Date	14th July 2022	Issued version	1.0
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Project	Glenshero LWS		
Subject	Habitat enhancement for the Upper River Spey		

1. INTRODUCTION

cbec eco-engineering UK Ltd was commissioned by the Spey Fishery Board and the Spey Catchment Initiative to undertake a geomorphic assessment to specify suitable locations for large wood placement in the Upper Spey within the Glenshero Estate for the purposes of habitat enhancement. Long-term monitoring by the Spey Fishery Board has indicated that salmonid numbers and productivity are low in the Upper Spey (relative to other similar tributaries), primarily owing to the barrier to migratory fish passage posed by the Spey Dam. However, proposed upgrading of the dam's fish pass in the near future is projected to increase the accessibility of the Upper Spey for salmonids. Accordingly, the present project aims to optimise the upstream habitat, ready to support the anticipated increased use of this habitat by salmonids. In this context, the implementation of large wood structures (LWS) is intended to 'kick-start' natural river processes in the reach to achieve the following objectives:

- Optimise in-stream habitat to support the spawning and rearing of salmonids;
- Contribute to climate resilience by slowing water movement and reducing flood peaks;
- Provide cooler refuge areas (i.e. in-channel cover) for aquatic life as temperatures rise under climate change.

Implementation of large wood enhances geomorphic process by encouraging localised bar development and associated bank erosion to induce the natural recruitment of alluvial material and, over time, large wood to the channel. The objectives of this project will also dovetail with past and future planting undertaken within the riparian zone, which is intended to ensure a future supply of natural wood to the Upper Spey.

It is intended that up to 80 to 100 LWS are to be installed across the surveyed reach. These LWS are to be a combination of 'bar apex' and 'medial' structures, both of which aim to encourage and/or enhance the natural fluvial processes of sediment erosion and deposition, thereby driving enhanced physical evolution of the channel.

Bar apex structures are recommended to encourage the development of existing proto-alluvial bar features (i.e. where there is evidence of some degree of sediment storage) and, through deflection of flow towards the opposite bank, enhance the recruitment of sediment (i.e. through erosion) and large wood (i.e. trees currently located near the channel bank edge). Medial structures are typically proposed in wider sections of channel to enhance flow diversity in these more uniform sections, with implications for enhanced geomorphic process.

A brief desk-based assessment (Section 2) was undertaken to provide an overview of the setting, geomorphic regime and ecological condition of the Upper Spey. This background information was used to inform the geomorphic survey, supporting the selection of geomorphically beneficial locations for LWS implementation. The geomorphic survey (see Section 3) has identified 114 potential locations for the installation of LWS. Each location has been assigned a priority rating of high, medium or low in relation to its potential for locally increasing stream complexity, habitat diversity and in-channel cover, while also taking into account the overall spatial distribution of structures throughout the study reach. The potential for each structure to encourage the future (natural) recruitment of large wood has not been considered explicitly here, as efforts to enhance riparian tree distribution are ongoing within the catchment. However, areas in which trees are located close to the channel bank edge have been highlighted, and the locations of the LWS implemented as part of this project can be used to guide future riparian planting. The implementation of the LWS is discussed further in Section 4.

2. DESK STUDY

2.1 STUDY AREA AND SETTING

From its headwaters around Loch Spey, the River Spey flows north-westerly to Spey Bay on the northern coast of Moray, passing through the Cairngorms National Park. This study focuses on a section of the Upper Spey, situated upstream of the Spey Dam at Laggan. The study area, consisting of 4 reaches pre-selected by the Spey Catchment Initiative (Figure 2.1), extends from the Shesgnan Burn confluence with the River Spey (OS NGR NN 4345 9422), ~1.4 km downstream of Loch Spey, to the Allt a' Ghamhna confluence (OS NGR NN 4927 9561), near Meall a' Ghiubhais, covering a total channel length of ~7 km.

2.2 HISTORIC CHANNEL ADJUSTMENT

A review of the National Library for Scotland's historic Ordnance Survey map archives highlighted the geomorphologically dynamic nature of this section of the River Spey, with evident lateral migration, typical of a meandering channel situated within an unconfined valley. Natural evolution of the channel planform over the period covered by available historical mapping, as illustrated within these map archives, demonstrates that the Upper Spey already possesses the energy required to carry out geomorphic work (i.e. to undertake sediment transport). The installation of LWS at various locations, deemed appropriate within the geomorphic context of the Spey's upper reaches, will act to 'kick-start' and enhance the processes already at work within the study area. These structures will further promote flow diversity and geomorphic heterogeneity, in particular by altering spatial patterns of erosion and deposition.

2.3 SALMON HABITAT & POPULATION ASSESSMENT 2017

Waterside Ecology, commissioned by SIMEC Lochaber Power and Morgan Fisheries Consultancy, undertook a baseline assessment of salmonid habitat provision and populations within the Upper Spey between November 2016 and September 2017. This ecological study was carried out to assess the implications of the fish pass on the Spey Dam, near Laggan, deemed inadequate by SEPA in 2016, owing to its effects on longitudinal connectivity for migratory fish. From Loch Spey downstream to

Laggan, the suitability and diversity of fluvial habitat was assessed in relation to the different freshwater stages of the salmonid lifecycle (i.e., spawning, fry, juvenile, glide and pool). Electrofishing and invertebrate samples were also carried out to assess the population size, diversity, and spatial distribution of aquatic fauna.

