time for 1 day site work for supervisor. Cost also includes £3000 for hydrological model to assess impacts on reservoir and reinstated channel; and £2000 for topographical survey.										
	Photo reference		Appendix B: Photos 9, 10, 11, 15 to 19			Further considerations		Funding mechanism / opportunities	Fund name				Applicability					
	Access		Potential access from the south via Calder Court				Scotland Rural Development Fund		Challenge Funds		✘							
	Reach length (m)		5						Rural Development Contracts – Land Manager Options		✓							
Rural Priorities – Forth Area									✓									
Pressure	Pressures to be addressed through regulatory means		<ul style="list-style-type: none">Rural diffuse pollutionMorphological				Scottish Natural Heritage		Natural Project Grants		✘							
	IHN		Broadleaved and yew woodland						Community Grants		✘							
	IHN opportunity area (JBA ID)		238_6303_RuralDP_BYW_327655_703302						Central Scotland Green Network		✘							
	Associated data sources		<ul style="list-style-type: none">Within local nature conservation siteCore paths around reservoir and along part of the reachFully within fluvial 200 yr															
Habitat	Type of existing habitat		Aquatic flora in artificial channel						SEPA Scottish restoration fund				✓					
	Extent of existing habitat		In channel only						Land developer (ie. of surrounding area)				✘					
	Quality of existing habitat		Poor quality aquatic vegetation				Other:				✘							
	Sensitivity of existing habitat to land use / habitat change		Very low															
	Indicative species mix for restoration		Not applicable															
	Establishment techniques required		Redirection of flow into natural watercourse															
Benefits	Barrier to restoration?		✓	Victorian sluice gate owned by Fife Coast and Countryside Trust			Other surveys required	Survey Type				Required						
	Capacity released – contribution to obtaining GES		0.77%					Ecological habitat survey				✘						
	Flood risk benefit?		✓	Removing engineering channel from the system will assist in naturalising flows.				Hydrological survey				✓						
	Public access (existing or can connect to?)		✓	Existing public access via core paths around the reservoir				Ground investigation				✘						
	Multiple WFD benefits			Potential benefit		Applicability		Topographical survey				✓						
				Opportunity to expand green/ecological network		✓		Water quality monitoring				✘						
				Help achieve good ecological status		✓		Construction / restoration costs				Methods		Access required		✓	Access to the upstream end of the site may be difficult / time consuming	
				Contribute to addressing flood risk		✓								Machinery required		✓	Machinery to be stored out of floodplain	
				Reduce invasive non-native species		✘								Mitigation measures		✓	Sediment control measures to minimise sediment disturbance and movement downstream. Measures for the protection of otters in the local area.	
				Climate change adaptation		✘		Timing		To be carried out during low flow periods								
				Raise awareness of the benefits of healthy water environments		✘		Logistics		Potentially multiple landowners to be consulted								
	Wider environmental benefits		Increase in in-channel and floodplain biodiversity															
Ownership	Suggested action owner		Fife Coast and Countryside Trust			CAR licensing required	Registration			Simple licence		✓	Complex licence					
	Land owner		Fife Coast and Countryside Trust				Realignment ≤ 3m wide											

ISSUE 5: Plantation forestry surrounding channel; excessive fine sediment in the channel bed					ACTION: Remove and replace plantation forestry			Unique ID: Bac_VRP_2, Bac_VRP_3				
Site information	Description	Downstream of Coul Reservoir			Cost estimate	Estimate (£k)	15	Width (m)	20			
	OS NGR	327315E 703760N to 327625E 703555N				Assumptions	All trees disposed of off-site; assumed 20m width on both sides of the waterway. Includes fencing, plants and labour costs.					
	Photo reference	Appendix B: Photo 21 and 22				Funding mechanism / opportunities	Fund name			Applicability		
	Access	Calder Court or B969					Scotland Rural Development Fund	Challenge Funds		✓		
	Reach length (m)	316						Rural Development Contracts – Land Manager Options		✓		
Pressure	Pressures to be addressed through regulatory means	<ul style="list-style-type: none">Rural diffuse pollutionMorphological			Rural Priorities – Forth Area			✓				
	IHN	None – gap in network			Scottish Natural Heritage	Natural Project Grants		✓				
	IHN opportunity area (JBA ID)	N/A				Community Grants		✗				
	Associated data sources	<ul style="list-style-type: none">Fully within fluvial 200 yrLocal nature conservation area is adjacent to area (upstream)Core path runs adjacent to the southern banks of the site				Central Scotland Green Network		✓				
Habitat	Type of existing habitat	Broadleaved plantation woodland, arable, improved grassland			Further considerations	SEPA Scottish restoration fund			✓			
	Extent of existing habitat	Full length of reach				Land developer (ie. of surrounding area)			✗			
	Quality of existing habitat	Moderate (ground flora is of high quality)				Other: <ul style="list-style-type: none">The Naturesave TrustThe Ibrahim Foundation			✓			
	Sensitivity of existing habitat to land use / habitat change	Medium										
	Indicative species mix for restoration	Alder, Great Sallow, Ash, Wych Elm										
	Establishment techniques required	Direct planting of bare-rooted stock; removal of exotic conifers on right bank										
Benefits	Barrier to restoration?	✗				Other surveys required	Survey Type			Required		
	Capacity released – contribution to obtaining GES	None					Ecological habitat survey			✓		
	Flood risk benefit?	✗					Hydrological survey			✗		
	Public access (existing or can connect to?)	✓	Existing core path on the southern banks of the downstream section of the site. This could be extended further upstream.				Ground investigation			✗		
	Multiple WFD benefits	Potential benefit		Applicability			Topographical survey			✗		
		Opportunity to expand green/ecological network		✓			Water quality monitoring			✗		
		Help achieve good ecological status		✓		Construction / restoration costs	Methods	Access required		✗		
		Contribute to addressing flood risk		✗				Machinery required		✗		
		Reduce invasive non-native species		✓				Mitigation measures		✗		
		Climate change adaptation		✗			Timing	Ideally planting to be done between November and February – avoiding snow and frost where possible				
	Raise awareness of the benefits of healthy water environments		✗		Logistics			N/A				
	Wider environmental benefits	Increase in floodplain and in-channel biodiversity				CAR licensing required	N/A					
Ownership	Action owner	Landowner										
	Land owner	Private - farmer directly adjacent to the burn; private residential to the south										

