



Boghead Burn Hydromorphic Character and Restoration Opportunities

FINAL

June 2012



JBA Project Manager

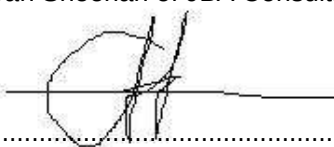
Caroline Anderton
Port Neuk
1 Longcraig Road
South Queensferry
Edinburgh
EH30 9TD

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Contract

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Prepared by  George Heritage BSc PhD
Head of Hydromorphology

Reviewed by  Kieran Sheehan BSc MSc PGCE MIEEM MifL
Senior Ecologist

Reviewed by  Caroline Anderton BSc MSc CEnv CSci
MCIWEM C.WEM
Principal Analyst

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Abbreviations

JBA	JBA Consulting – Engineers & Scientists
ID	Identifier
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 Boghead 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 have 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 Boghead 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 Boghead Burn / Bog Burn / Couston Water (water body ID: 3107) was classified as having an overall status of Bad with high confidence, with overall ecological status of Bad and Physico-Chem status of Moderate. In 2008, SEPA set the overall environmental objectives for the first, second and third River Basin Management Planning (RBMP) cycles, 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	Poor	Poor	Good

The pressures on the water body are morphological alterations (multiple pressures), diffuse source pollution (sewage disposal), diffuse source pollution (mining and quarrying of coal), point source pollution (sewage disposal) and morphological alterations (fish passage).

There is a total capacity of 41.00 % taken up by the morphological pressures on the Boghead Burn with 24.25 % 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	Bad
Pre-HMWB status	Bad
Overall Ecology	Bad
Hydromorphology	Moderate
Hydrology	High
Morphology	Moderate

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

However, currently the classification of the burn has been downgraded because of urban diffuse pollution and not because of rural diffuse pollution.

1.3 General character of Boghead Burn

The Boghead Burn rises on the high ground just South of Armadale in West Lothian and flows in a general Easterly direction before turning North in Bathgate and eventually joins the River Avon, which flows into the Forth north of Linlithgow.

The reach of the burn that forms part of this study stretches from the headwaters to the new Bathgate to Airdrie rail link in the town of Bathgate. This stretch of the watercourse is very varied, beginning in a rural location and flowing through a post-industrial landscape until it flows into the urban surroundings of Bathgate.

1.3.1 The Headwaters

The burn rises from a small grip in a forestry plantation South of Armadale near Tippethill House which meets a flush on a steep slope below the Tippethill Road. This forms the watercourse which then enters a small lochan with a fringe of emergent vegetation, especially reed mace *Typha latifolia* and reed canary grass *Phalaris arundinacea*. This was grazed with overwintered Scottish Blackface sheep at the time of the visit that had escaped through a hole in the fence from the nearby semi-improved grasslands, where a fallen tree had damaged the fencing. The lochan is shallow and is clearly silting-up and is drained by the Boghead Burn which empties from the northern part of the loch into a straight drain that runs between fields of reverting improved pasture alongside a prominent hawthorn *Crataegus monogyna* hedge. This drain flows down a convex slope and eventually the burn flows into a culvert under the farm road and thence, via another drain, into another lochan that has a fringe of unimproved grassland, rushy pasture and willows. Much of the area has recently been planted with mixed forestry.

1.3.2 The Middle Reaches

Here the burn flows through a pastoral agricultural landscape with suckler cow herds and sheep stratification farming systems. These systems are characterised by a mixture of improved and unimproved pastures and this area is no exception. Once again in this area there are a number of lochans although none of these are connected directly to the burn as above and these are probably the result of mining subsidence, due to their shallow nature and disconnection from the surrounding drainage systems. In addition to the lochans, the main feature of this part of the river is the main Whitburn to Falkirk road (A801) which is situated on a high embankment over the surrounding low-lying floodplain (see Figure 1-1).

Figure 1-1: Boghead Burn looking west near Half Loaf Pond showing the raised A801 road



1.3.3 Post Industrial Section

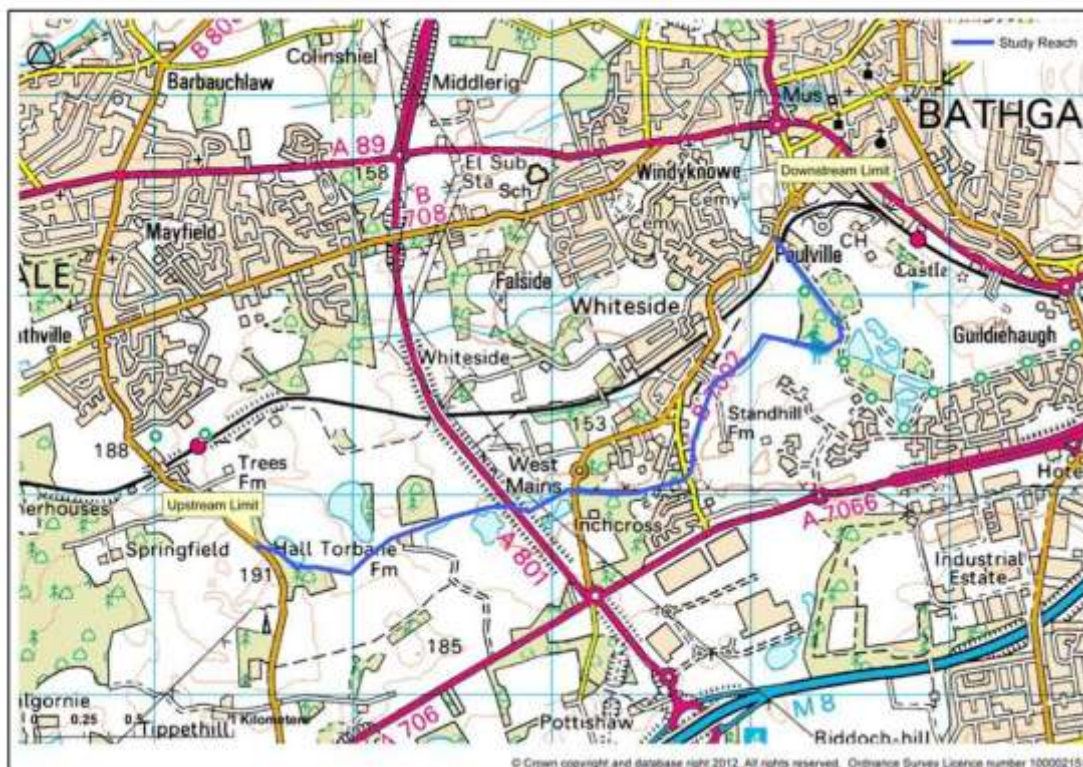
This is downstream of Half Loaf Pond and the B7002. Here there is much evidence of past industrial activity. The land is criss-crossed with old railway embankments which here and there have been cut through to permit drainage and extract mineral. Between the lines the land is wet and is basically composed of poor fen, usually with soft rush *Juncus effusus* or bottle sedge *Carex rostrata* as the dominant species. Elsewhere the land has been reclaimed, the coal and shale bings have been flattened and turned into gently undulating landforms upon which some forestry plantations have grown. Elsewhere pastureland has been allowed to develop, although this is now falling into disuse.

1.3.4 Canalised Urban Section

The final reach surveyed is where the river takes a dramatic turn to the north and flows between high flood banks towards the town of Bathgate, eventually entering the town under a series of bridges. The left bank of the burn is generally forested whilst the right bank is bing material that is currently undergoing reclamation and, on part of this site, a new supermarket has been built. The land away from the river is once again regraded bing material and is used by dog walkers as well as cyclists on the sustrans route which passes under the railway adjacent to the burn.

The Boghead Burn was subject to walkover survey in January 2011 from its source east of Tippetthill road past the confluence with the Bog Burn as far as Boghead Bridge (Figure 1-2).

Figure 1-2: The Boghead Burn hydromorphology survey limits



The character of the river varied considerably along the length of the surveyed watercourse. These are briefly described below working from upstream.

1.4 Detailed Reach Descriptions

1.4.1 The upper burn between Tippethill road and Hall Torbane Farm

The upper reaches of the Boghead Burn are characterised by a series of engineered ditches (Figure 1-3), many of which run dry (Figure 1-4). The featureless over-deep trapezoidal channels are generally straight and generally suffer from aggradation linked to excessive diffuse fine sediment inputs from surrounding tracks and farmland and the multiple channelling of flows along artificial watercourses.

Figure 1-3: The heavily modified over-deep upper Boghead Burn



Figure 1-4: Dry channel network of the upper Boghead Burn



Here the land use is exclusively pastoral with sheep farming being the order of the day on the reverting and semi-improved grazings. The marginal nature of the farming on the high ground here is demonstrated by the proliferation of forestry in recent years - a process that is still ongoing. Most of the burn is canalised but here and there it enters a series of lochans which are home to wading birds, ducks and geese. Around these the ground is generally unimproved or is effectively abandoned, the prime land use being rough shooting.

1.4.2 From Hall Torbane Farm to the A801

The main watercourse flows to the south of Hall Torbane Farm as an alluvial single thread channel which remains over-deep and sedimenting with some berm development along the channel margins. The alluviation appears worse where water is diverted into artificial feeder channels and culverts for nearby standing water bodies and where the channel has not been recently managed. Two channels exist immediately downstream of the farm with the upper artificial one running dry at the time of survey (Figure 1-5). The main channel is also disrupted and is infilled close to the abstraction point for the water body to the south (Figure 1-6). Downstream the channel exhibits limited local sinuosity inside the main over-deep

straightened channel and a Birch and Willow riparian woodland has developed on the left bank close to the A801 (Figure 1-7). This is a useful analogue on which to model the restoration of riparian margins across the farmland in the area.

Figure 1-5: Sedimenting dry channel at Hall Torbane Farm



Figure 1-6: Infilled channel downstream of abstraction culvert



Figure 1-7: Naturalising wet floodplain upstream of the A801



The land use is again unremarkable with sheep farming being the dominant land use although some inwintered suckler cows were present at Hall Torbane Farm. The land cover is mostly grassland, a mixture of types with large swathes of rank unimproved rushy pastures with tufted hair-grass, especially around the lochans. There is no evidence of the development of a riparian margin along the burn, which is over-straightened and heavily engineered. However, in one location the burn cuts (artificially) through a knoll and here the grassland is more acidic in nature and is being invaded by hawthorn scrub. This and the secondary birch *Betula spp.* and goat willow *Salix caprea* woodland that has developed upstream is an indication of what is likely to happen on the ungrazed loch margins in time.

1.4.3 Between the A801 and the B7002

The Burn flows through a culvert under the A801 into a straight engineered channel subject to intense sedimentation (Figure 1-8). A low floodwall and earth flood bank runs along much of the left bank reducing the connectivity of the watercourse with the floodplain (Figure 1-9).

Figure 1-8: Reed covered in-channel sediment downstream of the A801 culvert



Figure 1-9: Low flood bank and wall opposite Half Loaf Pond



The narrow area of land between two main roads is dominated by Half Loaf Pond. The pond is shallow and is likely the result of mining subsidence and this is not directly connected to the Boghead Burn, but there are small, natural channels within the alder *Alnus glutinosa* woodland on the north side of the lochan that allow water to cascade from the burn into the pond during floods. The burn is dead straight along this entire section which contains one improved field at the western end of the pond and another on the gentle slope on the North side of the burn where it meets the B7002. The rest of the land has now been turned over to forestry, especially on the right bank of the burn.

1.4.4 The channel through Standhill

The river flows through a culvert under Standhill Depot (Figure 1-10) before entering a more confined reach after the B7002 through Standhill. The channel gradient steepens here and is brick lined (Figure 1-11). Much of the brick lining is in poor condition.

Figure 1-10: The culvert under Standhill Depot



Figure 1-11: Brick lined channel through Standhill.



The land use here is industrial and the burn flows through a culvert under a large storage area before emerging into a corridor of planted trees and scrub that has been left as a result of a line of pylons. The ground at the downstream end of this area is quite steep and the burn flows at the bottom in a straight channel. After this the burn passes under a road within the industrial estate and through a narrow, hawthorn scrub dominated section between industrial units. Here the stream is very shaded by vegetation and suffers from numerous small inputs from the surrounding industrial land (exact sources unknown) (see Figure 1-12) and is in an ecologically poor condition. Iron deposits, which are the likely result of mine seepage, are visible within the channel from the industrial estate down to downstream of Standhill Road.

Figure 1-12: Unidentified congealed discharge from a small pipe in the Standhill Industrial Estate



1.4.5 Downstream of Inchcross Road to the confluence with Bog Burn

The river becomes less confined after Inchcross Road and assumes a more natural alluvial state. There is some morphological development with masonry debris organised into steep rapid areas with lower energy pools behind (Figure 1-13).