Waterside Ecology surveyed habitat distribution at a reach scale of ~250 m, many of which fall within the four larger, focus reaches within the present study. Table 2.1, below, details the survey reach distribution and summarises the fish habitats identified within the study reaches earmarked for the LWS survey.

Table 2.1. Summary of findings of Waterside Ecology report

LWS Reaches (R)	Salmon Habitat Surveyed Reaches (S; 2017)	Summary of habitat
1	55, 56, 57, 58 & 59	Low to moderate gradient; glide, riffle and run sequences; varied habitat with abundant coarse sediment (cobble and pebble); scarce boulders; meandering planform; widespread habitat suitable for spawning
2	47, 48, 49, 50, 51 & 52	Low gradient, meandering channel; long glide reaches; substrate dominated by sand to cobble; boulders scarce; potential spawning habitat where glides merge into runs
3	41 & 42	Flat valley floor, broad meanders; much of reach classed as unstable with rapid erosion; glide, riffle, run sequences; abundant spawning habitat but potential for redd washout
4	34, 35, 36 & 37	Flat valley floor, broad sweeping bends; low banks, non-vegetated point bars; substrate mainly cobbles, small boulders and pebbles; predominantly glide, riffle and run; many spawning opportunities; potential holding habitat in deep glides; pool habitat scarce
Additional areas		
Between R1 & 2	53 & 54	See R1 description above
Between R2 & 3	43, 44, 45 & 46	See R3 description above
Between R3 & 4	37, 38, 39, 40 & 41	See R4 description above

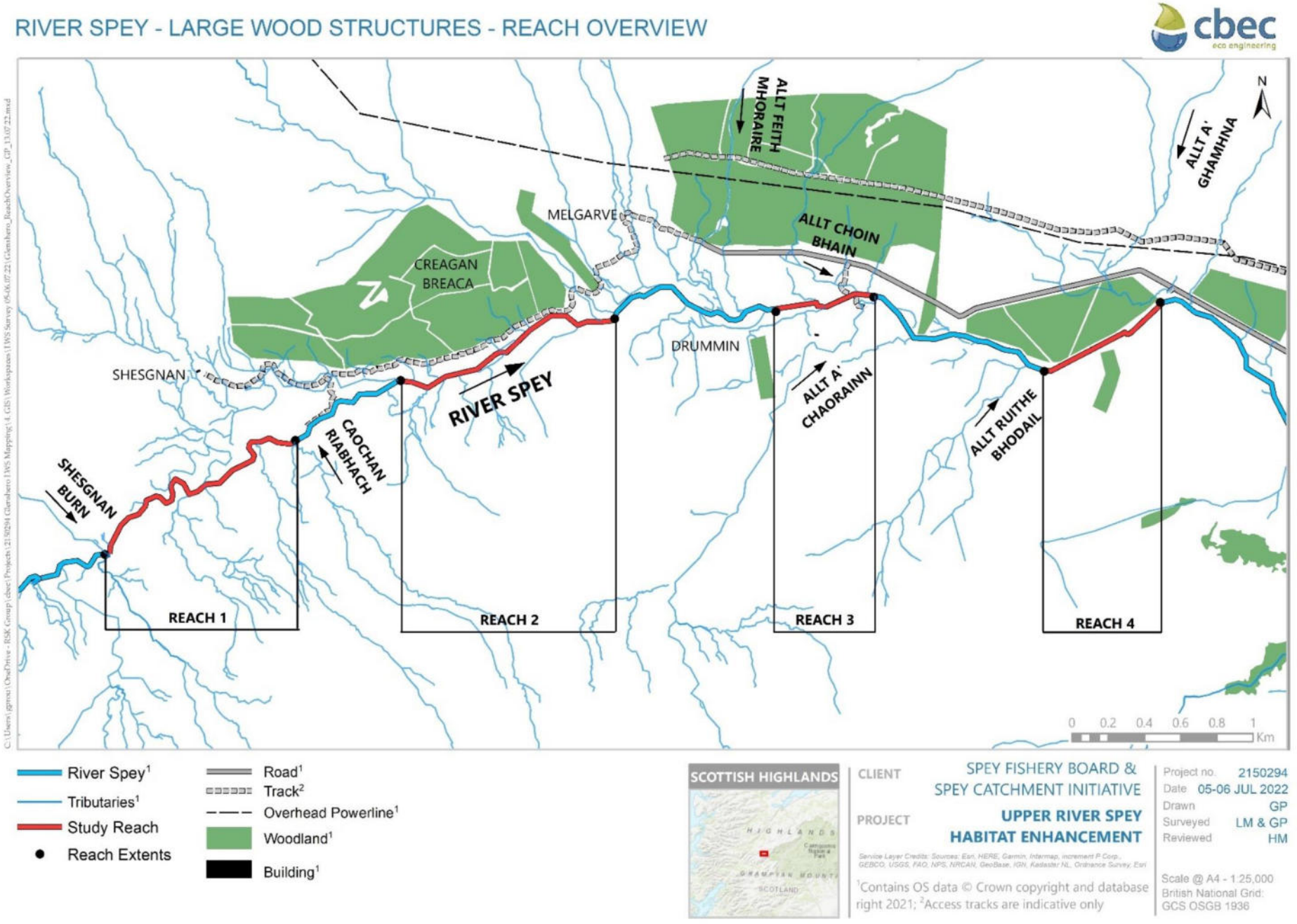

Figure 2.1. Overview map showing locations of reaches earmarked for LWS implementation