ISSUE 6: Floodplain disconnection					ACTION: Remove / set back floodbanks					Unique ID: Bac_FBRe_1, Bac_FBRe_2							
Site information	Description	Upstream of B969			Cost estimate	Estimate (£k)	39	Dimensions		2m height x 1m width							
	OS NGR	327665E 703548n to 327958E 703424N				Assumptions	All material to be disposed of off-site. Flood banks on both side of waterway. Includes 3 days time for site engineer.										
	Photo reference	None			Further considerations	Funding mechanism / opportunities	Fund name				Applicability						
	Access	Access via B969 (Western Avenue) and track alongside burn					Scotland Rural Development Fund	Challenge Funds		✘							
	Reach length (m)	233						Scotland Rural Development Fund	Rural Development Contracts – Land Manager Options		✘						
				Rural Priorities – Forth Area					✓								
Pressure	Pressures to be addressed through regulatory means	<ul style="list-style-type: none">Rural diffuse pollutionMorphological					Scotland Natural Heritage	Natural Project Grants		✘							
	IHN	None – gap in network						Community Grants		✘							
	IHN opportunity area (JBA ID)	N/A						Central Scotland Green Network		✘							
	Associated data sources	<ul style="list-style-type: none">Fully within fluvial 200 yrCore path runs adjacent to the southern banks of the site															
Habitat	Type of existing habitat	Floodbank and concrete/stone armour channel lining.					Further considerations	Other surveys required	SEPA Scottish restoration fund				✓				
	Extent of existing habitat	233m							Land developer (ie. of surrounding area)				✘				
	Quality of existing habitat	Poor			Other				✘								
	Sensitivity of existing habitat to land use / habitat change	Low															
	Indicative species mix for restoration	Plant alder on stream banks															
	Establishment techniques required	Bare root planting															
Benefits	Barrier to restoration?	✘			Further considerations	Other surveys required			Survey Type				Required				
	Capacity released – contribution to obtaining GES	Realignment of 632m of channel uses 0.67% (total length of two floodwalls is 233m – as a proportion this is about 0.25%)							Ecological habitat survey				✘				
	Flood risk benefit?	✓		Increase floodplain connectivity; reduce water backing up through area and lower risk of upstream flooding. Removal of material will increase storage capacity of floodplain.					Hydrological survey				✓				
	Public access (existing or can connect to?)	✓		Existing core path on the southern banks of the downstream section of the site. This could be extended further upstream.					Ground investigation				✓				
	Multiple WFD benefits	Potential benefit					Applicability		Topographical survey				✓				
		Opportunity to expand green/ecological network					✘		Water quality monitoring				✘				
		Help achieve good ecological status					✓		Construction / restoration costs	Methods	Access required		✓ Need to arrange access via the B969 road at the downstream end. Traffic management would be required to ensure disruption to traffic minimised.				
		Contribute to addressing flood risk					✓				Machinery required		✓ Machinery to be stored out of floodplain				
		Reduce invasive non-native species					✘				Mitigation measures		✓ <ul style="list-style-type: none">Sediment control to minimise sediment disturbance and movement downstreamMachinery to be kept out of the watercourse				
		Climate change adaptation					✘			Timing		To be carried out during low flow periods					
	Raise awareness of the benefits of healthy water environments			✓		Logistics		Potentially multiple landowners – public and private. Material to be disposed of off-site									
	Wider environmental benefits			Increase in-channel and floodplain biodiversity and improve reach morphology													
	Ownership	Suggested action owner	Landowner			Further considerations	CAR licensing required	Registration			Simple licence		✓		Complex licence		
		Land owner	Private land -farmer					All set-back embankments and set-back floodwalls									