Figure 1-13: Masonry rapids in the channel after Inchcross Road.



The river enters a wide floodplain area shared with the Bog Burn. There is generally good connectivity (Figure 1-14); however, floodplain processes are disrupted by a complex set of high flood banks running parallel and perpendicular to the channel and by a new road crossing of the floodplain interrupting the downstream continuity of flow processes. Local channel instability has already been triggered at the culvert under the new road (Figure 1-15).

Figure 1-14: Channel - floodplain connectivity on Boghead Burn



Figure 1-15: Morphological instability at the new road crossing of the Boghead Burn



In terms of landuse east of Inchcross Road the burn emerges into a more rural landscape, although this can be misleading. The land on the left bank of the river is made up of tipped bing materials and is covered by recent forestry plantations. The right bank is made up of semi-improved grassland that is summer grazed by cattle: the only grazing stock at the time of the visit were roe deer *Capreolus capreolus*. The sides of the channel are lined with bricks that are falling away and this is home to a number of plant species, including male fern *Dryopteris filis-mas* (see Figure 1-16).

Figure 1-16: Male fern and bryophytes growing on the eroding brickwork channel sides



The woodland continues on the right bank until the burn flows past Standhill farm where the woodland gives way to a patchwork of semi-improved grassland fields separated by tall, overgrown hawthorn hedges. Here the burn follows a less managed course although it is still constrained by the presence of an old mineral line on the right banks under which it flows, along with the adjacent farm track, in a culvert. Here the area of grazed by rabbits *Oryctolagus cuniculus* and is frequented by dog walkers.

Further downstream the burn enters a wide area of floodplain where it joins with the Bog Burn. Here the floodplain is a mosaic of poor fen intersected by old mineral lines (raised platforms / raised embankments for removing the mineral extracted from the mines – i.e. railway embankments). This has caused the formation of a series of isolated wetlands, each with its own dominant plant species. This is usually soft rush but in some basins this is replaced with bottle sedge and, occasionally reed canary grass.

1.4.6 The Bog Burn down to Boghead Bridge

The Bog Burn is a heavily modified alluvial single thread channel devoid of any significant in-channel morphology apart from narrow lateral fine sediment berms (Figure 1-17). Flow is sluggish and ponded, being influenced at low flow by a pipe crossing at Boghead Bridge (Figure 1-18).

Figure 1-17: Hydromorphically degraded reach of the Bog Burn



Figure 1-18: Low flow control on Bog Burn



In terms of landuse here the burn is constrained between old railway lines and sections of more recent plantings, some of which are up to 80 or so years old. On the left bank there is some improved grassland which ends in an ancient hedgerow within which there is a small channel that flows into the Boghead Burn. The confluences with other drainage channels are a feature of this part of the floodplain, especially on the right bank. In one location here there is a very large inflow through a triple culvert that drains another area of railway-isolated fen to the south.

The left bank after the ancient hedge line is made up of a very large field which is underlain by regraded bing material. The burn appears to have been redirected around this when the land was reclaimed and it now has a wide detour to the southeast via two long straight stretches and here there are stretches of fen (see Figure 1-19). On the inside of this detour there is an area of forestry in which there is a very large population of broad-leaved helleborine *Epipactis helleborine*. This woodland is generally wet and composed mainly of poplar cultivars, a

number of which have fallen over in recent gales. Part of this woodland (and the field mentioned above) has been isolated from the burn by the construction of a flood bank that has a core of gabion baskets that is exposed periodically.

Figure 1-19: Poor reed canary grass fen bordering forestry adjacent to the Boghead Burn



The right bank is made up of a cycle path behind which there is a large area of poor fen and lochans, which are used by birds, including mallard *Anas platyrhynchos*. Downstream of this the path crosses the burn and the right bank is currently undergoing redevelopment. An old bing is being removed and the site is being built on: including the new supermarket and further work is ongoing behind this with the lorries travelling along the riverbank. This has destroyed any existing ecology. The reach ends at the Boghead Bridge, where the river passes under the road and railway, from where it enters a housing estate within the town of Bathgate.

1.4.7 Summary

Overall the Boghead Burn is a heavily modified watercourse, with an artificial ditch network in its upper reaches moving through to a channelised alluvial watercourse with flood banks and a steeped brick lined and culverted channel. Further downstream floodplain connectivity improves but the burn remains morphologically degraded. The Bog Burn is similarly highly modified and morphologically poor.

1.5 Boghead Burn restoration opportunities

The very poor in-channel morphology and significant fine sediment issues on the Boghead Burn make restoration difficult, as the fine sediments will smother 'restored' morphology unless it is addressed. However, a number of local opportunities for restoration have been identified.

Downstream of Standhill there are a number of opportunities for improvement, in particular where the new road crosses over the burn at the confluence between the Bog Burn and the Boghead Burn. The road here has cut across the least altered part of the floodplain and is constricting the burn and causing a scour hole to develop upstream. Consideration should be given to investigating whether this road can be removed.

The artificial looped section near Whiteside is entirely man-made and the river is completely canalised and isolated from its floodplain by the numerous old railway lines and the height of the made land to the north of the channel (see Figure 1-20). In order to reconnect the river with its floodplain and improve the overall ecology of this area, consideration should be given to excavating the old bing material between Boghead Bridge and the ancient hedge line to create a lower lying area of floodplain through which the burn can flow. A new sinuous course could be created and the burn allowed to work the existing material and create its own in-channel features. The outflow from the pumping station on the right bank should be redirected northwest along the present channel of the Bog Burn until it reaches the old hedgeline where it

can join the new channel. This will allow the areas of fen in this area to be fed by the water from this source. The current straight course of the Bog Burn can then be allowed to become a backwater and silt-up, This will in time become colonised by alder and willow trees and this process can be helped on the right bank when the works there are completed.

Figure 1-20: Canalised section of Bog Burn with poor fen on the left hand side and forestry on the made ground on the right



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. Multi-criteria analysis has also been conducted on each option to prioritise these options holistically.

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
Redirect flow	RFI
Remove channel	ChRe
Remove channel infill	CIR
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 Boghead Burn

Issue	Unique ID	Action	Location Description	OS NGR	Pressure	Pros	Cons	Cost (£k)	Movement towards GES
ISSUE 1: Diffuse pollution from surrounding farmland – sediment and other contaminants	Bog_EdFP_1	Improve farm practice management through education, construction management, sediment input control	Upper reaches – Hall Torbane Farm	294689E 666788N to 295379E 666715N	Diffuse Source Pollution	Major positive impact on channel sedimentology, positive impact on fish and invertebrate communities, likely improvement to riparian margins,	Requires strong 'buy-in' and commitment from various property owners within the catchment. Effects may be slow to be realised. Methodologies not fully proven in larger catchments. Further assessment is required to define specific options	Requires further assessment	None – no information on capacity released through improving diffuse pollution.
ISSUE 2: Sedimentation in engineered channel with an additional adjacent dry drainage channel Flow disappears underground	Bog_ChRe_1, Bog_CIRe_1, Bog_AV_1	Remove section of reach from drainage network Assess abstraction value	Upper reaches – Hall Torbane Farm	295102E 666689N to 295562E 666913N – Bog_ChRe_1 295390E 666823N – Bog_CIRe_1 295410E 666844N – Bog_AV_1	Diffuse Source Pollution	Improved flow habitats along reach; improvement of secondary bed sedimentology; restoration of off-channel morphological connections.	May require further work once flow/abstraction has been assessed. High cost of works.	61.1	No capacity info
ISSUE 3: No riparian vegetation or buffer from surrounding farm land	Bog_RMC_1, Bog_RMC_2, Bog_RMC_3	Create riparian margins	Upper reaches – Hall Torbane Farm	295474E 666862N to 295705E 666921N	Diffuse Source Pollution	Improved marginal habitats, reduced bank erosion and channel movement, reduced fine sediment load input. Aesthetic improvements. Localised positive impacts for low cost.	May reduce angler access to the waterway.	4.6	No capacity info
ISSUE 4: Floodplain disconnection: channel has been straightened and has flood banks and flood walls on both sides. High in-channel sedimentation and reed growth. Lack of riparian margin.	Bog_FBRe_1; Bog_RMC_4, Bog_RMC_5	Remove flood banks and flood walls; Create riparian margin, plant willow and alder and fence off	Adjacent to Half Loaf Pond	295785E 666953N to 296086E 667049N	Morphology	Flood attenuation downstream; re-establishment of floodplain dynamics; rare floodplain habitats reconnected; likely improvement to riparian margins. Potential decrease in duration of flooding to surrounding farmland.	Increase in frequency of flooding to farmland; potential drop in local geomorphic activity. May require traffic management for truck movements entering the site.	43	4.87% (pressure not fully covered capacity dataset)
ISSUE 5: Heavily sedimented tributary channel	Bog_ChR_1	Restore tributary channel – remove sediment	Standhill – downstream of B7002	296113E 666995N to 296282E 666862N	Morphology	Improved flow habitats along reach; improvement of secondary bed sedimentology; restoration of off-channel morphological connections.	High cost of works; may have adverse impacts such as changing flood risk to surrounding industrial property (these would need to be quantified); current extent of channel not known - would require further investigation.	60	No capacity info
ISSUE 6: Lined channel	Bog_LCRe_1, Bog_LCRe_2	Remove lined channel	Standhill – upstream of Standhill Road	296321E 666999N to 296655E 667063N	Morphology	Naturalised riparian margin, naturalised channel bed, restored channel dynamics	Local bank instability may lead to adverse public reaction; adjacent ground conditions would need to be assessed to determine whether there would be any undermining of development platforms.	44	4.87% (pressure not fully covered capacity dataset)
ISSUE 7: Diffuse source pollution - iron seepage	Bog_IDS_1	Investigate and identify diffuse source, quantify inflow and design wetland.	Standhill – between Whitburn Road and Standhill Road and downstream of Standhill Road	296117E 667025N to 296717E 667301N	Diffuse	Positive impact on aquatic and riparian ecosystem	May be difficult to identify and mitigate source of pollution	0.94	No capacity info
ISSUE 8: Poor channel	Bog_ChR_2	Encourage naturalisation:	Standhill	296686E 667082N to	Diffuse	Narrowing and morphological	Increased channel activity	26	4.87% (pressure not

morphology, degraded masonry bank protection, bank erosion, rapids formed from out of eroded masonry material		remove masonry material, restore rapids	downstream of Standhill Road	296720E 667294N	Source Pollution	reinstatement will improve bed morphology, hydraulics and sedimentology, fisheries and invertebrate improvements, necessarily restored channel dynamics.	may lead to adverse public reaction. Hydraulics must be appropriate with restored morphology otherwise restoration will fail in the long term. May need to create temporary site access.		fully covered capacity dataset)
ISSUE 9: Degraded riparian strip	Bog_VP_1	Improve riparian strip - planting	Downstream of Standhill Road	296736E 667333N to 296933E 667609N	Diffuse Source Pollution	Improved marginal habitats, reduced bank erosion and channel movement, reduced fine sediment load input; aesthetic improvements	May reduce angler access to the waterway.	15	No capacity info
ISSUE 10: New road and culvert across burn and floodplain – splitting floodplain and restricting movement of flood flows	Bog_RdRe_1, Bog_CRe_1	Remove road and culvert	Downstream of Standhill Road, road connecting Whitburn Road and Leyland	296770E 667730N to 297134E 667534N – Bog_RdRe_1 296933E 667612N to 296961E 667658N – Bog_CRe_1	Morphology	Flood attenuation downstream; re-establishment of floodplain dynamics; rare floodplain habitats reconnected, likely improvement to riparian margins; flood concentration zones removed.	Local flooding frequency increase (duration may reduce), potential drop in geomorphic activity in channel promoting sedimentation locally; road and culvert recently constructed to unlikely to be removed.	Not costed	No capacity info
ISSUE 11: Embankments on floodplain adjacent to burn; failed geotextile protection through dissected embankment	Bog_FBRe_2, Bog_FBRe_3, Bog_FBRe_4, Bog_GRe_1	Remove embankments; remove failed geotextile material	Whiteside	297018E 667752N to 297281E 667748N	Morphology	Flood attenuation downstream; re-establishment of floodplain dynamics; rare floodplain habitats reconnected, likely improvement to riparian margins; flood concentration zones removed; potential reduction in flood duration in surrounding floodplain.	Local flooding frequency increase; potential drop in local geomorphic activity and associated decrease in sedimentation. Very high estimated costs of works due to high volume of material and disposal costs.	312.5	0.2%
ISSUE 12: Degraded riparian strip	Bog_VP_2	Improve riparian strip - planting	Whiteside	297291E 667716N to 297429E 667735N	Diffuse Source Pollution	Improved marginal habitats, reduced bank erosion and channel movement, reduced fine sediment load input. Aesthetic improvements. Localised positive impacts for low cost.	May reduce angler access to the waterway.	4	No capacity info
ISSUE 13: Straightened artificial channel, with poor morphology. Channel is too deep and straight and is disconnected from floodplain.	Bog_ChR_3	Narrow channel significantly, introduce berms/bars using woody debris to encourage naturalization and sinuosity. Create a two stage channel to increase flood capacity along the left bank.	Upstream of Boghead Bridge	297120E 6687930N to 297388E 667930N	Morphology	Narrowing and morphological reinstatement will improve bed morphology, hydraulics and sedimentology, fisheries and invertebrate improvements, necessarily restored channel dynamics. Releases a large proportion of capacity.	Increased channel activity may lead to adverse public reaction. Hydraulics must be appropriate with restored morphology otherwise restoration will fail in the long term. Will take time for channel to adjust to changes. High cost of works.	81	7.04% (pressure not fully covered capacity dataset)
ISSUE 14: Sheet piling on bank	Bog_StRe_1	Investigate removal and removal sheet piling	Boghead Bridge - immediately downstream of Whitburn Road	297088E 668296N	Morphology	Improve floodplain connectivity and allow riparian margins to reconnect.	May be costly / difficult to remove. Unknown costs until further investigation is undertaken.	Requires further assessment	No capacity info
ISSUE 15: Poor channel morphology – pipe weir in channel	Bog_StRe_2	Investigate removal of pipe weir	Boghead Bridge - immediately downstream of Whitburn Road	297088E 668296N	Morphology	Local increase in gradient will improve channel dynamics slightly; aquatic ecosystem improvements.	Need to establish pipe function. Must be done in combination with channel naturalisation.	5.9	No capacity info