3. GEOMORPHIC SURVEY

cbec undertook a walkover survey of the Upper Spey on 5th and 6th July 2022 to identify suitable locations for the different types of LWS. Survey conditions were variable, ranging from dry weather to moderately heavy rainfall and high winds; water levels on the river were low to normal during the period of the survey. The survey covered a reach extending from NN 4345 9422 to NN 4927 9561, focusing on four reaches specified by the client:

- Reach 1 NN 4345 9422 to NN 4450 9485 (~1.5 km);
- Reach 2 NN 4508 9518 to NN 4626 9552 (~1.3 km);
- Reach 3 NN 4715 9556 to NN 4769 9564 (~0.5 km);
- Reach 4 NN 4863 9523 to NN 4927 9561 (~0.75 km).

However, suitable locations elsewhere within the wider reach were also considered. All locations were recorded and geo-referenced during the survey using a mobile GIS platform (QField) with integral GPS capability.

Table 3.1 provides a summary of the number of potential LWS locations identified in each of the four proposed reaches. Potential locations in the sections between each reach are also provided in the table.

The following information has been presented for each proposed structure:

- Structure reference number, ordered numerically from the upstream extent of Reach 1 (OS NGR NN 4345 9422) to the downstream end of Reach 4 (NN 4927 9561);
- Structure location, given as OS NGR grid references;
- Type of structure, indicating the location of installation of the large wood across the channel (i.e. left bar apex, right bar apex, medial);
- Priority level, assessed in relation to the degree of geomorphic or ecological benefit that could be realised through installation of the structure;
- Habitat, extracted from the Waterside Ecology report;
- Additional comments, including reasons for site selection, potential benefits for geomorphic and habitat diversity and potential constraints;
- Annotated photographs illustrating the direction of flow (blue arrows) and the proposed locations of root plates for the LWS (yellow arrows).

The prioritisation of the proposed locations was undertaken based on field observation, GIS analysis and consideration of the habitat maps provided in the Waterside Ecology (2017) report detailing salmon habitats and populations within the Upper River Spey. Proposed locations were assigned High priority where the channel was observed to be homogeneous with little existing geomorphic diversity (although some proto-alluvial bar forms may be present in these locations). Medium priority was assigned to locations in which some habitat diversity was already present at or near the location, but where there is considered to be potential to enhance the extent or quality of existing features. Locations were assigned a Low priority where the channel was already geomorphically diverse but where existing features could be further accentuated; this category also includes locations at which the Waterside Ecology (2017) study highlighted the existence of good salmonid habitat but where the installation of LWS would offer benefits in the form of in-channel cover and shading.

Table 3.1. LWS locations by reach

Reaches (R)	OS Grid Reference		Length (~km)	Large Wood Structures	
	Upstream	Downstream		Total	Structure Numbers
1	NN 4345 9422	NN 4450 9485	1.5	30	1 - 30
2	NN 4508 9518	NN 4626 9552	1.3	28	40 - 67
3	NN 4715 9556	NN 4769 9564	0.5	11	73 - 83
4	NN 4863 9523	NN 4927 9561	0.7	15	100 - 114
Additional areas					
Between R1 & 2	NN 4450 9485	NN 4508 9518	0.75	9	31 - 39
Between R2 & 3	NN 4626 9552	NN 4715 9556	1.05	5	68 - 72
Between R3 & 4	NN 4769 9564	NN 4863 9523	1.12	16	84 - 99

Logistical issues, such as ease of access/installation and the availability of trees and boulders locally were not explicitly considered in the ranking process, although the ranking table includes comments on these factors where appropriate, and the options maps provided indicate the locations of wooded/ forested areas and indicative locations where boulders can be found in the channel. Based on these factors, it is clear that implementation of LWS in Reach 1 is likely to be logistically difficult owing to the large distances over which both trees and boulders must be transported. Additionally, we consider the greatest potential benefit to habitat to be achievable in Reach 4, Reach 3 and in the section between these reaches. Accordingly, we suggest that the lower parts of the studied reach be prioritised for implementation if the number of structures to be installed is limited by budget or practicality, with the reaches prioritised as follows, from highest to lowest priority: Reach 4, Reach 3, between Reach 3 & Reach 4, Reach 2.

The proposed locations are illustrated in Figure 3.1 to Figure 3.7. Full details of each structure are provided in Appendix A.