ISSUE 7: <div><div>- Flow splitting as channel is culverted through the residential area. Bed sedimentation after flow diversion</div><div>- Debris on banks of burn</div><div>- Engineered channel at downstream end of reach</div></div>					ACTIONS: <div><div>- Restore original flow and reinstate channel</div><div>- Remove debris</div><div>- Abandon engineered channel</div></div>					Unique ID: Bac_FIR_2, Bac_DRe_1, Bac_ACh_2				
Site information	Description		Section through residential area at Balfarg, between B969 and A92											
	OS NGR		328048E 703294N to 328509E 703190N - Bac_FIR_2 328009E 703373N to 328082E 703283N - Bac_DRe_1											
	Photo reference		Appendix B – Photos 24 to 32											
	Access		Via Kilmichael Road											
	Reach length (m)		20											
Pressure	Pressures to be addressed through regulatory means		<div><div>• Rural diffuse pollution</div><div>• Morphological</div></div>											
	IHN		None – gap in network											
	IHN opportunity area (JBA ID)		N/A											
	Associated data sources		<div><div>• Fully within fluvial 200 yr</div><div>• Core path runs adjacent to the southern banks of burn in this area</div></div>											
Habitat	Type of existing habitat		Amenity grassland, shrubberies and gardens											
	Extent of existing habitat		Full length of reach											
	Quality of existing habitat		Very low											
	Sensitivity of existing habitat to land use / habitat change		Very low											
	Indicative species mix for restoration		Alder and grey willow											
	Establishment techniques required		Bare root planting											
Benefits	Barrier to restoration?		✓	Very close to surrounding residential properties										
	Capacity released – contribution to obtaining GES		Removing all culverts along this section (223m) releases 1.08% capacity.											
	Flood risk benefit?		?	Would need further investigation to determine potential risk										
	Public access (existing or can connect to?)		✓	Existing core path on the southern banks of the downstream section of the site. This could be extended further upstream.										
	Multiple WFD benefits		Potential benefit			Applicability								
			Opportunity to expand green/ecological network			✓								
			Help achieve good ecological status			✓								
			Contribute to addressing flood risk			?								
			Reduce invasive non-native species			✗								
			Climate change adaptation			✗								
	Raise awareness of the benefits of healthy water environments		✗											
	Wider environmental benefits		Increase in-channel and floodplain biodiversity and improve reach morphology											
	Ownership	Suggested action owner		Fife Council										
		Land owner		Most land immediately adjacent to the burn is owned by Fife Council. Residential properties are also within a 100m buffer of the waterway.										
Cost estimate	Estimate (£k)		10.6		Width (m)		2							
	Assumptions		Hydrological model = £3000, topographical survey = £2000k, 1 day scraping/excavation = £1660 with site engineer. Assume that at least of excavated material will be able to be used as fill onsite.											
Further considerations	Funding mechanism / opportunities	Scotland Rural Development Fund				Fund name			Applicability					
						Challenge Funds		✗						
						Rural Development Contracts – Land Manager Options		✗						
		Rural Priorities – Forth Area		✗										
				Scotland Natural Heritage		Natural Project Grants		✗						
		Community Grants		✗										
				Central Scotland Green Network		✓								
		SEPA Scottish restoration fund				✓								
		Land developer (ie. of surrounding area)				✗								
		Other				✗								
		Other surveys required	Survey Type				Required							
			Ecological habitat survey				✗							
			Hydrological survey				✓							
			Ground investigation				✓							
	Topographical survey				✓									
	Water quality monitoring				✗									
	Construction / restoration costs		Methods	Access required		✗		Machinery to be stored outside the floodplain						
		Machinery required		✓										
		Mitigation measures		✓										
		Timing		Works to be carried out during low flow periods										
		Logistics	Multiple land owners in adjacent area											
			CAR licensing required											
		Registration				Simple licence		✓	Complex licence					
	Realignment on a river ≤ 3m wide													

ISSUE 8: Bank and in-channel structures					ACTION: Remove weirs					Unique ID: Bac_WRe_1, Bac_WRe_2						
Site information	Description		Through the Den and Balbirne Park			Cost estimate	Estimate (£k)		15.9	Dimensions		5m width 1m height				
	OS NGR		328692E 702687N – Bac_WRe_1 328734E 702571N – Bac_WRe_2				Assumptions		Excavated material to be disposed of off-site. Costs include a hydrological model (£3000) and 2 days site work per weir for site engineer.							
	Photo reference		Appendix B – Photo 38 and 39			Further considerations	Funding mechanism / opportunities	Fund name				Applicability				
	Access		Via residential area to west and core path through park					Scotland Rural Development Fund	Challenge Funds		✘					
	Reach length (m)		10						Rural Development Contracts – Land Manager Options		✘					
					Rural Priorities – Forth Area				✘							
Pressure	Pressures to be addressed through regulatory means		<ul style="list-style-type: none">MorphologicalRural diffuse pollution					Scottish Natural Heritage	Natural Project Grants		✘					
	IHN		Broadleaved and yew woodland						Community Grants		✘					
	IHN opportunity area (JBA ID)		<ul style="list-style-type: none">1_6303_Morph_BYW_328733_702676225_6303_RuralDP_BYW_327655_703302						Central Scotland Green Network		✘					
	Associated data sources		<ul style="list-style-type: none">Fully within fluvial 200 yrCore path runs alongside northern banks of burnLevel 1 groundwater floodingGardens and Designed Landscapes – Bilbirnie ParkAdjacent to planned development area													
Habitat	Type of existing habitat		Semi-natural woodland, designed landscape.					SEPA Scottish restoration fund							✓	
	Extent of existing habitat		Entire length of reach					Land developer (ie. of surrounding area)							✘	
	Quality of existing habitat		Good			Other: <ul style="list-style-type: none">Heritage Lottery Fund							✓			
	Sensitivity of existing habitat to land use / habitat change		High													
	Indicative species mix for restoration		Not applicable													
	Establishment techniques required		Not applicable													
Benefits	Barrier to restoration?		✘				Other surveys required	Survey Type				Required				
	Capacity released – contribution to obtaining GES		None – no capacity information available			Ecological habitat survey				✘						
	Flood risk benefit?		✘					Hydrological survey				✓				
	Public access (existing or can connect to?)		✓	Existing public access to site via core path the runs alongside burn.				Ground investigation				✓				
	Multiple WFD benefits		Potential benefit		Applicability			Topographical survey				✘				
			Opportunity to expand green/ecological network		✓			Water quality monitoring				✘				
			Help achieve good ecological status		✓											
			Contribute to addressing flood risk		✘		Construction / restoration costs	Methods	Access required		✘					
			Reduce invasive non-native species		✘				Machinery required		✓	Machinery to be stored outside of floodplain				
	Climate change adaptation		✘		Mitigation measures				✓	Sediment control to minimise sediment disturbance and movement downstream						
			Raise awareness of the benefits of healthy water environments		✘		Timing		Works to be carried out during low flow periods							
	Wider environmental benefits		Increase in-channel biodiversity and improve reach morphology. Potential improvements in fish passage through reach.			Logistics	Redundant material to be disposed of off-site									
	Ownership	Suggested action owner		Fife Council			CAR licensing required	Registration			Simple licence		✓	Complex licence		
Land owner		Fife Council (directly adjacent to the burn); private residential to the south and privately owned golf course to the north.			In-stream structure ≤ 3m wide											