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 pressure database and the capacity that is calculated as having been used up by each of these pressures. There is a total capacity of 41.00 % taken up by the morphological pressures on the Boghead Burn with 24.25 % of these being on this particular study reach. The pressures identified by SEPA are culverts, embankments, set back embankments, grey bank protection, low impact channel realignment. No high impact channel realignment or green 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 entire study reach of this river has been realigned, although this has not been picked up within the SEPA pressures dataset. The reach between the Hall Torbane Farm and the B7002 is also dominated by agricultural embanks which are not shown on the SEPA dataset. Multiple pressures are also sometimes simplified with only the primary pressure classified, this occurs along the watercourse through and immediately downstream of Standhill industrial estate. Differences also occur with regard to the severity of the pressure, the reach of the watercourse immediately downstream of the Bog Burn confluence all the way to the Whitburn Road has been significantly straightened with very little or no morphological variation within the channel. This is presently classified as low impact re-alignment but could be regarded as a high impact re-alignment. 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 Boghead Burn presents an ideal location for achieving multiple benefits through watercourse and floodplain restoration. Works suggested within this report would lead to increased habitat biodiversity and improved morphology. Linking these works with future developments (currently at masterplan stage) to the west of Bathgate will not only allow improved riparian areas to be created and incorporated as part of the developments but also presents the opportunity to construct public access pathways which link a number of large urban areas within the West Lothian region.

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

- Issue 1 - Control diffuse sediment input
- Issue 4 - Remove floodbanks and floodwalls, create riparian margin
- Issue 6 - Remove channel lining
- Issue 10 - Remove floodbanks, floodwalls and geotextile

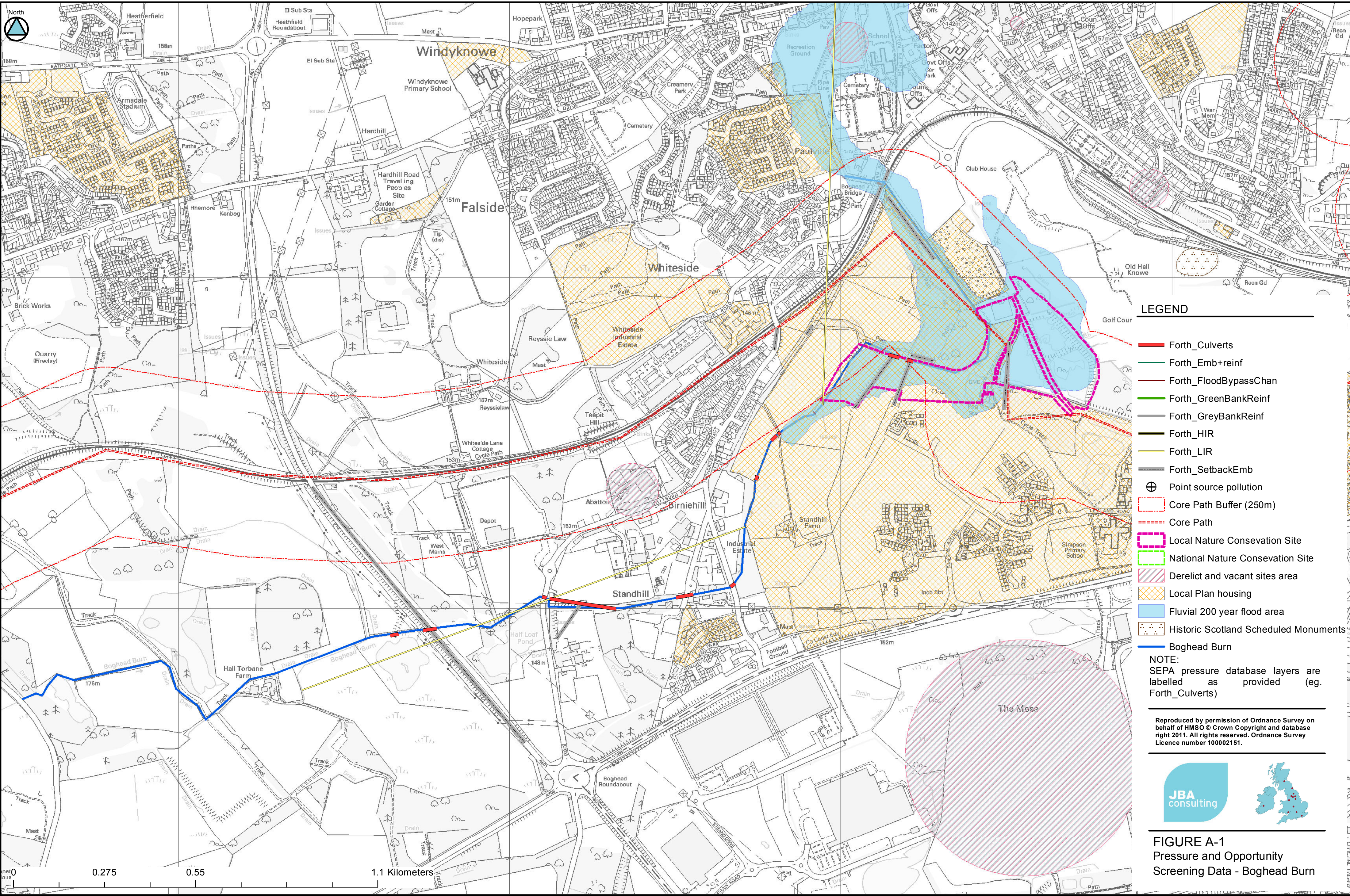
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Appendices

A Phase 1 screening features

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

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



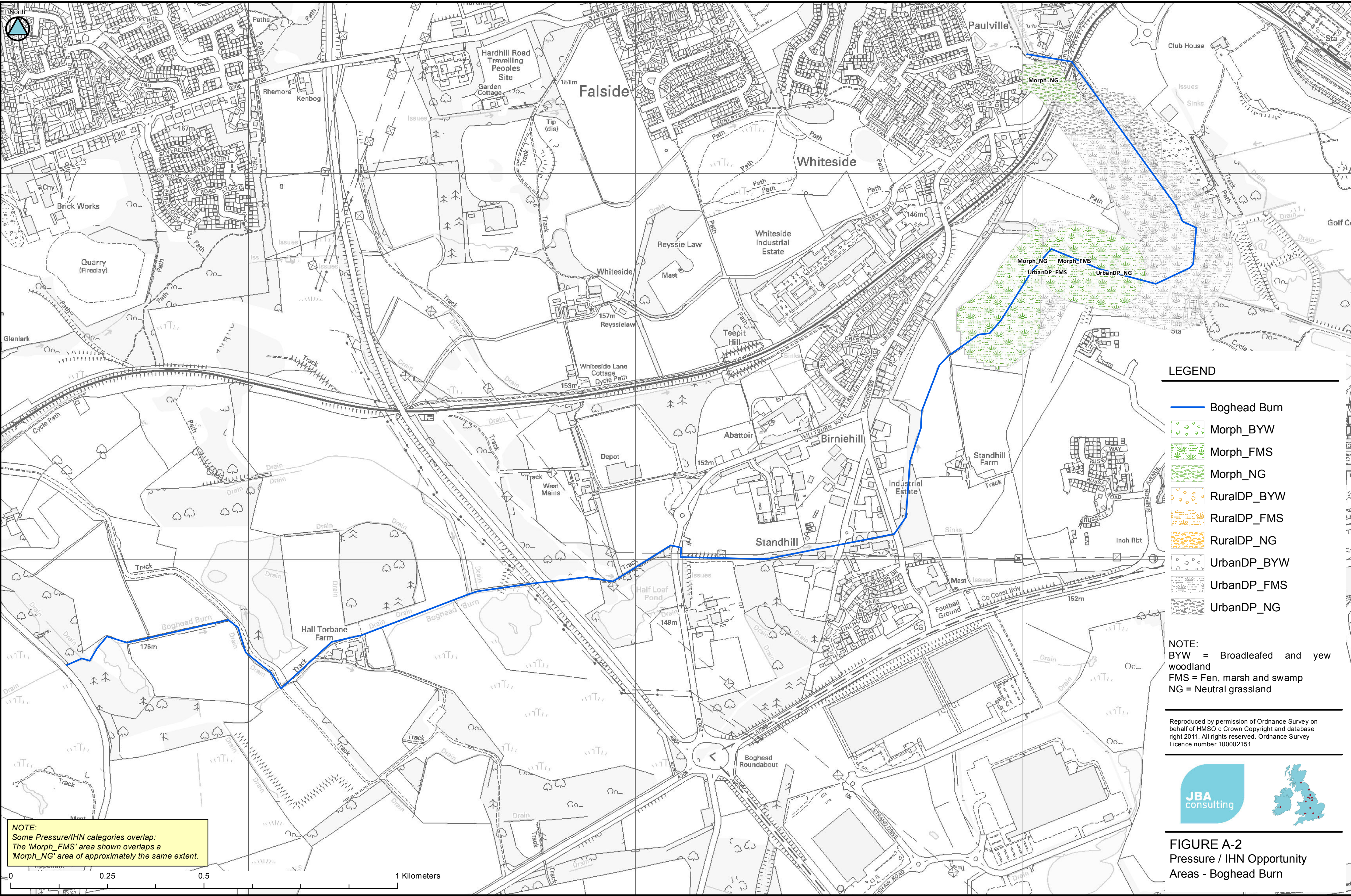
- LEGEND**
- Forth_Culverts
 - Forth_Emb+reinf
 - Forth_FloodBypassChan
 - Forth_GreenBankReinf
 - Forth_GreyBankReinf
 - Forth_HIR
 - Forth_LIR
 - Forth_SetbackEmb
 - ⊕ Point source pollution
 - Core Path Buffer (250m)
 - Core Path
 - Local Nature Consevation Site
 - National Nature Consevation Site
 - Derelict and vacant sites area
 - Local Plan housing
 - Fluvial 200 year flood area
 - Historic Scotland Scheduled Monuments
 - Boghead Burn

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

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



LEGEND

- Boghead Burn
- Morph_BYW
- Morph_FMS
- Morph_NG
- RuralDP_BYW
- RuralDP_FMS
- RuralDP_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 - Boghead 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).