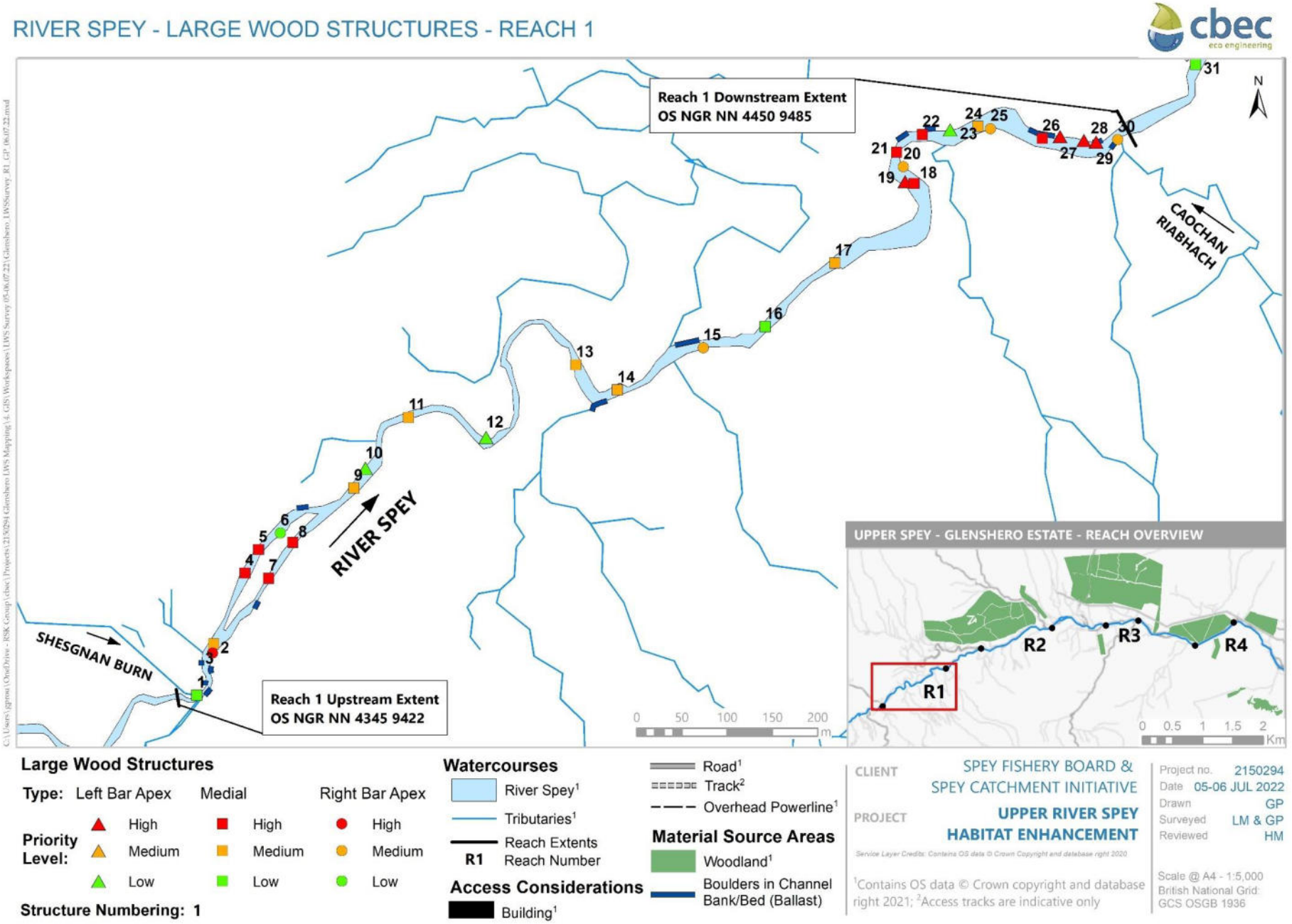

Figure 3.1. Proposed LWS locations, Reach 1

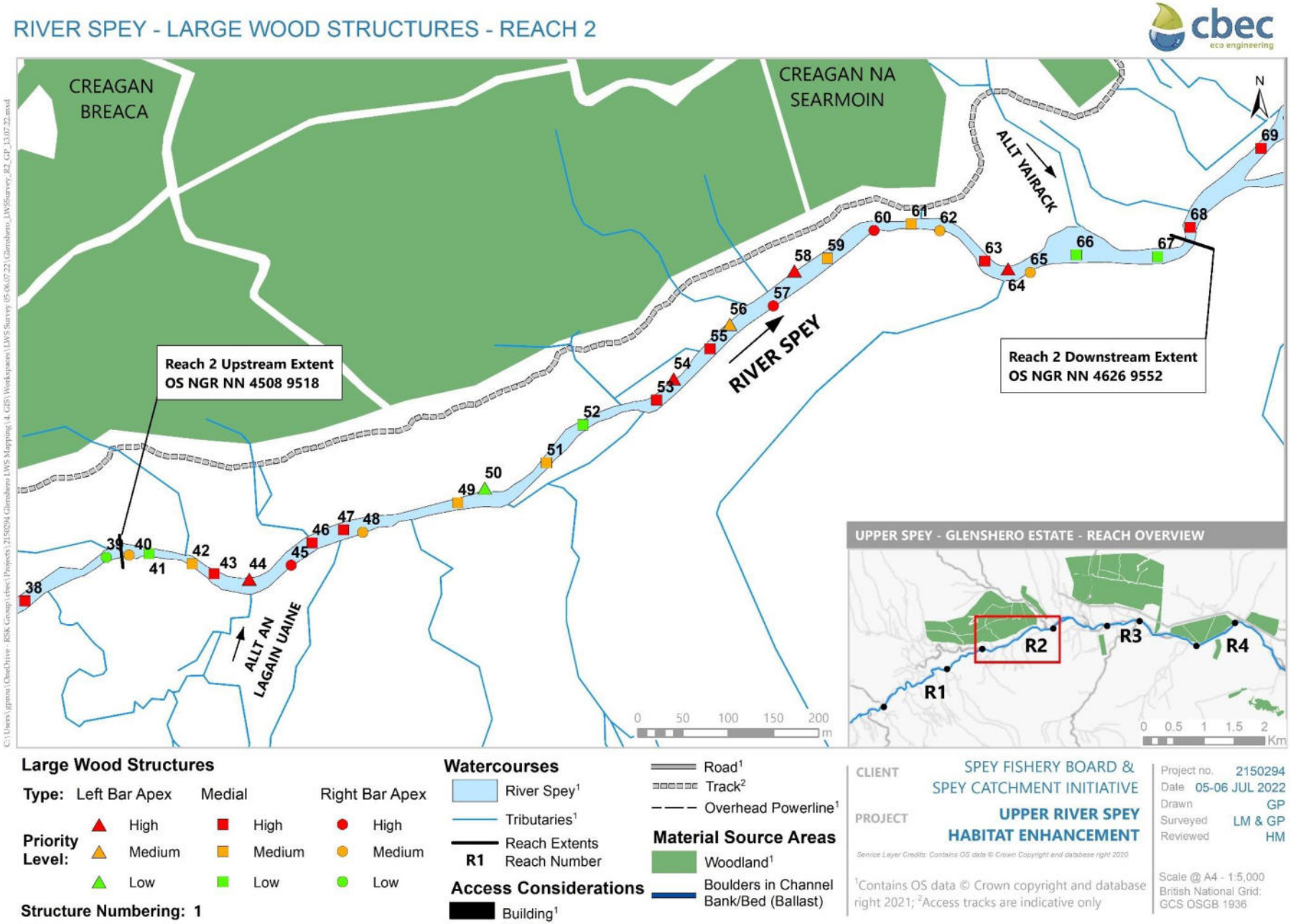