ISSUE 9: Poor in-channel morphology			ACTION: Improve morphology / channel restoration by introducing gravel to create berms and bars					Unique ID: Bac_ChR_1						
Site information	Description	Through Bilbirnie Park			Cost estimate	Estimate (£k)	9.9	Width (m)		5m wide				
	OS NGR	328927E 702609N to 329048E 702761N				Assumptions	Assume that gravel can be sourced from within the catchment. Costs include 1 day excavation time, with time for one site agent.							
	Photo reference	Appendix B – Photo 41			Further considerations	Funding mechanism / opportunities	Fund name			Applicability				
	Access	Via core paths through park / golf course					Scotland Rural Development Fund	Challenge Funds		✘				
	Reach length (m)	157						Rural Development Contracts – Land Manager Options		✘				
Pressure	Pressures to be addressed through regulatory means	<ul style="list-style-type: none">Rural diffuse pollutionMorphological						Rural Priorities – Forth Area		✘				
	IHN	Broadleaved and yew woodland					Scottish Natural Heritage	Natural Project Grants		✘				
	IHN opportunity area (JBA ID)	225_6303_RuralDP_BYW_327655_703302						Community Grants		✘				
	Associated data sources	<ul style="list-style-type: none">Fully within fluvial 200 yrCore path runs alongside northern banks of burnLevel 1 groundwater floodingGardens and Designed Landscapes – Bilbirnie Park						Central Scotland Green Network		✘				
Habitat	Type of existing habitat	Golf course					SEPA Scottish restoration fund			✓				
	Extent of existing habitat	Entire reach					Land developer (ie. of surrounding area)			✘				
	Quality of existing habitat	Very low					Other: <ul style="list-style-type: none">Heritage Lottery Fund			✓				
	Sensitivity of existing habitat to land use / habitat change	Very low: aquatic vegetation present (<i>Ranaunculus aquatilis</i>) will colonise any newly created areas												
	Indicative species mix for restoration	Not applicable												
	Establishment techniques required	Not applicable												
Benefits	Barrier to restoration?	✘				Other surveys required	Survey Type			Required				
	Capacity released – contribution to obtaining GES	None – no capacity information available					Ecological habitat survey			✘				
	Flood risk benefit?	✘	Existing public access to site via core paths and park				Hydrological survey			✓				
	Public access (existing or can connect to?)	✓					Ground investigation			✓				
	Multiple WFD benefits	Potential benefit			Applicability		Topographical survey			?				
		Opportunity to expand green/ecological network			✘		Water quality monitoring			✘				
		Help achieve good ecological status			✓		Construction / restoration costs	Methods	Access required		✓			
		Contribute to addressing flood risk			✘				Machinery required		✓		Machinery to be stored outside of floodplain	
		Reduce invasive non-native species			✘				Mitigation measures		✓		Sediment control to minimise sediment disturbance and movement downstream	
		Climate change adaptation			✘			Timing		Works to be carried out during low flow periods				
		Raise awareness of the benefits of healthy water environments			✓			Logistics		Temporary access required – liaise with golf course				
	Wider environmental benefits	Improvement to channel morphology												
Ownership	Suggested action owner	Golf course owner / Fife Council			CAR licensing required	Registration			Simple licence		✓	Complex licence		
	Land owner	Fife Council owns property on the downstream portion of the reach. The upstream portion of the reach is a privately owned golf course (Balbirnie Park))				Channel modification for rivers ≤ 3m wide								