	Location : 1 Description: Flow off of roadway disappears underground drying the surface channel OS NGR: 29460 66676 Notes:
	Location : 1 Description: Underground flow path OS NGR: 29460 66676 Notes:

	Location : 2 Description: poorly defined drainage channel OS NGR: 29475 66680 Notes:
	Location : 3 Description: Poor cobble plane-bed – riffle channel OS NGR: 29496 66683 Notes: Channel remains engineered and over-deep
	Location : 4 Description: Flow inputs from Hall Torbane Farm pond. OS NGR: 29505 66670 Notes:

	Location : 5 Description: Culvert offtake to Half Loaf Pond OS NGR: 29536 66681 Notes:
	Location : 6 Description: Heavily sedimented engineered channel OS NGR: 29541 66684 Notes:
	Location : 7 Description: Dry additional drainage channel OS NGR: 29557 66691 Notes:

	Location : 8 Description: Developing local channel sinuosity OS NGR: 29561 66692 Notes:
	Location : 9 Description: Upstream of A801 OS NGR: 29569 66693 Notes: Detail of developing riparian
	Location : 9 Description: Upstream of A801 OS NGR: 29569 66693 Notes: developing riparian on left bank

	Location : 10 Description: A801 Road Culvert OS NGR: 29575 66694 Notes: Note heavy fine sediment bed load
	Location : 11 Description: Heavily sedimented straightened channel OS NGR: 29580 66694 Notes: Strong reed growth controlling upstream water levels
	Location : 12 Description: Local channel bank undercutting OS NGR: 29583 66694 Notes:

	Location : 13 Description: Local channel activity increasing sinuosity OS NGR: 29587 66695 Notes: Left bank flood wall also present
	Location : 14 Description: Flood banks on left bank of Boghead Burn OS NGR: 29593 66694 Notes:
	Location : 15 Description: Alder lined channel margin OS NGR: 29603 66700 Notes:

	Location : 16 Description: Outflow from Half Loaf Pond OS NGR: 29606 66701 Notes:
	Location : 17 Description: Over-deep alluvial single-thread channel OS NGR: 29609 66703 Notes: Heavily engineered with disconnected floodplain
	Location : 18 Description: Flow into culvert under Standhill Depot OS NGR: 29611 66702 Notes: Majorly sedimented channel

	Location : 19 Description: Sedimented tributary OS NGR: 29611 66699 Notes:
	Location : 20 Description: Lined channel after Standhill depot culvert OS NGR: 29649 66703 Notes:
	Location : 21 Description: Lined bed and banks to the channel OS NGR: 29657 66704 Notes:

	Location : 22 Description: degraded masonry bank protection OS NGR: 29663 66706 Notes:
	Location : 23 Description: Bank erosion along failed protection OS NGR: 29668 66708 Notes:
	Location : 24 Description: Rapids formed from masonry OS NGR: 29670 66712 Notes:

	Location : 25 Description: developing low level berm features OS NGR: 29682 66754 Notes: Channel remains over-deep
	Location : 26 Description: Culvert for new road crossing OS NGR: 29697 66765 Notes: Exit erosion occurring
	Location : 26 Description: Culvert under new road OS NGR: 29697 66765 Notes: Erosion at culvert exit

	Location : 27 Description: Straightened but well connected channel across the floodplain OS NGR: 29704 66777 Notes:
	Location : 28 Description: Failed geotextile protection through dissected embankment OS NGR: 29722 66774 Notes:
	Location : 29 Description: Floodplain area west of Whiteside OS NGR: 29733 66771 Notes:

	Location : 30 Description: Bog Burn OS NGR: 29739 66792 Notes: Straightened artificial channel
	Location 31: Boghead Bridge OS NGR: 29725 66798 Notes: Sheet piling on channel bank
	Location : 32 Description: Pipe structure at Boghead Bridge OS NGR: 29709 66829 Notes:

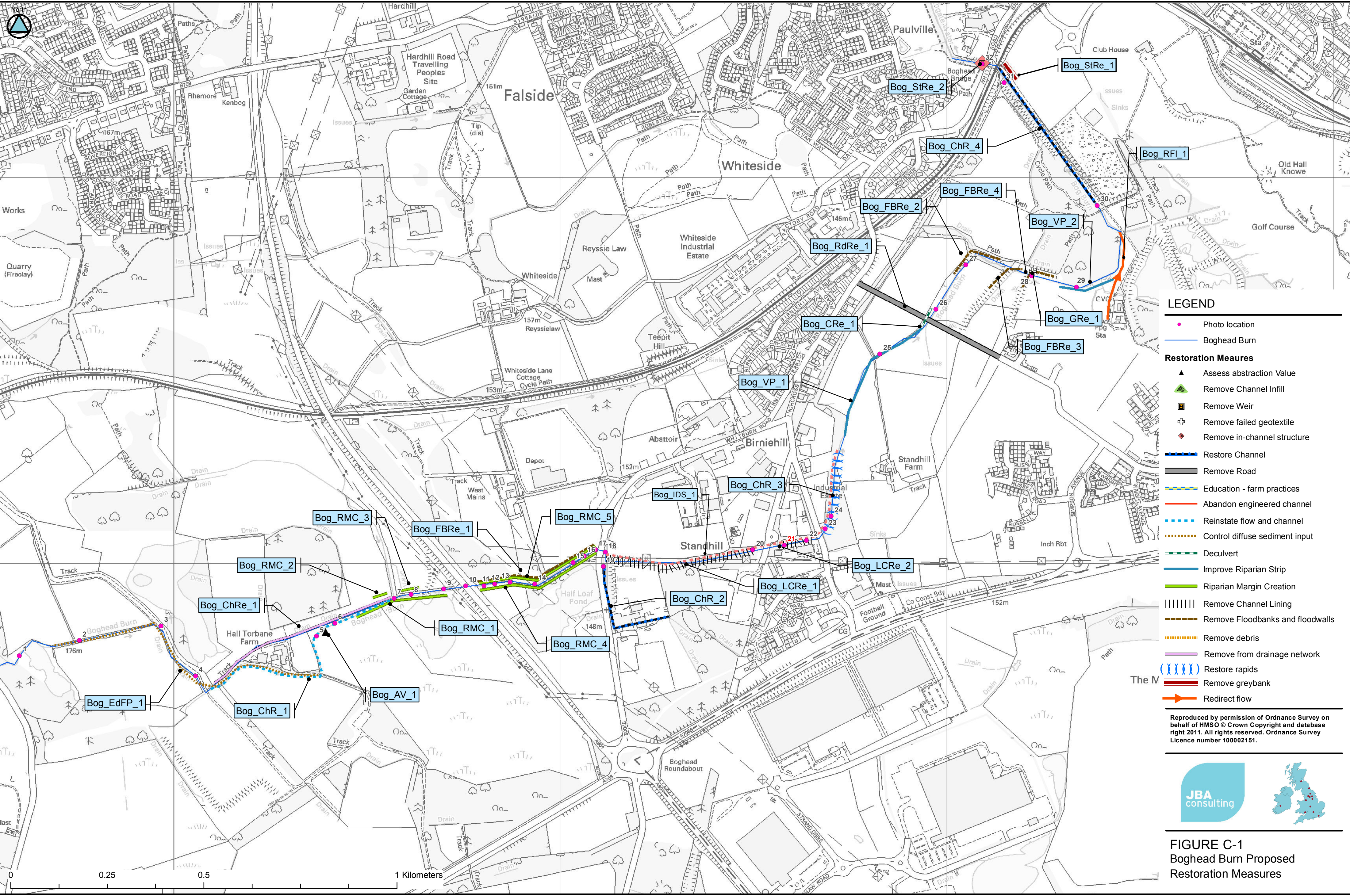
C Restoration opportunity maps and tables

Figure C- 1: Boghead Burn Proposed Restoration Measures

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

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

Table C- 1: Restoration Measure Assessment Tables



LEGEND

● Photo location

— Boghead Burn

Restoration Measures

- ▲ Assess abstraction Value
- ▲ Remove Channel Infill
- Remove Weir
- ⊕ Remove failed geotextile
- ◆ Remove in-channel structure
- Restore Channel
- Remove Road
- Education - farm practices
- Abandon engineered channel
- Reinstate flow and channel
- Control diffuse sediment input
- Deculvert
- Improve Riparian Strip
- Riparian Margin Creation
- Remove Channel Lining
- Remove Floodbanks and floodwalls
- Remove debris
- Remove from drainage network
- () Restore rapids
- Remove greybank
- Redirect flow

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FIGURE C-1
Boghead Burn Proposed
Restoration Measures

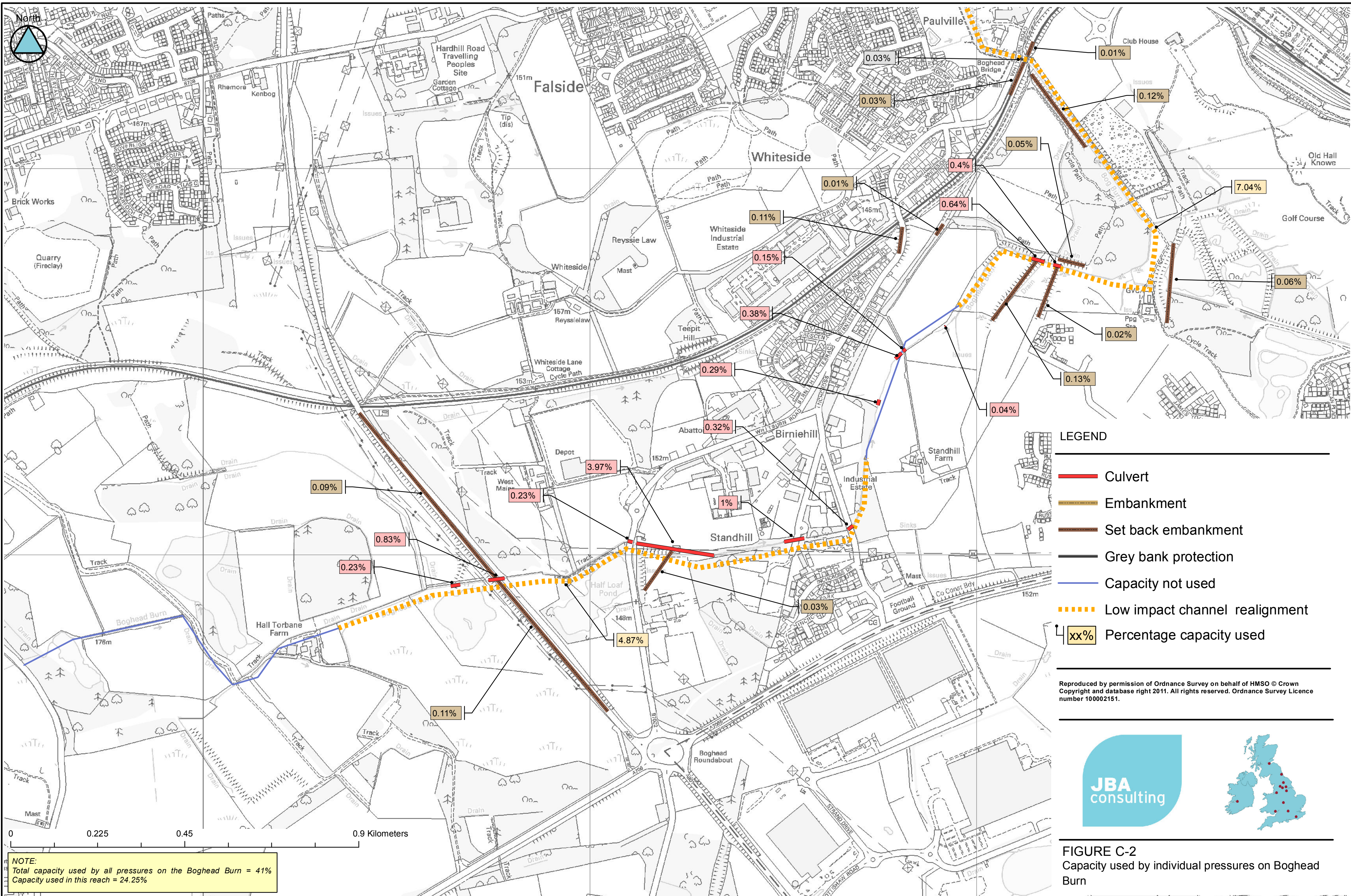


Table C-1: Restoration Measure Assessment Tables

ISSUE 1: Diffuse pollution from surrounding farmland – sediment and other contaminants				ACTION: Improve farm practice management through education, construction management, sediment input control						Unique ID: Bog_EdFP_1			
Site information	Description		Upper reaches – Hall Torbane Farm			Cost estimate	Estimate	Requires further assessment – can't be quantified at this stage. Education, construction management and sediment input control 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		294689E 666788N to 295379E 666715N										
	Photo reference		Appendix B – photos 2, 3, 4			Further considerations	Funding mechanism / opportunities	Fund name				Applicability	
	Access		Via farm track					Scotland Rural Development Fund	Challenge Funds		✘		
	Reach length (m)		800m						Rural Development Contracts – Land Manager Options		✓		
Rural Priorities – Forth Area									✓				
Pressure	Pressures to be addressed through regulatory means		- Morphological - Diffuse source pollution					Scottish Natural Heritage	Natural Project Grants		✘		
	IHN		None – gap in the network						Community Grants		✓		
	JBA ID		N/A						Central Scotland Green Network		✘		
	Associated data sources		None					SEPA Scottish restoration fund				✓	
Habitat	Type of existing habitat		Unimproved grassland, semi-improved grassland, upland heathland, coniferous plantation, native broadleaf plantation, oligotrophic standing water bodies					Land developer (ie. of surrounding area)				✓	
	Extent of existing habitat		Entire length of reach on both sides of the burn					Other: - The Naturesave Trust - The Ibrahim Foundation - The Steel Charitable Trust				✓ ✓ ✓	
	Quality of existing habitat		Variable: water bodies are in good condition, unimproved grassland is in moderate condition and; semi-improved grassland and the plantation woodlands are poor condition.										
	Sensitivity of existing habitat to land use / habitat change		Low, except for standing water bodies										
	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 information on capacity released through improving diffuse pollution			Ecological habitat survey				✘			
	Flood risk benefit?		✘					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	N/A			
			Contribute to addressing flood risk		✘				Machinery required	N/A			
			Reduce invasive non-native species		✘				Mitigation measures	N/A			
			Climate change adaptation		✘			Timing	N/A				
	Raise awareness of the benefits of healthy water environments		✓		Logistics	N/A							
	Wider environmental benefits		Positive impacts on downstream sedimentology and biodiversity; planting will contribute to extending IHN - the nearest area is located just upstream of the reach.										
	Ownership	Suggested action owner		SEPA and farmer			CAR licensing required	N/A					
Land owner		Private – farmer (Hall Torbane Farm)											