Figure 3.2. Proposed LWS locations, Reach 2

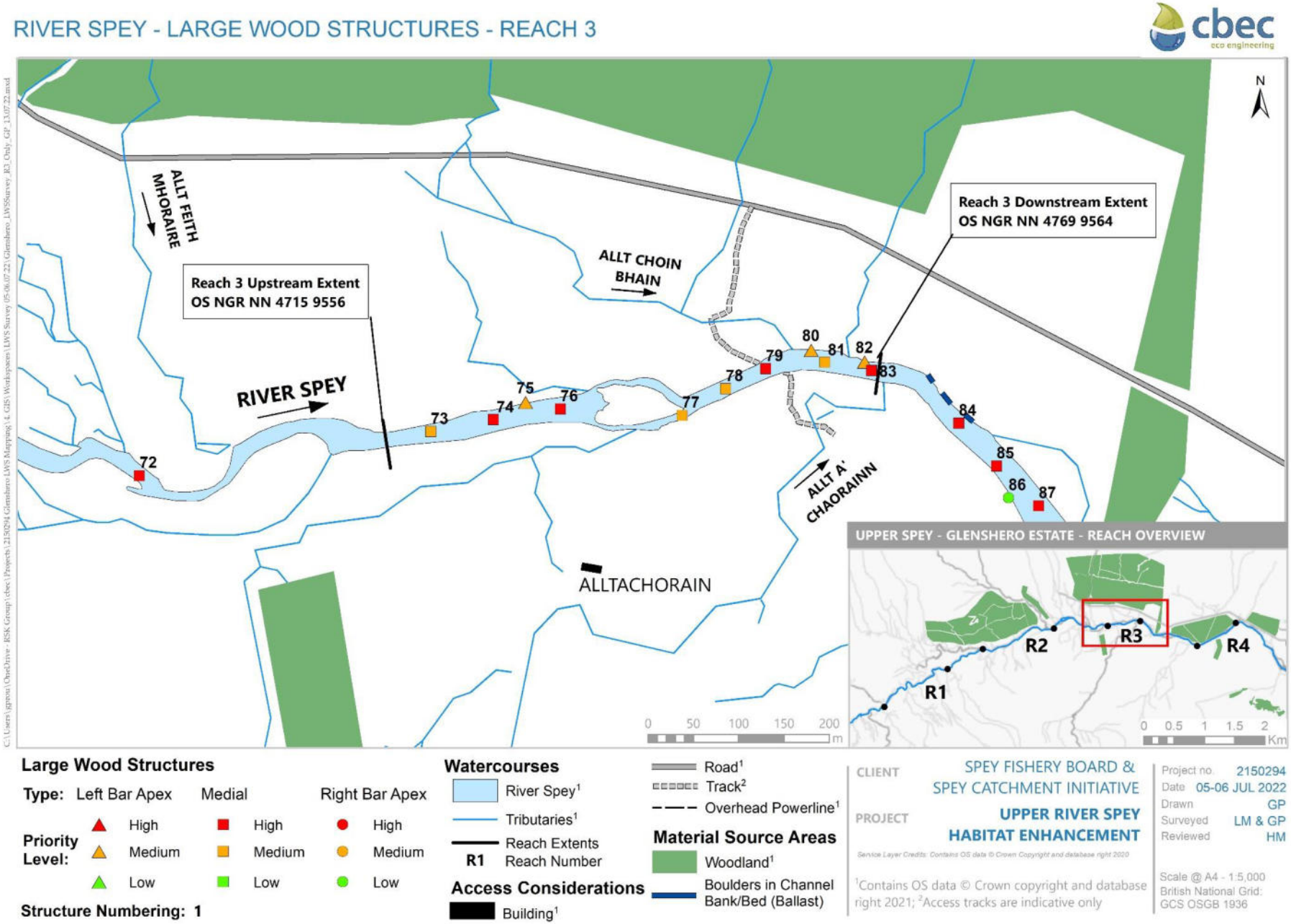

Figure 3.3. Proposed LWS locations, Reach 3