ISSUE 10: Poor channel morphology				ACTION: Introduce large woody debris to encourage naturalisation and sinuosity				Unique ID: Bac_LWD_1							
Site information	Description	Through Bilbirnie Park			Cost estimate	Estimate (£k)	1.1								
	OS NGR	329132E 702740N to 329249E 702630N				Assumptions	Large woody debris is sourced from within catchment. Cost includes time for 1 days site work for 2 people.								
	Photo reference	Appendix B – Photo 42			Further considerations	Funding mechanism / opportunities	Fund name					Applicability			
	Access	Via core paths through park					Scotland Rural Development Fund	Challenge Funds			✘				
	Reach length (m)	165						Rural Development Contracts – Land Manager Options			✘				
Pressure	Pressures to be addressed through regulatory means	<ul style="list-style-type: none">Rural diffuse pollutionMorphological						Rural Priorities – Forth Area			✘				
	IHN	Broadleaved and yew woodland					Scottish Natural Heritage	Natural Project Grants			✘				
	IHN opportunity area (JBA ID)	225_6303_RuralDP_BYW_327655_703302						Community Grants			✘				
	Associated data sources	<ul style="list-style-type: none">Fully within fluvial 200 yrCore paths to west and east of reachLevel 1 groundwater floodingGardens and Designed Landscapes – Bilbirnie Park						Central Scotland Green Network			✘				
Habitat	Type of existing habitat	Broadleaved woodland					SEPA Scottish restoration fund					✓			
	Extent of existing habitat	Full length of reach					Land developer (ie. of surrounding area)					✘			
	Quality of existing habitat	Good					Other: <ul style="list-style-type: none">Heritage Lottery Fund					✓			
	Sensitivity of existing habitat to land use / habitat change	High													
	Indicative species mix for restoration	Not applicable													
	Establishment techniques required	Not applicable													
Benefits	Barrier to restoration?	✘					Other surveys required	Survey Type					Required		
	Capacity released – contribution to obtaining GES	None – no capacity information available						Ecological habitat survey					✘		
	Flood risk benefit?	✘						Hydrological survey					✘		
	Public access (existing or can connect to?)	✓	Existing public access to site via core paths and park					Ground investigation					✘		
	Multiple WFD benefits	Potential benefit			Applicability										
		Opportunity to expand green/ecological network			✘										
		Help achieve good ecological status			✓										
		Contribute to addressing flood risk			✘										
		Reduce invasive non-native species			✘										
		Climate change adaptation			✘										
	Wider environmental benefits	Raise awareness of the benefits of healthy water environments			✓		Construction / restoration costs	Methods	Access required		✓				
									Machinery required		✘				
									Mitigation measures		✘				
					Timing	Works to be carried out during low flow periods									
					Logistics	N/A									
Ownership	Suggested action owner	Fife Council			CAR licensing required	Registration			Simple licence		✓	Complex licence			
	Land owner	Fife Council directly adjacent to the burn; privately owned golf course (Bilbirnie Park) to the south				In-stream structures in rivers ≤ 3m wide									

ISSUE 11: Modified channel – straightening, paleo channel evident				ACTION: Improve in-channel morphology by creating two stage channel anastomosed wetland creation				Unique ID: Bac_ChR_2, Bac_WC_1						
Site information	Description	Newton Braes - downstream of Stob Cross Road		Cost estimate	Estimate (£k) – channel restoration	52	Dimensions	171m length x 4m width						
					Assumptions	At least 25% of excavated material would need to be disposed of off-site. Includes costs for 5 days of site engineers time.								
	OS NGR	329702E 702485N to 329874E 702505N – Bac_ChR_2 329694E 702451N – Bac_WC_1			Estimate (£k) – wetland	93	Dimensions	50m x 30m						
	Photo reference	Appendix B – Photo 43 and 44		Further considerations	Assumptions	Wetland design and study - £5000; scraping, planting, disposal costs = £48,000. Includes 10 days planting time and 5 days for site engineer.								
	Access	Stob Cross Road and across Markinch Hill Plantation			Funding mechanism / opportunities		Fund name			Applicability				
	Reach length (m)	210					Scotland Rural Development Fund	Challenge Funds		✘				
	Pressure	Pressures to be addressed through regulatory means	<ul style="list-style-type: none">Rural diffuse pollutionMorphological					Rural Development Contracts – Land Manager Options	Rural Priorities – Forth Area		✓			
IHN		Broadleaved and yew woodland							Natural Project Grants		✘			
IHN opportunity area (JBA ID)		225_6303_RuralDP_BYW_327655_703302					Community Grants		✘					
Associated data sources	<ul style="list-style-type: none">Fully within fluvial 200 yrCore path to the south of Markinch Hill PlantationLevel 1 groundwater flooding		Scottish Natural Heritage				Central Scotland Green Network		✓					
Habitat	Type of existing habitat	Wet grassland				SEPA Scottish restoration fund			✓					
	Extent of existing habitat	Full length of reach on right bank				Land developer (ie. of surrounding area)			✘					
	Quality of existing habitat	Moderate				Other: <ul style="list-style-type: none">The Naturesave TrustThe Ibrahim Foundation			✓					
	Sensitivity of existing habitat to land use / habitat change	Medium							✓					
	Indicative species mix for restoration	Lesser pond sedge, branched burr-reed, yellow flag iris												
	Establishment techniques required	Direct planting												
Benefits	Barrier to restoration?	✘			Other surveys required	Survey Type			Required					
	Capacity released – contribution to obtaining GES	Realignment of 884m in this area will release 0.94% of capacity (the proposed improvements are only a proportion of this)				Ecological habitat survey			✓					
	Flood risk benefit?	✓	Will allow flood flows to flow over floodplain and through wetland, reducing flow velocities through reach.			Hydrological survey			✓					
	Public access (existing or can connect to?)	✓	Could connect to existing core paths – existing path is located upstream of Stob Cross Road and to the south of Markinch Hill Plantation.			Ground investigation			✓					
	Multiple WFD benefits	Potential benefit		Applicability		Topographical survey			✘					
		Opportunity to expand green/ecological network		✓		Water quality monitoring			✘					
		Help achieve good ecological status		✓		Construction / restoration costs	Methods	Access required		✓				
		Contribute to addressing flood risk		✓				Machinery required		✓	Machinery to be stored outside of floodplain			
		Reduce invasive non-native species		✘				Mitigation measures		✓	Sediment control to minimise sediment disturbance and movement downstream			
		Climate change adaptation		✘			Timing	Works to be carried out during low flow periods						
	Raise awareness of the benefits of healthy water environments		✘		Logistics		Temporary access required							
	Wider environmental benefits	Increase in-channel and floodplain biodiversity with long term positive ecological effects; contribute to improving IHN			CAR licensing required	Registration			Simple licence		✓	Complex licence		
	Ownership	Suggested action owner	Landowner			Channel modifications in rivers ≤ 3m wide								
	Land owner	Private – Markinch Hill Plantation (to the south) and Newton Braes (to the north)												

D Methodology for calculation of costs of proposed restoration measures

Cost estimates for restoration options are difficult to define at the outline stage due to uncertainty regarding the choice and phasing of the proposed options, the volumes of material and sediment involved and other aspects such as access, local contractor rates and planting costs.