ISSUE 2: - Sedimentation in engineered channel with an additional adjacent dry drainage channel - Flow disappears underground				ACTIONS: - Remove section of reach from drainage network and divert flows around it. Restore secondary channel downstream of the diversion - Excavate and fill immediately upstream of entrance to current channel to divert flow, excavate downstream of diversion to restore flow - Assess abstraction value				Unique ID: Bog_ChRe_1, Bog_ChR_1, Bog_AV_1								
Site information	Description	Upper reaches – Hall Torbane Farm			Cost estimate	Estimate (£k) Restore channel	60	Width (m)		3m (channel excavation)						
	OS NGR	295102E 666689N to 295562E 666913N – Bog_ChRe_1 295095E 666674E to 295562E 666908N – Bog_ChR_1 295410E 666844N _ Bog_AV_1				Assumptions	100% of excavated material downstream of diversion will be disposed of off-site. Material excavated upstream of diversion will be used to fill / divert flows. Includes 5 days time for site engineer. Hydrological survey (£3k) and topo survey (£2k) included.									
	Photo reference	Appendix B – photos 5 to 9				Estimate (£k) Assess abstraction	1.1	Site investigation – approx 3 days								
	Access	Via farm track			Further considerations	Funding mechanism / opportunities	Fund name				Applicability					
	Reach length (m)	210					Scotland Rural Development Fund	Challenge Funds		✗						
Rural Development Contracts – Land Manager Options								✓								
Pressure	Pressures to be addressed through regulatory means	• Morphological • Diffuse source pollution		Rural Priorities – Forth Area				✓								
	IHN	None – gap in network					Scottish Natural Heritage	Natural Project Grants		✗						
	JBA ID	N/A						Community Grants		✗						
	Associated data sources	None		Central Scotland Green Network				✗								
Habitat	Type of existing habitat	Unimproved acid grassland, wet grassland					SEPA Scottish restoration fund				✓					
	Extent of existing habitat	Full length of watercourse					Land developer (ie. of surrounding area)				✓					
	Quality of existing habitat	Good					Other:				✗					
	Sensitivity of existing habitat to land use / habitat change	Medium														
	Indicative species mix for restoration	Not applicable														
	Establishment techniques required	Not applicable														
Benefits	Barrier to restoration?	✗														
	Capacity released – contribution to obtaining GES	None				Other surveys required	Survey Type				Required					
	Flood risk benefit?	✓		Removal of channel infill will increase flood plain connectivity; riparian planting will increase floodplain roughness and reduce flood flow velocities.				✓								
	Public access (existing or can connect to?)	✗		Private land				✓								
	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		✗												
	Ownership	Raise awareness of the benefits of healthy water environments		✓		Construction / restoration costs	Methods	Access required		✓		Machinery to be stored outside floodplain Prevent sediment movement when removing channel infill				
		Wider environmental impacts		Restoration of tributary channel and morphological connections				Machinery required		✓						
Suggested action owner		Landowner		Mitigation measures				✓								
Ownership	Land owner	Private – farmer (Hall Torbane Farm)			CAR licensing required	Registration			Simple licence				Complex licence		✓	
				Sediment management >50m in rivers												

ISSUE 3: No riparian vegetation or buffer from surrounding farm land				ACTION: Create riparian margins				Unique ID: Bog_RMC_1, Bog_RMC_2, Bog_RMC_3				
Site information	Description	Upper reaches – Hall Torbane Farm			Cost estimate	Estimate (£k)	4.6	Width (m)		10m width		
	OS NGR	295474E 666862N to 295705E 666921N – Bog_RMC_1, Bog_RMC_2, Bog_RMC_3				Assumptions	Assumes width of 10 metre, 244m length along one side and 86m along the other. Includes fencing, plants and labour costs.					
	Photo reference	Appendix B – photos 5 to 9				Funding mechanism / opportunities	Fund name				Applicability	
	Access	Via farm track					Scotland Rural Development Fund	Challenge Funds		✘		
	Reach length (m)	244 on right bank; 86 on left bank						Rural Development Contracts – Land Manager Options		✓		
Rural Priorities – Forth Area					?							
Pressure	Pressures to be addressed through regulatory means	- Morphological - Diffuse source pollution			Further considerations		Scottish Natural Heritage	Natural Project Grants		✘		
	IHN	None – gap in network				Community Grants		✓				
	JBA ID	N/A				Central Scotland Green Network		✓				
	Associated data sources	None										
Habitat	Type of existing habitat	Unimproved acid grassland, wet grassland, improved grassland			Further considerations	SEPA Scottish restoration fund				✓		
	Extent of existing habitat	Full length of reach				Land developer (i.e. of surrounding area)				✓		
	Quality of existing habitat	Medium				Other: - The Naturesave Trust - The Ibrahim Foundation				✓		
	Sensitivity of existing habitat to land use / habitat change	Low								✓		
	Indicative species mix for restoration	Alder, grey willow, common reed, watercress										
	Establishment techniques required	Direct planting into banks, watercourse										
Benefits	Barrier to restoration?	✘				Other surveys required	Survey Type				Required	
	Capacity released – contribution to obtaining GES	None			Ecological habitat survey				✘			
	Flood risk benefit?	✓	Reduction in rate of runoff from surrounding farm land.				Hydrological survey				✘	
	Public access (existing or can connect to?)	✘	Private land				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	N/A				
	Raise awareness of the benefits of healthy water environments		✓		Logistics	N/A						
	Wider environmental benefits		Contribute to increasing IHN between areas upstream and downstream.			CAR licensing required	N/A					
Ownership	Suggested action owner	Landowner or developer										
	Land owner	Private – farmer (Hall Torbane Farm) to the north of the burn; developer to the south of the burn										

ISSUE 4: - Floodplain disconnection: channel has been straightened and has flood banks and flood walls on both sides - High in-channel sedimentation and reed growth - Lack of riparian margin			ACTIONS: - Remove flood banks and flood walls - Create riparian margin, plant willow and alder and fence off							Unique ID: Bog_FBRe_1; Bog_RMC_4, Bog_RMC_5		
Site information	Description	Adjacent to Half Loaf Pond		Cost estimate	Estimate (£k) Bog_FBRe_1	34	Flood wall dimensions		2m width x 1m height			
	OS NGR	295785E 666953N to 296086E 667049N			Estimate (£) Bog_RMC_4, Bog_RMC_5	9	Planting width		10m width on both sides of burn			
	Photo reference	Appendix B – photos 11 to 17			Assumptions	Planting assumes width of 10 metres on either side of burn. Includes fencing, plants and labour costs. Flood wall removal includes 5 days time for site engineer. Includes hydrological survey (£3k) and topographical survey (£2k).						
	Access	Via farm track to the north / Whitburn Road (downstream)		Further considerations	Funding mechanism / opportunities	Fund name			Applicability			
	Reach length (m)	330				Scotland Rural Development Fund	Challenge Funds		✗			
Pressure	Pressures to be addressed through regulatory means	• Morphological • Diffuse source pollution					Rural Development Contracts – Land Manager Options	✓				
	IHN	None – gap in network						Rural Priorities – Forth Area		✓		
	JBA ID	N/A				Scottish Natural Heritage	Natural Project Grants		✗			
	Associated data sources	None					Community Grants		✓			
Habitat	Type of existing habitat	Industrial area, broadleaved plantation woodland					Central Scotland Green Network		✓			
	Extent of existing habitat	Length of reach				SEPA Scottish restoration fund			✓			
	Quality of existing habitat	Very low				Land developer (i.e. of surrounding area)			✗			
	Sensitivity of existing habitat to land use / habitat change	Very low				Other: • The Naturesave Trust • The Ibrahim Foundation			✓ ✓			
	Indicative species mix for restoration	Alder, grey sallow, creeping bent										
	Establishment techniques required	Direct planting										
Benefits	Barrier to restoration?	✗			Other surveys required	Survey Type			Required			
	Capacity released – contribution to obtaining GES	Realignment along a 1616m section of the reach releases 4.87% (this action applies 330m of the reach – as a proportion this is 0.99%)				Ecological habitat survey			✗			
	Flood risk benefit?	✓ Creation of riparian margin will increase riparian roughness, reducing flood flow velocities. Removal of flood walls will increase floodplain connectivity and transmission of flood flows.				Hydrological survey			✓			
	Public access (existing or can connect to?)	✗ Private land				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	✓	May require traffic management for truck movements accessing site from Whitburn Road		
		Contribute to addressing flood risk		✓				Machinery required	✓	Machinery to be stored outside floodplain		
		Reduce invasive non-native species		✗				Mitigation measures	✓	• Machinery to stay out of watercourse • Sediment fences to be used		
		Climate change adaptation		✗			Timing		Works to be carried out during low flow periods			
		Raise awareness of the benefits of healthy water environments		✗			Logistics		N/A			
	Wider environmental benefits	Contribute to increasing IHN between areas upstream and downstream; reconnection of floodplain habitats		CAR licensing required	Registration		Simple licence	✓	Complex licence			
	Suggested action owner	Landowner			All set-back embankments and set-back floodwalls							
	Land owner	Private – farmer										

ISSUE 5: Heavily sedimented tributary channel				ACTION: Restore tributary channel – remove sediment				Unique ID: Bog_ChR_2											
Site information	Description		Standhill – downstream of B7002				Cost estimate	Estimate (£k)		60	Width (m)		2						
	OS NGR		296113E 666995N to 296282E 666862N					Assumptions		All excavated material will be disposed of off-site. Includes 5 days time for site engineer; hydrological survey (£3k), topographical survey (£2k) and ecological survey (£2k)									
	Photo reference		Appendix B – photo 19				Further considerations	Funding mechanism / opportunities	Fund name				Applicability						
	Access		Via adjacent road or Scotwaste						Scotland Rural Development Fund	Challenge Funds		✘							
	Reach length (m)		312			Rural Development Contracts – Land Manager Options				✘									
Rural Priorities – Forth Area						✓													
Pressure	Pressures to be addressed through regulatory means		- Morphological - Diffuse source pollution			Scottish Natural Heritage			Natural Project Grants		✘								
	IHN		None – gap in network						Community Grants		✘								
	JBA ID		N/A						Central Scotland Green Network		✘								
	Associated data sources		None																
Habitat	Type of existing habitat		Acid grassland, broadleaved plantation woodland and bare ground						SEPA Scottish restoration fund				✓						
	Extent of existing habitat		On right bank – left bank is a metalled road						Land developer (i.e. of surrounding area)				✘						
	Quality of existing habitat		Low						Other:				✘						
	Sensitivity of existing habitat to land use / habitat change		Low																
	Indicative species mix for restoration		Not applicable																
	Establishment techniques required		Not applicable																
Benefits	Barrier to restoration?		✓	Channel not being used at present and not readily accessible					Other surveys required	Survey Type				Required					
	Capacity released – contribution to obtaining GES		None					Ecological habitat survey				✓							
	Flood risk benefit?		✓	Removal of sediment will increase flow capacity of channel						Hydrological survey				✓					
	Public access (existing or can connect to?)		✘	Private land						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		✓	Temporary access would need to be created		
			Contribute to addressing flood risk			✓								Machinery required		✓	Machinery to be stored outside floodplain		
			Reduce invasive non-native species			✘								Mitigation measures		✓	Prevent sediment movement downstream when removing channel infill		
			Climate change adaptation			✘		Timing		Works to be carried out during low flows									
			Raise awareness of the benefits of healthy water environments			✘		Logistics		Liaise with Scotwaste regarding access and logistics of machinery on site; material to be disposed of offsite									
	Wider environmental benefits		Restoration of tributary channel and morphological connections					CAR licensing required	Registration		Simple licence		Complex licence		✓				
Suggested action owner		Unknown					Sediment management > 50m in length												
Land owner		Private – Scotwaste																	