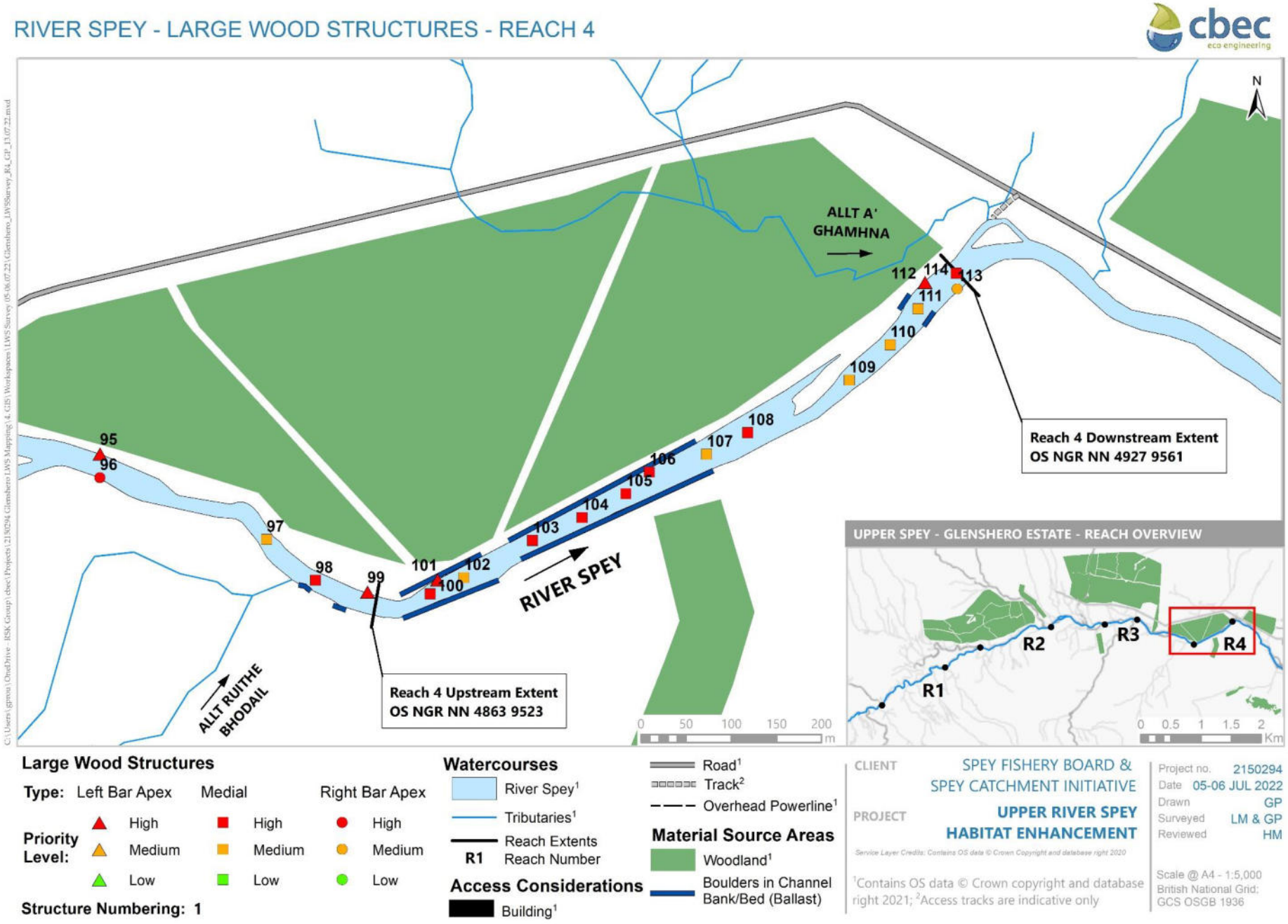

Figure 3.4. Proposed LWS locations, Reach 4

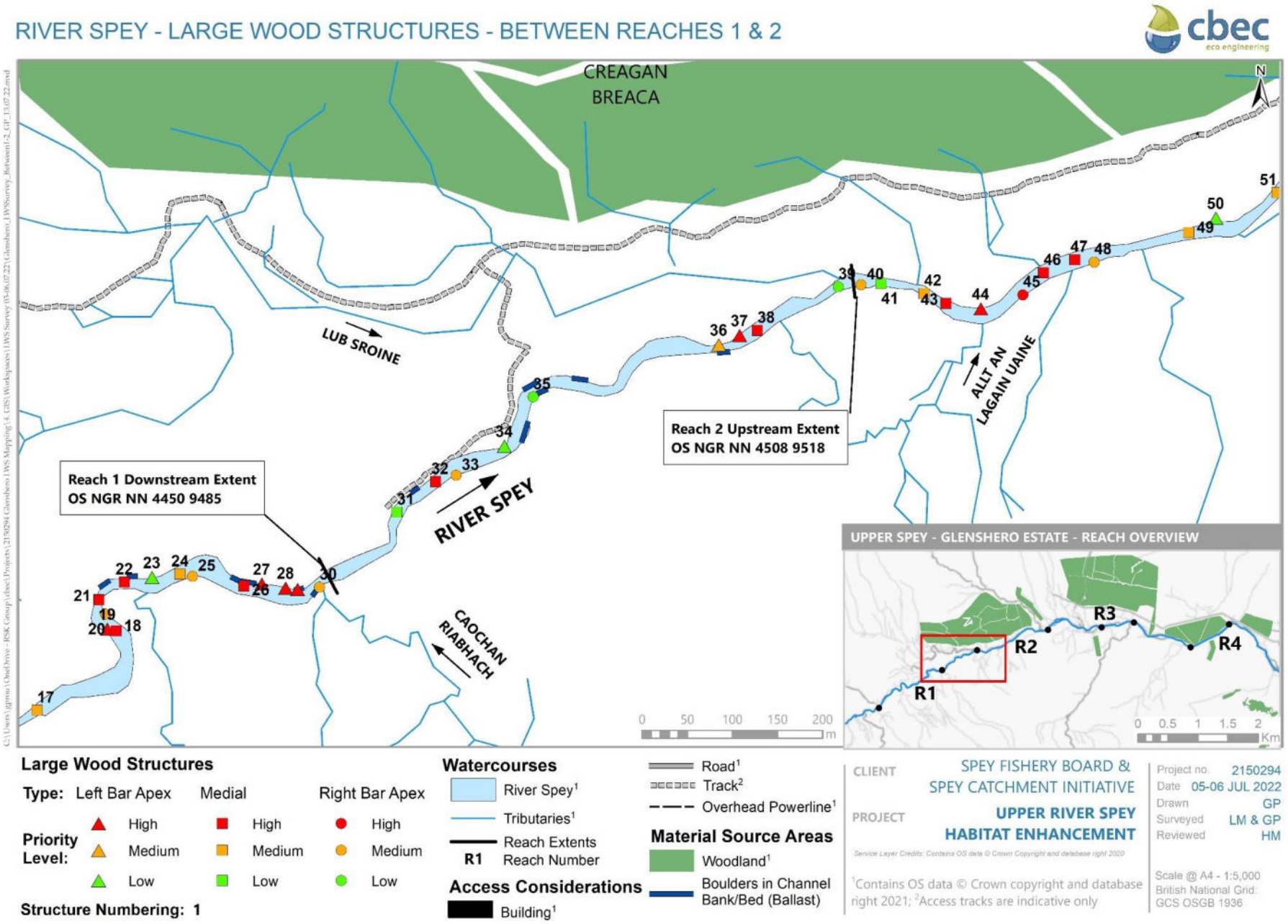

Figure 3.5. Proposed LWS