Indicative costs have been built up using a range of cost information available from research reports, guidance documents, unit costs and price indices documents (e.g. SPONs¹). Costs for these options are generic and should be considered to be indicative at this stage before more detailed operations are defined.

A spreadsheet provided by Natural England² for use in other restoration works has been used as a baseline tool to build up costs for each of the options assessed³. This has been used for a number of restoration studies by the Environment Agency and Natural England.

The following general assumptions to all options apply:

- Capital costs have been assumed. Long term maintenance costs have not been calculated, but are assumed to be minimal. Some additional maintenance or monitoring costs may also be applicable but have not been determined at this stage.
- An optimism bias of 60% has been used. This is appropriate at this level of study due to the uncertainties involved and the inherent systematic tendency to be over-optimistic about key project parameters. At detailed design stage it is common practice to develop a risk register and this will enable the reduction of the optimism bias⁴.
- No land purchase costs have been assumed. If land purchase is required, the costs for this could be significant.
- Contractor management costs have been assumed based on the following typical assumptions (see cost breakdown for actual costs assumed).
- Planting personnel (@ £80 per day)
- Site agent (@ £240 per day)
- Site engineer (@ £350 per day)
- No costs for stakeholder consultation and negotiation have been included at this time
- There are no costs included for the possible construction of new access tracks

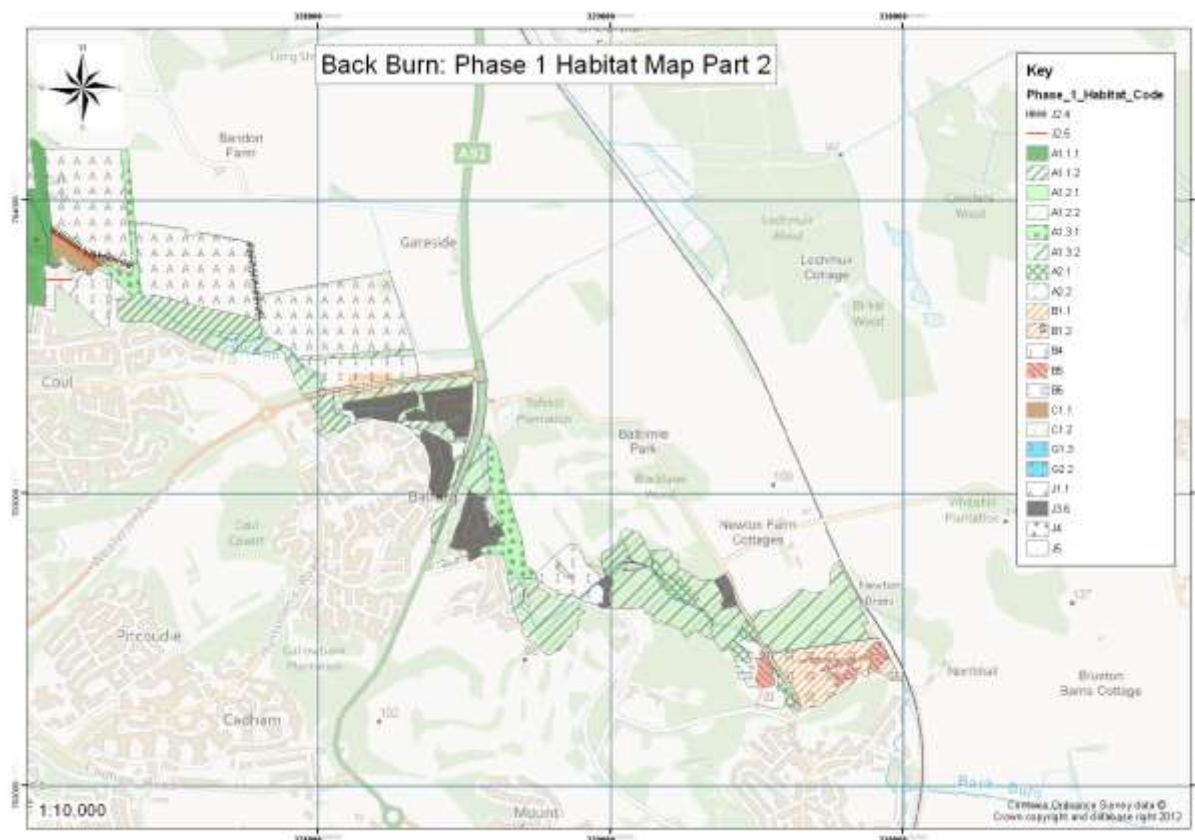
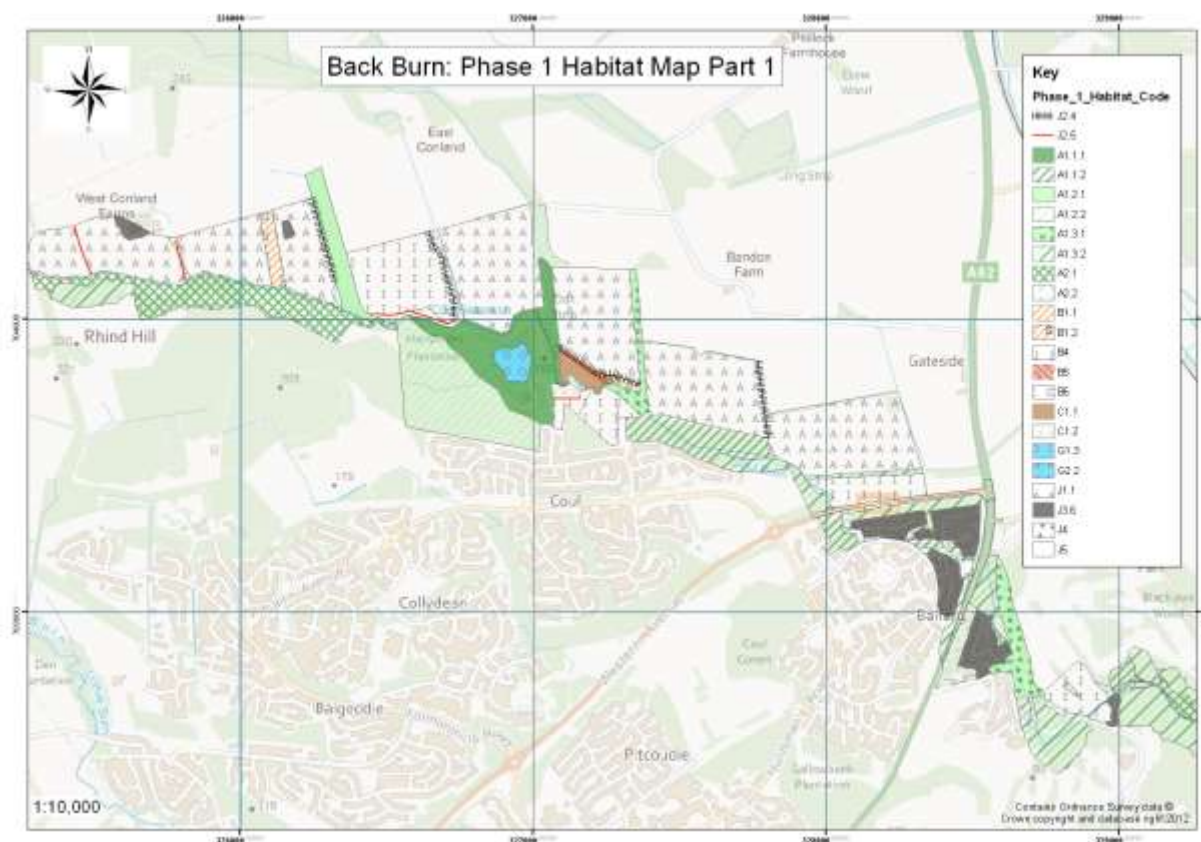
All other assumptions relating to specific calculations for individual proposed restoration measures are included in the explanation tables for each measure.