ISSUE 6: Lined channel				ACTION: Remove lined channel				Unique ID: Bog_LCRe_1, Bog_LCRe_2					
Site information	Description	Standhill – upstream of Standhill Road			Cost estimate	Estimate (£k)	44	Width (m)		2			
	OS NGR	296321E 666999N to 296655E 667063N				Assumptions	100% of material to be disposed of offsite. Includes 5 days time for site agent. Includes costs for ecological survey.						
	Photo reference	Appendix B – photos 20, 21, 22			Further considerations	Funding mechanism / opportunities	Fund name				Applicability		
	Access	Via roads that cross reach					Scotland Rural Development Fund	Challenge Funds		✘			
	Reach length (m)	492 (total length)						Rural Development Contracts – Land Manager Options		✘			
Rural Priorities – Forth Area								?					
Pressure	Pressures to be addressed through regulatory means	- Morphological - Diffuse source pollution					Scottish Natural Heritage	Natural Project Grants		✘			
	IHN	None – gap in network						Community Grants		✘			
	JBA ID	N/A						Central Scotland Green Network		✘			
Habitat	Associated data sources	Adjacent to planned development area (to the south around Inchcross Drive)					SEPA Scottish restoration fund				✓		
	Type of existing habitat	Industrial areas, broadleaved plantation woodland, bare ground, road					Land developer (ie. of surrounding area)				✘		
	Extent of existing habitat	Full length of reach					Other:				✘		
	Quality of existing habitat	Very low (woodland is low)											
	Sensitivity of existing habitat to land use / habitat change	Very low											
	Indicative species mix for restoration	Alder, grey sallow, creeping bent											
Benefits	Establishment techniques required	Direct planting and seeding					Other surveys required	Survey Type				Required	
	Barrier to restoration?	✘						Ecological habitat survey				✓	
	Capacity released – contribution to obtaining GES	Low impact realignment along a 1616m section of the reach releases 4.87% (this action applies to 492m of the reach – as a proportion this is about 1.48%)						Hydrological survey				✘	
	Flood risk benefit?	✘						Ground investigation				✓	
	Public access (existing or can connect to?)	✓ Council owned land, but no paths in area						Topographical survey				✘	
	Multiple WFD benefits?	Potential benefit		Applicability		Water quality monitoring				✘			
		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	Restoration of channel dynamics			Construction / restoration costs	Methods		Access required	✓				
Suggested action owner	West Lothian Council / industrial landowners			Machinery required			✓						
				Mitigation measures			✓		Sediment control measures to prevent movement of sediment downstream				
				Timing	Works to be carried out during low flow periods								
Ownership	Land owner	West Lothian Council; private residential at the downstream end; Scotwaste and other industrial landowners at the upstream end.			CAR licensing required	Logistics	- Surrounding landowners to be contacted regarding machinery access 100% of material to be disposed of off-site						
	Registration		Simple licence	✓		Complex licence		In stream structure in river ≤ 3m wide					

ISSUE 7: Diffuse source pollution – iron seepage				ACTION: Investigate and identify diffuse source. Coal authority to tackle by 2027				Unique ID: Bog_IDS_1						
Site information	Description		Standhill – between Whtiburn Road and Standhill Road and downstream of Standhill Road			Cost estimate	Estimate (£k)		0.94					
	OS NGR		296117E 667025N to 296717E 667301N				Assumptions		2 day investigation for 2 people					
	Photo reference		Appendix B – photos 20 to 24			Further considerations	Funding mechanism / opportunities	Fund name			Applicability			
	Access		Via roads that cross reach					Scotland Rural Development Fund	Challenge Funds		✘			
	Reach length (m)		795m						Rural Development Contracts – Land Manager Options		✓			
Rural Priorities – Forth Area									✓					
Pressure	Pressures to be addressed through regulatory means		- Morphological - Diffuse source pollution					Scottish Natural Heritage	Natural Project Grants		✘			
	IHN		None – gap in network						Community Grants		✓			
	JBA ID		N/A						Central Scotland Green Network		✘			
	Associated data sources		Adjacent to planned development area (to the south around Inchcross Drive)											
Habitat	Type of existing habitat		Industrial areas, broadleaved plantation woodland, bare ground, road					SEPA Scottish restoration fund			✓			
	Extent of existing habitat		Full length of reach					Land developer (ie. of surrounding area)			✘			
	Quality of existing habitat		Very low (woodland is low)					Other: - The Naturesave Trust - The Ibrahim Foundation - The Steel Charitable Trust			✓			
	Sensitivity of existing habitat to land use / habitat change		Very low								✓			
	Indicative species mix for restoration		Alder, grey willow, creeping bent								✓			
	Establishment techniques required		Direct planting and seeding											
Benefits	Barrier to restoration?		✘					Other surveys required	Survey Type			Required		
	Capacity released – contribution to obtaining GES		None – no information on capacity released by improving diffuse pollution						Ecological habitat survey			✘		
	Flood risk benefit?		✘						Hydrological survey			✘		
	Public access (existing or can connect to?)		✓		Council owned land, but no paths in 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	N/A		
			Contribute to addressing flood risk		✘						Machinery required	N/A		
			Reduce invasive non-native species		✘						Mitigation measures	N/A		
			Climate change adaptation		✘					Timing	N/A			
	Raise awareness of the benefits of healthy water environments		✓		Logistics	Need to liaise with surrounding landowners during investigation								
	Wider environmental benefits		Positive impacts on downstream biodiversity											
	Ownership	Suggested action owner		West Lothian Council / Coal Authority			CAR licensing required	N/A						
Land owner		West Lothian Council; private residential at the downstream end; Scotwaste and other industrial landowners at the upstream end.												

ISSUE 8: Poor channel morphology, degraded masonry bank protection, bank erosion, rapids formed from out of eroded masonry material					ACTION: Encourage naturalisation: remove masonry material, restore rapids					Unique ID: Bog_ChR_3					
Site information	Description		Standhill downstream of Standhill Road			Cost estimate	Estimate (£k)		26						
	OS NGR		296686E 667082N to 296720E 667294N				Assumptions		Includes 3 days site work for 2 people. 100% of material disposed of off-site.						
	Photo reference		Appendix B – photos 23 and 24			Further considerations	Funding mechanism / opportunities	Fund name				Applicability			
	Access		Standhill Road or potential access through industrial estate					Scotland Rural Development Fund	Challenge Funds		✘				
	Reach length (m)		204						Rural Development Contracts – Land Manager Options		✘				
	Width (m)		3						Rural Priorities – Forth Area		?				
Pressure	Pressures to be addressed through regulatory means		- Morphological - Diffuse source pollution					Scottish Natural Heritage	Natural Project Grants		✘				
	IHN		None – gap in network						Community Grants		✘				
	JBA ID		N/A						Central Scotland Green Network		✘				
	Associated data sources		Adjacent to planned development area (to the east)					SEPA Scottish restoration fund				✓			
Habitat	Type of existing habitat		Unimproved acid grassland, bare ground, broadleaved plantation woodland					Land developer (ie. of surrounding area)				✘			
	Extent of existing habitat		Full length of reach					Other:				✘			
	Quality of existing habitat		Very low (bare ground), low (woodland) and good (unimproved grassland)												
	Sensitivity of existing habitat to land use / habitat change		Low												
	Indicative species mix for restoration		Alder, grey sallow, creeping bent, watercress												
	Establishment techniques required		Direct planting and seeding												
Benefits	Barrier to restoration?		✘					Other surveys required	Survey Type				Required		
	Capacity released – contribution to obtaining GES		Low impact realignment along a 1616m section of the reach releases 4.87% (this action applies to 204m of the reach – as a proportion this is about 0.62%)				Ecological habitat survey				✘				
	Flood risk benefit?		✘						Hydrological survey				✘		
	Public access (existing or can connect to?)		✓		Council owned land, but no paths in 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		✓		
				Contribute to addressing flood risk			✘				Machinery required		✓		
				Reduce invasive non-native species			✘				Mitigation measures		✓		
				Climate change adaptation			✘			Timing		Works to be carried out in low flow periods			
				Raise awareness of the benefits of healthy water environments			✘			Logistics		Multiple landowners in industrial estate may need to be contacted regarding access, etc.			
	Wider environmental benefits		Improvements to bed morphology, hydraulics and channel dynamics				CAR licensing required	Registration				Simple licence		✓	
Ownership	Suggested action owner		West Lothian Council					In-stream structures in rivers ≤ 3m wide				Complex licence			
	Land owner		West Lothian Council												

ISSUE 9: Degraded riparian strip				ACTION: Improve riparian strip - planting				Unique ID: Bog_VP_1						
Site information	Description		Downstream of Standhill Road			Cost estimate	Estimate (£k)		15					
	OS NGR		296736E 667333N to 296933E 667609N				Assumptions		Assumes width of 20 metres on either side of burn. Includes fencing, plants and labour costs.					
	Photo reference		Appendix B – photo 25			Further considerations	Funding mechanism / opportunities	Fund name			Applicability			
	Access		Via farm track					Scotland Rural Development Fund	Challenge Funds		✘			
	Reach length (m)		360						Rural Development Contracts – Land Manager Options		✓			
					Rural Priorities – Forth Area				✓					
Pressure	Pressures to be addressed through regulatory means		- Morphological - Diffuse source pollution					Scottish Natural Heritage	Natural Project Grants		✘			
	IHN		- Fen, marsh and swamp - Neutral grassland						Community Grants		✓			
	JBA ID		391_3107_Morph_NG_297096_667730 393_3107_Morph_FMS_297065_667702 394_3107_UrbanDP_NG_296804_668468 395_3107_UrbanDP_FMS_296842_668945						Central Scotland Green Network		✓			
	Associated data sources		- Within planned development area - Partially within fluvial 200 year											
Habitat	Type of existing habitat		Unimproved and semi-improved acid grassland, scrub, wet grassland					SEPA Scottish restoration fund		✓				
	Extent of existing habitat		Full length of reach					Land developer (i.e. of surrounding area)		✓				
	Quality of existing habitat		Good			Other: - The Naturesave Trust - The Ibrahim Foundation		✓ ✓						
	Sensitivity of existing habitat to land use / habitat change		High											
	Indicative species mix for restoration		Alder, grey willow, watercress, yellow flag iris											
	Establishment techniques required		Direct planting											
Benefits	Barrier to restoration?		✘				Other surveys required	Survey Type			Required			
	Capacity released – contribution to obtaining GES		None – no capacity information available for improvements to riparian strip			Ecological habitat survey			✘					
	Flood risk benefit?		✓		Increase in riparian roughness will reduce flood flow velocities.			Hydrological survey			✘			
	Public access (existing or can connect to?)		✘		Private land			Ground investigation			✘			
								Topographical survey			✘			
								Water quality monitoring			✘			
	Multiple WFD benefits			Potential benefit		Applicability		Construction / restoration costs	Methods	Access required		N/A		
				Opportunity to expand green/ecological network		✓				Machinery required		N/A		
				Help achieve good ecological status		✓				Mitigation measures		N/A		
				Contribute to addressing flood risk		✓			Timing - Ideally between November and February - Avoid frost and snow where possible					
				Reduce invasive non-native species		✓			Logistics				N/A	
				Climate change adaptation		✓								
		Raise awareness of the benefits of healthy water environments		✘										
		Wider environmental benefits		Extend IHN's upstream. Reduction in bank erosion and sediment input.										
Ownership	Suggested action owner		West Lothian Council / landowner Standhill Farm			CAR licensing required	N/A							
	Land owner		Private – farmer -Standhill Farm (to the east of the burn); private residential to the west; and West Lothian Council upstream and downstream.											