locations, section between Reaches 1 and 2

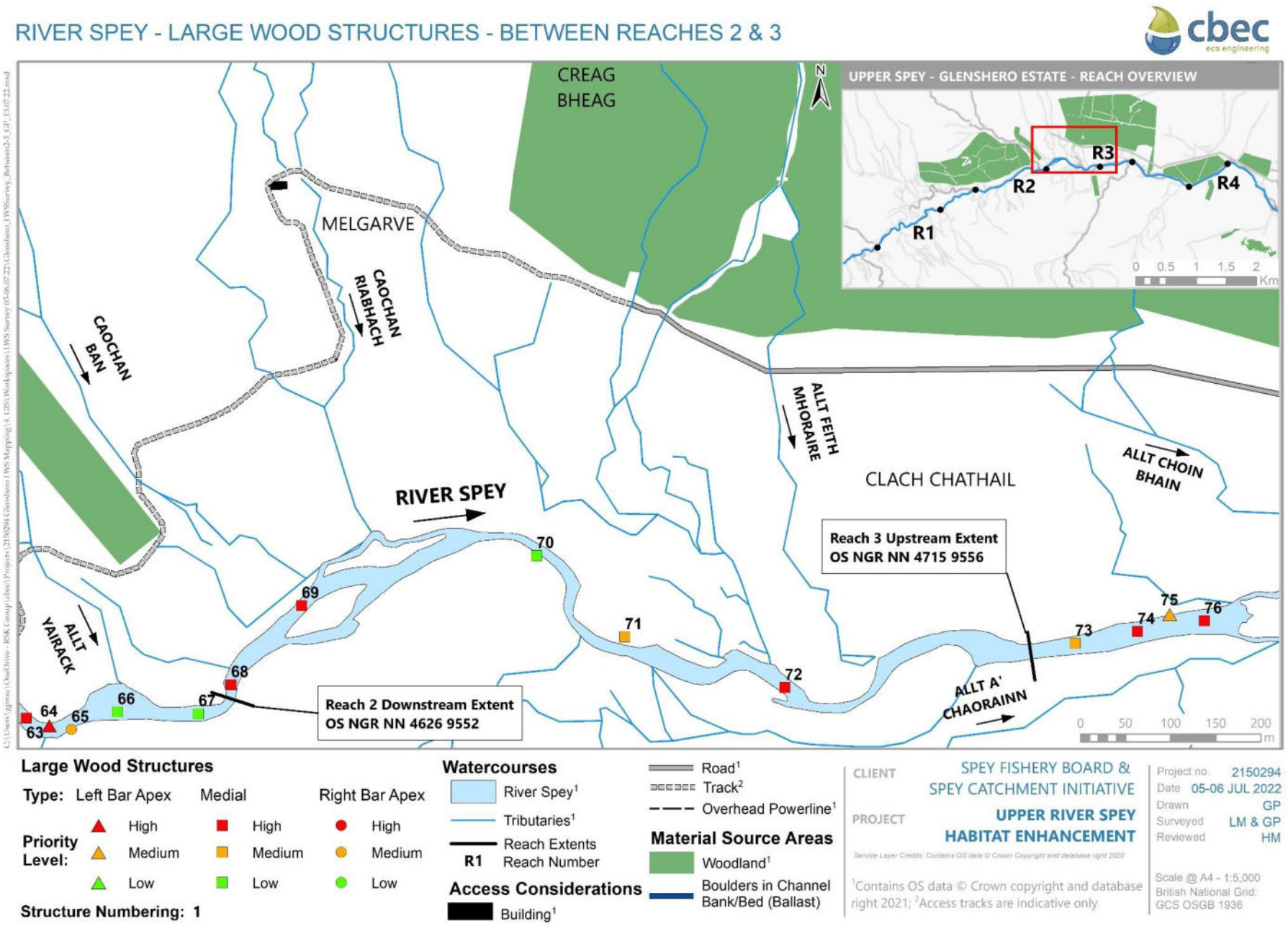

Figure 3.6. Proposed LWS locations, section between Reaches 2 and 3