¹ SPON'S Civil Engineering and Highway Works Price Book, 2008

² 'EA River Restoration project spreadsheet', Natural England, 2008

³ This spreadsheet was used for the 'Estimating costs of delivering the river restoration element of the SSSI PSA target', Final Report January 2008 (Environment Agency).

E Phase 1 habitat mapping



F Options assessment: multi-criteria analysis

INDICATOR AND RATING DESCRIPTIONS

Feature	Indicator	Description	Rating			Weighting of indicator
			Positive	Neutral	Low	
Area / length	Length of reach	What is the length of reach that the measure will improve?	> 1km	200m - 1km	<200m	Secondary
Flood risk	Flood risk reduction	Will the measure reduce or increase flood risk? Consider no. of properties affected, depth of flooding, velocities, frequency etc.	Reduction in flood risk	No change to flood risk	Increase in flood risk to adjacent land	Primary
Capacity	Release capacity	Does the measure release capacity to contribute to obtaining GES?	≥1%	<1%	None	Primary
Multiple benefits	Multiple benefits	Does the measure provide multiple benefits? Eg. Expand ecological network, achieve ecological status, address flood risk, reduce invasive species, climate change adaptation, raise public awareness	3 or more potential benefits	1 or 2 potential benefits	None of these potential benefits	Primary
Ecology / morphology	Habitat expansion / connection	Will action increase length of existing good habitat by linking or extending reaches of existing good quality habitat?	Links 2 or more good areas	Links one good area	No linkage of good quality habitat	Primary
	Biological status	Does the action contribute to improving biological status?	Strong improvement	Some improvement	No likely improvement	Secondary
	Chemical status	Does the action contribute to improving chemical status?	Strong improvement	Some improvement	No likely improvement	Secondary
	Broader ecological effects	Does the measure have potential wider ecological benefits or adverse effects? Eg. to local terrestrial or aquatic populations.	Strong improvement	Some improvement	No improvement; Deterioration	Secondary
	Invasive non-native species reduction	Will the action reduce non-native species populations	Long term eradication / removal over large area		No reduction or removal of species	Primary
Climate change	Climate change adaptation	Does the measure contribute to helping adapt to climate change?	Yes - does contribute to climate change adaptation		No - does not contribute to climate change adaptation	Primary
Socio - economic	Public awareness	Does the measure increase public awareness of the benefits of healthy waterways and environments?	Large contribution	Moderate contribution	Little or no contribution	Primary
	Recreation	Is the measure compatible with current recreation in the area? Does it increase public access to the waterway (core paths) or create other recreation opportunities?	Potential for new opportunity	No effect on current recreation access	Not compatible with current recreation in the area	Secondary
	Costs to landowner or business	Will the action result in long term or significant losses to businesses / adjacent landowners. Eg. reduced yield or land value	No long-term costs	Some long-term costs	Significant long-term costs	Primary
	Upstream or downstream effects?	Any adverse or positive effects on upstream or downstream parties. Eg. Flood risk, recreation, habitat, fisheries... Etc.	Positive upstream or downstream effects	No upstream or downstream effects	Potential adverse upstream or downstream effects	Secondary
	Physical barrier to restoration	Are there physical barriers that may restrict the implementation of the measure? Any historic features that may be protected?	No physical or historic barriers		Physical / historic barrier present	Primary
	Community / landowner support	Is there landowner / community support?	Known landowner / community support	Potentially favoured	Not supported by community or landowner	Secondary
	On-going management	Will the measure require on-going maintenance, monitoring or any other works?	Minimal on-going management	Small-scale management needed	Intensive or long-term management required	Secondary
	Cost of implementation	What is the estimated cost of the measure?	< £10k	≥ £10k < £50k	≥ £50k	Primary
	Funding	Likelihood of potential funding?	Potential funding highly likely	Some potential funding options	No funding possibilities	Secondary
	Construction / restoration impacts	Access impacts, environmental impacts, logistics, effects on surrounding residents	Little or no impacts during construction / restoration (impacts are able to be effectively managed)	Some impacts during construction / restoration (with mitigation)	Moderate to high impacts during construction / restoration - impacts not able to be fully mitigated	Secondary