ISSUE 10: New road and culvert across burn and floodplain – splitting floodplain and restricting movement of flood flows					ACTION: Remove road and culvert			Unique ID: Bog_RdRe_1, Bog_CRe_1					
Site information	Description	Downstream of Standhill Road, road connecting Whitburn Road and Leyland Road				Cost estimate	Estimate	Not costed as not deemed feasible					
	OS NGR	296770E 667730N to 297134E 667534N – Bog_RdRe_1 296933E 667612N to 296961E 667658N – Bog_CRe_1											
	Photo reference	Appendix B – photo 26				Further considerations	Funding mechanism / opportunities	Fund name			Applicability		
	Site access	Via new road											
	Reach length (m)	55						Scotland Rural Development Fund	Challenge Funds		✘		
Pressure	Pressures to be addressed through regulatory means	- Morphological - Diffuse source pollution			Rural Development Contracts – Land Manager Options				✘				
	IHN	- Fen, marsh and swamp - Neutral grassland			Rural Priorities – Forth Area				✓				
	JBA ID	391_3107_Morph_NG_297096_667730 393_3107_Morph_FMS_297065_667702 394_3107_UrbanDP_NG_296804_668468 395_3107_UrbanDP_FMS_296842_668945			Natural Project Grants			✘					
	Associated data sources	- Within planned development area - Partially within fluvial 200 year - Adjacent to local nature conservation site			Community Grants			✘					
Habitat	Type of existing habitat	Acid grassland, wet floodplain grassland			SEPA Scottish restoration fund			✓					
	Extent of existing habitat	Full length of reach			Land developer (ie. of surrounding area)			✓					
	Quality of existing habitat	Good			Other:			✘					
	Sensitivity of existing habitat to land use / habitat change	High											
	Indicative species mix for restoration	Reed canary grass, bottle sedge, creeping bent											
	Establishment techniques required	Direct planting											
Benefits	Barrier to restoration?	✓	Road and culvert have already been constructed. Development on the floodplain has already begun.				Other surveys required	Survey Type			Required		
	Capacity released – contribution to obtaining GES	None			Ecological habitat survey								
	Flood risk benefit?	✓	Removal of the road and culvert will allow flood flows to be transmitted across floodplain instead of backing up behind the road. This would alleviate flooding upstream of the road. Removal of the road would also increase flood storage capacity in this area.					Hydrological survey			✓		
	Public access (existing or can connect to?)	✓	Existing public access via the road. Opportunity to expand public access to waterway. This could be integrated into planned development.					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		✓									
		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	✓	Sediment control measures to minimise sediment disturbance and movement downstream		
				Machinery required	✓								
				Mitigation measures	✓								
		Timing	To be carried out during low flow periods										
	Logistics	Multiple land owners - liaise with developer and / or surrounding residential property owners											
Ownership	Suggested action owner	SEPA to enforce CAR licence conditions				CAR licensing required	Registration		Simple licence	✓	Complex licence		
	Land owner	West Lothian Council					Closed culverts not used for footpaths, cycle routes or single track roads in rivers						

ISSUE 11: Embankments on floodplain adjacent to burn; failed geotextile protection through dissected embankment				ACTION: Remove embankments; remove failed geotextile material				Unique ID: Bog_FBRe_2, Bog_FBRe_3, Bog_FBRe_4, Bog_GRe_1					
Site information	Description	Whiteside		Cost estimate	Estimate (£k) –embankments	309	Dimensions		4m height x 2.5m width				
	OS NGR	297018E 667752N to 297281E 667748N			Estimate (£k) – geotextile	3.5			1m width x 1m depth (on both sides of the burn)				
	Photo reference	Appendix B – photos 27 and 28			Assumptions	100% of material to be disposed of off-site. Includes 10 days time for site engineer for embankment removal and 3 days site engineer time for geotextile removal. Includes costs for hydrological survey (£2k) and topographical survey (£2k)							
	Access	Via surrounding paths / vacant land		Further considerations	Funding mechanism / opportunities	Fund name				Applicability			
	Reach length (m)	320				Scotland Rural Development Fund	Challenge Funds		✘				
	Feature lengths (m)	Total embankment length – 370m; geotextile – 20m length					Rural Development Contracts – Land Manager Options		✓				
Pressure	Pressures to be addressed through regulatory means	- Morphological - Diffuse source pollution		Further considerations	Funding mechanism / opportunities		Scotland Rural Development Fund	Rural Priorities – Forth Area		✓			
	IHN	- Fen, marsh and swamp - Neutral grassland				Natural Project Grants		✘					
	JBA ID	391_3107_Morph_NG_297096_667730 393_3107_Morph_FMS_297065_667702 394_3107_UrbanDP_NG_296804_668468 395_3107_UrbanDP_FMS_296842_668945				Community Grants		✘					
	Associated data sources	- Within planned development area - Partially within fluvial 200 year - Partially within local nature conservation site - Groundwater flood hazard area to the north				Central Scotland Green Network		✓					
Habitat	Type of existing habitat	Floodplain mire, acid grassland		Further considerations	Funding mechanism / opportunities	SEPA Scottish restoration fund				✓			
	Extent of existing habitat	Full length of reach				Land developer (i.e. of surrounding area)				✓			
	Quality of existing habitat	Good				Other: - Paths for All – Community Links - The Naturesave Trust - The Ibrahim Foundation - J Paul Getty JR Charitable Trust				✓			
	Sensitivity of existing habitat to land use / habitat change	High								✓			
	Indicative species mix for restoration	Alder, reed canary grass, bottle sedge								✓			
	Establishment techniques required	Direct planting								✓			
Benefits	Barrier to restoration?	✓	Road and culvert already constructed. New development already started in surrounding area.		Other surveys required	Survey Type				Required			
	Capacity released – contribution to obtaining GES	Set back three embankments/floodwalls – total capacity gained = 0.2%				Ecological habitat survey				✘			
	Flood risk benefit?	✓	Increase in flood plain connectivity			Hydrological survey				✓			
	Public access (existing or can connect to?)	✓	Existing paths adjacent to reach could be expanded			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	✓	- Sediment control measures to minimise disturbance and movement during removal - Measures to stabilise site after removal			
		Contribute to addressing flood risk		✓				Machinery required	✓				
		Reduce invasive non-native species		✘				Mitigation measures	✓				
		Climate change adaptation		✘			Timing	To be carried out during low flow periods					
	Raise awareness of the benefits of healthy water environments		✘		Logistics		All material to be disposed of offsite						
	Wider environmental benefits		Re-establishment of floodplain dynamics and reconnection of floodplain habitats		CAR licensing required		Registration			Simple licence	✓	Complex licence	
	Suggested action owner		West Lothian Council			Set-back embankment							
Land owner		West Lothian Council											

ISSUE 12: Degraded riparian strip			ACTION: : Improve riparian strip – planting, redirect flow from pumping station to the north west					Unique ID: Bog_VP_2, Bog_RFI_1					
Site information	Description	Whiteside				Cost estimate	Estimate (£k)	4					
	OS NGR	297291E 667716N to 297429E 667735N (Bog_VP_2) 297411E 667629N to 297446E 667858N (Bog_RFI_1)					Assumptions	Assumes width of 10 metres on either side of burn. Includes fencing, plants and labour costs. Would need further investigation to determine costs of redirecting flow from pumping station. Liaison with pumping station required.					
	Photo reference	Appendix B – photo 29				Funding mechanism / opportunities		Fund name				Applicability	
	Access	Via surrounding paths / vacant land						Scotland Rural Development Fund	Challenge Funds		✘		
	Reach length (m)	145 (Bog_VP_2) 237 (Bog_RFI_1)							Rural Development Contracts – Land Manager Options		✓		
Rural Priorities – Forth Area									✓				
Pressures to be addressed through regulatory means	- Morphological - Diffuse source pollution				Scottish Natural Heritage			Natural Project Grants		✘			
IHN	- Fen, marsh and swamp - Neutral grassland							Community Grants		✘			
JBA ID	391_3107_Morph_NG_297096_667730 393_3107_Morph_FMS_297065_667702 394_3107_UrbanDP_NG_296804_668468 395_3107_UrbanDP_FMS_296842_668945							Central Scotland Green Network		✓			
Associated data sources	- Within planned development area - Fully within fluvial 200 year - Within local nature conservation site - Partially within groundwater flood hazard area (eastern section of the reach)												
Habitat	Type of existing habitat	Mixed plantation woodland and acid grassland (left bank), floodplain grassland (right bank)						Further considerations	SEPA Scottish restoration fund				✓
	Extent of existing habitat	Full length of reach							Land developer (i.e. of surrounding area)				✓
	Quality of existing habitat	Good (wet grassland mire), moderate (grassland and mixed woodland)				Other:				✓			
	Sensitivity of existing habitat to land use / habitat change	High (valley mire), low (woodland and acid grassland)				- J Paul Getty JR Charitable Trust - Paths for All – Community Links - The Naturesave Trust - The Ibrahim Foundation				✓ ✓ ✓ ✓			
	Indicative species mix for restoration	Grey sallow, alder, reed canary grass											
	Establishment techniques required	Direct planting											
Benefits	Barrier to restoration?	✘					Other surveys required		Survey Type				Required
	Capacity released – contribution to obtaining GES	None – no capacity information available for improvements to riparian strip							Ecological habitat survey				✘
	Flood risk benefit?	✓		Reduce runoff rates					Hydrological survey				✘
	Public access (existing or can connect to?)	✓		Existing paths adjacent to reach could be expanded along waterway.					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	N/A		
		Contribute to addressing flood risk			✓		Machinery required			N/A			
		Reduce invasive non-native species			✘		Mitigation measures			N/A			
		Climate change adaptation			✓		Timing		- Ideally between November and February - Avoid frost and snow where possible				
	Raise awareness of the benefits of healthy water environments			✘		Logistics	Need to liaise with pumping station owners.						
	Ownership	Wider environmental benefits	Contribute to enhancing IHN in local area					CAR licensing required					
		Suggested action owner	West Lothian Council						N/A				
	Land owner	West Lothian Council											

ISSUE 13: Straightened artificial channel, with poor morphology. Channel is too deep and straight and is disconnected from floodplain.				ACTION: Narrow channel significantly, introduce berms/bars using woody debris to encourage naturalization and sinuosity. Create a two stage channel to increase flood capacity along the left bank.				Unique ID: Bog_ChR_4								
Site information	Description		Upstream of Boghead Bridge		Cost estimate	Estimate (£k)		81								
	OS NGR		297120E 6687930N to 297388E 667930N			Assumptions		50% of excavated material to be disposed of off-site, remaining material to be used on site if possible. Costs included for several berms along reach. Includes 5 days time for 2 people on site. Includes costs for hydrological survey (£3k). topographical survey (£2k). ecological survey (£2k).								
	Photo reference		Appendix B – photo 30		Further considerations	Funding mechanism / opportunities		Fund name			Applicability					
	Access		Via Whitburn Road / surrounding paths					Scotland Rural Development Fund		Challenge Funds		✘				
	Reach length (m)		425							Rural Development Contracts		✘				
Pressures to be addressed through regulatory means		- Morphological - Diffuse source pollution		Rural Priorities – Forth Area						✓						
Pressure	IHN		- Fen, marsh and swamp - Neutral grassland					Scottish Natural Heritage		Natural Project Grants		✓				
	JBA ID		394_3107_UrbanDP_NG_296804_668468 395_3107_UrbanDP_FMS_296842_668945							Community Grants		✘				
	Associated data sources		- Within planned development area - Fully within fluvial 200 year - Within local nature conservation site - Within groundwater flood hazard area							Central Scotland Green Network		✘				
	Habitat	Type of existing habitat		Mixed plantation woodland, riparian woodland (left bank), bare ground and industrial uses (right bank).				SEPA Scottish restoration fund		Land developer (i.e. of surrounding area)		Other: - J Paul Getty JR Charitable Trust - The Naturesave Trust - The Ibrahim Foundation		✓ ✓ ✓		
Extent of existing habitat		Semi-natural on left bank for full reach and industrial and construction on right bank for full length of reach														
Quality of existing habitat		Good (left bank), very poor (right bank)														
Sensitivity of existing habitat to land use / habitat change		High (left bank), very low (right bank)														
Indicative species mix for restoration		Alder, grey sallow, bottle sedge, watercress, reed canary grass														
Establishment techniques required		Direct planting														
Benefits	Barrier to restoration?		✓ Recent development has occurred to the east of the waterway.			Other surveys required		Survey Type			Required					
	Capacity released – contribution to obtaining GES		Realignment of 2195m of channel releases 7.04% of capacity. This section of the channel is 426m long which equates to about 1.36% of capacity.					Ecological habitat survey			✓					
	Flood risk benefit?		✓ Creation of two stage channel will increase flood storage capacity. Increased sinuosity will reduce flood flows.					Hydrological survey			✓					
	Public access (existing or can connect to?)		✓ Existing paths adjacent to reach					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		N/A		
	Raise awareness of the benefits of healthy water environments		✓		Logistics		N/A									
	Wider environmental benefits		Improvements to bed morphology, hydraulics and channel dynamics		CAR licensing required		Registration		Simple licence		✓		Complex licence			
	Suggested action owner		Land developer of surrounding area				Channel modification and green bank reinforcement									
Land owner		West Lothian Council to the south west; private land (unknown owner) and Morrisons supermarket to the north east.														

ISSUE 14: Sheet piling on bank					ACTION: Remove sheet piling					Unique ID: Bog_StRe_1							
Site information	Description		Upstream of Boghead Bridge			Cost estimate	Estimate (£k)	Not able to be costed at this stage as requires further assessment. Further investigation would be needed to determine depth of exact depth of sheet piling, soil and ground conditions. 1 day site investigation for site engineer and agent = £600									
	OS NGR		297208E 668214N to 297146E 668294N														
	Photo reference		Appendix B – photo 31			Further considerations	Funding mechanism / opportunities	Fund name				Applicability					
	Access		Via Whitburn Road or paths adjacent to residential area					Scotland Rural Development Fund	Challenge Funds		✘						
	Reach length (m)		50						Rural Development Contracts – Land Manager Options		✘						
Pressure	Pressures to be addressed through regulatory means		- Morphological - Diffuse source pollution						Scottish Natural Heritage	Rural Priorities – Forth Area		✘					
	IHN		Adjacent to: - Fen, marsh and swamp area - Neutral grassland area					Natural Project Grants		✘							
	JBA ID		392_3107_Morph_NG_297067_668233 394_3107_UrbanDP_NG_296804_668468					Community Grants		✘							
	Associated data sources		- Adjacent to planned development areas (upstream and downstream) - Fully within fluvial 200 year - Within groundwater flood hazard area - Core path crosses the burn just downstream of reach					Central Scotland Green Network		✘							
Habitat	Type of existing habitat		Unimproved acid grassland (left bank), buildings (right bank)					SEPA Scottish restoration fund				✓					
	Extent of existing habitat		Full length of reach.					Land developer (i.e. of surrounding area)				✘					
	Quality of existing habitat		Poor (left bank), very low (right bank)					Other:				✘					
	Sensitivity of existing habitat to land use / habitat change		Low (left bank), negligible (right bank)														
	Indicative species mix for restoration		Alder, reed canary grass														
	Establishment techniques required		Direct planting														
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 public access via paths from road and residential areas adjacent to the reach				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			✓		Sediment control measures to minimise sediment disturbance				
		Climate change adaptation			✘			Timing		To be carried out during low flow periods							
	Raise awareness of the benefits of healthy water environments			✓				Logistics		N/A							
	Wider environmental benefits		Help reconnect floodplain habitats					CAR licensing required	Registration			Simple licence		✓		Complex licence	
Suggested action owner		Morrison's			In-stream structures in rivers affecting ≤ 50m of river length												
Land owner		West Lothian Council to the south and Morrison's supermarket to the north															

ISSUE 15: Poor channel morphology – pipe weir in channel				ACTION: Investigate removal of pipe weir				Unique ID: Bog_StRe_2					
Site information	Description	Boghead Bridge - immediately downstream of Whitburn Road			Cost estimate	Estimate (£)	5.9						
	OS NGR	297088E 668296N				Assumptions	Material deposited off site. Includes costs for 1 day site agent; hydrological model (£3k) and topographical survey (£2k)						
	Photo reference	Appendix B – photo 32			Further considerations	Funding mechanism / opportunities	Fund name				Applicability		
	Site access	Via Whitburn Road or paths adjacent to residential area					Scotland Rural Development Fund	Challenge Funds		✘			
	Reach length (m)	1						Rural Development Contracts – Land Manager Options		✘			
	Weir dimensions	5m width x 1m length						Rural Priorities – Forth Area		✘			
Pressure	Pressures to be addressed through regulatory means	- Morphological - Diffuse source pollution					Scottish Natural Heritage	Natural Project Grants		✘			
	IHN	Adjacent to: - Fen, marsh and swamp area - Neutral grassland area						Community Grants		✘			
	JBA ID	392_3107_Morph_NG_297067_668233 394_3107_UrbanDP_NG_296804_668468						Central Scotland Green Network		✘			
	Associated data sources	- Adjacent to planned development areas (upstream and downstream) - Fully within fluvial 200 year - Within groundwater flood hazard area - Core path crosses the burn just downstream of reach					SEPA Scottish restoration fund				✔		
Habitat	Type of existing habitat	Urban, improved grassland					Land developer (i.e. of surrounding area)	✘					
	Extent of existing habitat	Localised at location, just outside study area.						Other:	✘				
	Quality of existing habitat	Low											
	Sensitivity of existing habitat to land use / habitat change	Low											
	Indicative species mix for restoration	Alder, creeping bent.											
	Establishment techniques required	Direct planting and seeding											
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 public access via paths from road and residential areas adjacent to the reach				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	✔	Sediment control measures to minimise sediment disturbance and movement downstream during removal			
		Climate change adaptation		✘			Timing	To be carried out during low flow periods					
		Raise awareness of the benefits of healthy water environments		✔			Logistics	N/A					
	Wider environmental benefits	Improvements to aquatic ecosystem			CAR licensing required	Registration		Simple licence	✔	Complex licence			
	Ownership	Suggested action owner	West Lothian Council			In-stream structures in rivers affecting ≤ 50m of river length							
	Land owner	West Lothian Council (to the south) and private residential to the north and west.											

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.

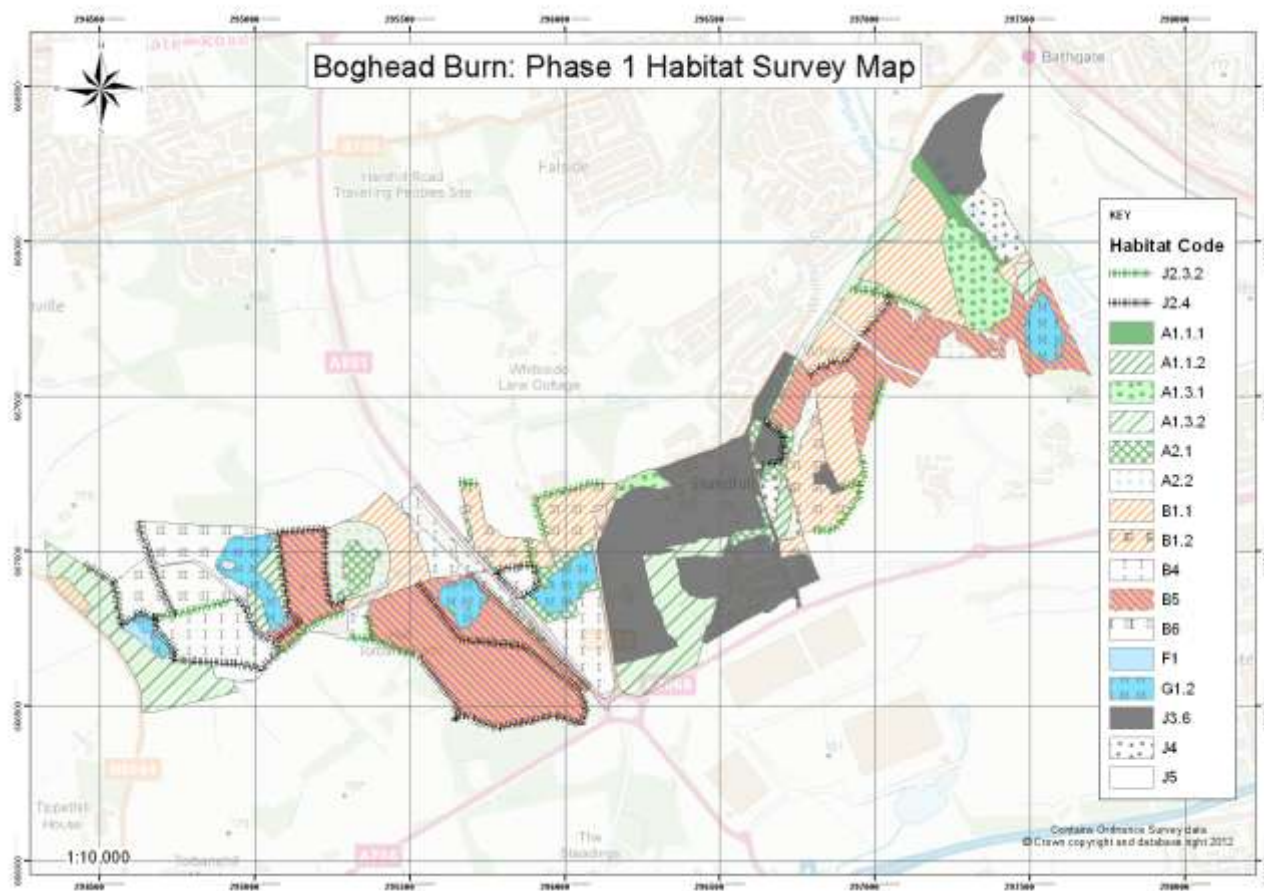
¹ SPON'S Civil Engineering and Highway Works Price Book, 2008

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).

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E Phase 1 habitat mapping



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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

BOGHEAD 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
1	Bog_EdFP_1	Control diffuse sediment input	> 1km	Neutral	Unknown	Neutral	Low	Neutral	Positive	Neutral	Low	No	Positive	Neutral	Neutral	Positive	Not present	Unknown	Positive	Unknown	Positive	Positive	1.37
2	Bog_ChRe_1, Bog_ChR_1, Bog_AV_1	Remove from drainage network; reinstate flow and channel; assess abstraction value	200m - 1km	Positive	Low	Positive	Neutral	Neutral	Neutral	Low	Low	No	Low	Neutral	Neutral	Positive	Not present	Unknown	Neutral	Positive	Positive	Positive	1.64
3	Bog_RMC_1, Bog_RMC_2, Bog_RMC_3	Riparian margin creation	200m - 1km	Positive	Unknown	Positive	Neutral	Positive	Neutral	Positive	Low	Yes	Low	Neutral	Neutral	Positive	Not present	Unknown	Neutral	Positive	Positive	Positive	1.58
4	Bog_FBRe_1, Bog_RMC_4, Bog_RMC_5	Remove floodbanks and floodwalls; riparian margin creation	> 1km	Positive	Neutral	Neutral	Neutral	Positive	Neutral	Positive	Low	Yes	Low	Neutral	Neutral	Positive	Not present	Unknown	Neutral	Neutral	Positive	Neutral	1.41
5	Bog_ChR_2	Restore channel	200m - 1km	Positive	Unknown	Neutral	Low	Positive	Neutral	Neutral	Low	No	Low	Neutral	Low	Neutral	Present	Unknown	Low	Low	Neutral	Low	1.67
6	Bog_LCRe_1, Bog_LCRe_2	Remove channel lining	200m - 1km	Neutral	Positive	Neutral	Low	Neutral	Low	Neutral	Low	No	Low	Neutral	Neutral	Positive	Not present	Unknown	Positive	Neutral	Neutral	Low	1.53
7	Bog_ChR_3	Restore rapids	<200m	Neutral	Neutral	Neutral	Low	Neutral	Low	Neutral	Low	No	Low	Neutral	Neutral	Positive	Not present	Unknown	Neutral	Neutral	Neutral	Low	1.59
8	Bog_VP_1	Improve riparian strip	200m - 1km	Positive	Unknown	Positive	Positive	Positive	Neutral	Positive	Low	No	Low	Neutral	Neutral	Positive	Not present	Unknown	Neutral	Neutral	Positive	Positive	1.54
10	Bog_FBRe_2, Bog_FBRe_3, Bog_FBRe_4, Bog_GRe_1	Remove floodbanks and floodwalls; remove geotextile	200m - 1km	Positive	Neutral	Positive	Low	Neutral	Low	Neutral	Low	No	Positive	Positive	Neutral	Positive	Present	Unknown	Positive	Low	Positive	Neutral	1.53
11	Bog_VP_2	Improve riparian strip	<200m	Positive	Unknown	Positive	Positive	Positive	Neutral	Positive	Low	Yes	Positive	Positive	Neutral	Positive	Not present	Unknown	Neutral	Positive	Positive	Positive	1.73
12	Bog_ChR_4	Restore channel	<200m	Positive	Positive	Positive	Low	Neutral	Low	Neutral	Low	No	Positive	Neutral	Neutral	Positive	Present	Unknown	Low	Neutral	Positive	Neutral	1.77
13	Bog_StRe_1	Remove in-channel structure	<200m	Neutral	Low	Neutral	Low	Neutral	Low	Neutral	Low	No	Positive	Neutral	Positive	Positive	Not present	Unknown	Positive	Unknown	Neutral	Low	1.73
14	Bog_StRe_2	Investigate weir removal	<200m	Neutral	Low	Positive	Positive	Positive	Low	Positive	Low	No	Positive	Neutral	Positive	Positive	Not present	Unknown	Positive	Positive	Neutral	Low	1.77

**Average score only averages values if greater than or equal to 1.
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/negative = 3

Weighting for primary factors (divisor)
2



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Registered Office

South Barn

Broughton Hall

SKIPTON

North Yorkshire

BD23 3AE

t: +44(0)1756 799919

e: info@jbagroup.co.uk

JBA Group Limited

Registered in England 6396638

Visit our website

www.jbagroup.co.uk