Values allocated for different factors

Rating	Value
Positive	1
Neutral	2
Low	3

* Lower scores indicate more favourable options

** Primary factors have been weighted by dividing values by 2

BACK BURN OPTIONS

Issue No	ID	Measure	Length of reach	Flood risk reduction	Capacity release	Multiple benefits	Habitat expansion / connection	Biological status	Chemical status	Broader ecological effects	Invasive non native species	Climate change adaptation	Public awareness	Recreation	Costs to landowner or business	Upstream or downstream effects?	Physical barrier	Community / landowner support	On-going management	Cost of implementation	Funding	Construction / restoration impacts	Average score	Rank
1	Bac_VP_1, Bac_VP_2, Bac_VP_3, Bac_VRP_1	Plant low valley sides/ plant terraces, Remove and replace plantation forestry	> 1km	Positive	Unknown	Positive	Neutral	Neutral	Neutral	Neutral	Low	Yes	Positive	Positive	Neutral	Positive	Not present	Unknown	Neutral	Low	Positive	Neutral	1.65	2
2	Bac_EdFP_1	Education - farm practices	> 1km	Positive	Unknown	Positive	Low	Positive	Positive	Neutral	Low	No	Neutral	Positive	Neutral	Positive	Not present	Unknown	Low	Unknown	Neutral	Positive	1.50	1
3	Bac_FIR_1, Bac_ACh_1, Bac_SRe_1	Reinstate flow and channel, abandon engineered channel, remove structure (sluice gate)	200m - 1km	Positive	Neutral	Positive	Low	Neutral	Neutral	Neutral	Low	No	Positive	Neutral	Positive	Positive	Not present	Unknown	Positive	Neutral	Positive	Low	1.79	5
4	Bac_VP_4	Improve riparian strip	<200m	Positive	Unknown	Positive	Neutral	Neutral	Positive	Neutral	Low	Yes	Positive	Positive	Neutral	Positive	Not present	Unknown	Neutral	Positive	Positive	Positive	1.71	3
5	Bac_VRP_2, Bac_VRP_3	Remove and replace plantation forestry	200m - 1km	Neutral	Unknown	Positive	Neutral	Neutral	Low	Neutral	Positive	No	Positive	Positive	Positive	Neutral	Not present	Unknown	Neutral	Neutral	Positive	Low	1.92	10
6	Bac_FBR_1, Bac_FBR_2	Remove floodbanks and floodwalls	200m - 1km	Positive	Neutral	Positive	Low	Neutral	Low	Low	Low	No	Positive	Positive	Positive	Positive	Not present	Unknown	Positive	Neutral	Neutral	Neutral	1.86	8
7	Bac_ACh_2, Bac_DRe_1, Bac_FIR_2	Abandon engineered channel, remove debris, reinstate flow and channel	200m - 1km	Unknown	Positive	Neutral	Low	Neutral	Low	Neutral	Low	No	Positive	Positive	Positive	Positive	Present	Unknown	Neutral	Neutral	Neutral	Low	1.83	7
8	Bac_WRe_1, Bac_WRe_2	Remove weirs	<200m	Neutral	Low	Neutral	Positive	Positive	Low	Positive	Positive	No	Positive	Neutral	Positive	Positive	Not present	Unknown	Positive	Neutral	Neutral	Low	1.82	6
9	Bac_ChR_1	Improve in channel morphology	200m - 1km	Neutral	Low	Neutral	Low	Neutral	Low	Neutral	Low	No	Positive	Neutral	Positive	Positive	Not present	Unknown	Neutral	Positive	Neutral	Low	1.93	11
10	Bac_LWD_1	Introduce large woody debris	200m - 1km	Neutral	Low	Neutral	Low	Neutral	Low	Neutral	Low	No	Positive	Neutral	Positive	Positive	Not present	Unknown	Neutral	Positive	Neutral	Neutral	1.87	9
11	Bac_WC_1, Bac_ChR_2	Anastomosed wetlands, improve in channel morphology	200m - 1km	Positive	Neutral	Positive	Neutral	Positive	Neutral	Positive	Low	Yes	Positive	Neutral	Neutral	Positive	Not present	Unknown	Neutral	Low	Neutral	Low	1.75	4

**Average score only averages
ie. If there are any unknowns this indicator will not be calculated in the average.

Lower scores = better
High/positive = 1
Med/neutral = 2
Low/Low = 3

Weighting for primary factors (divisor)
2



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