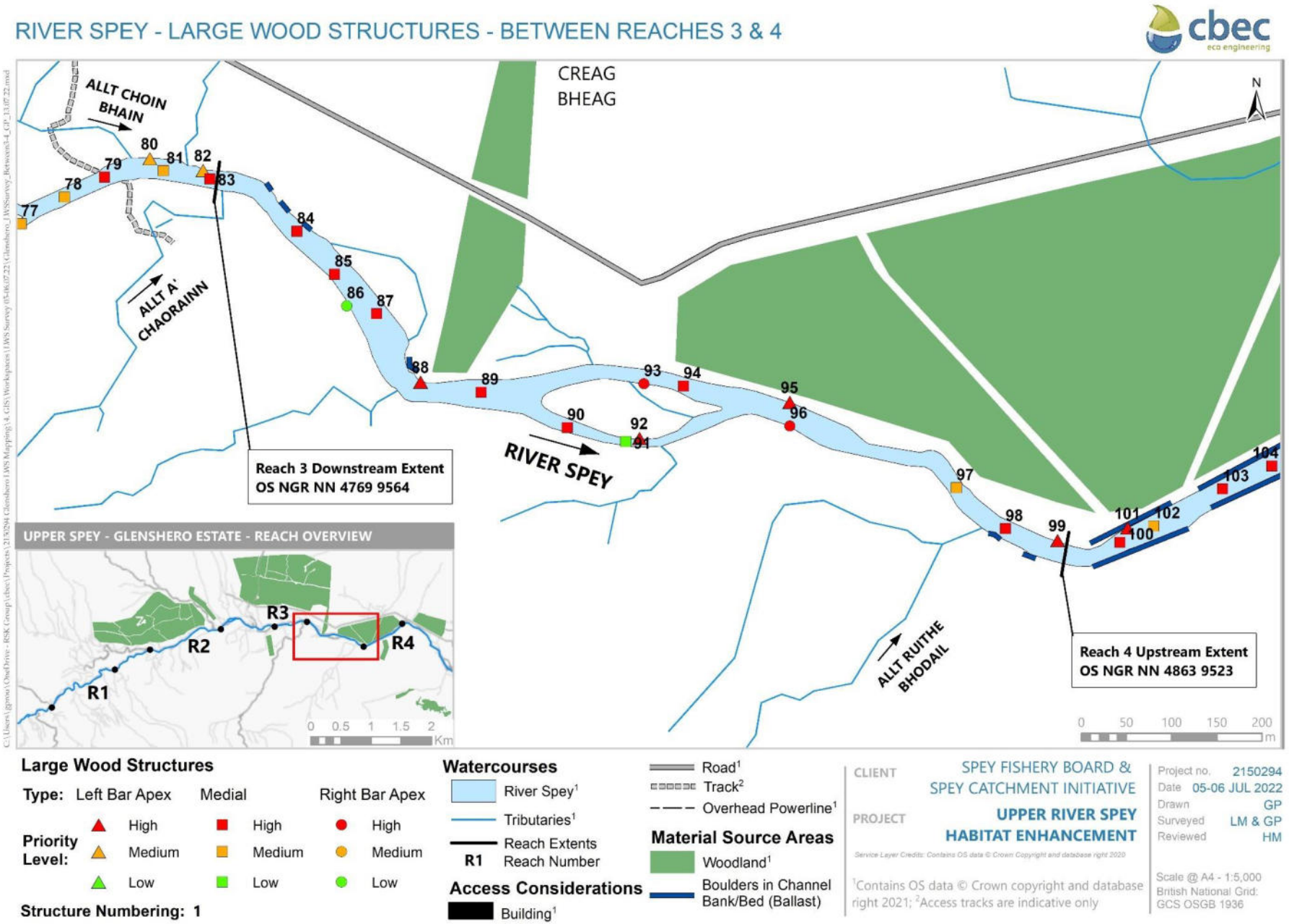

Figure 3.7. Proposed LWS locations, section between Reaches 3 and 4

4. IMPLEMENTATION

To ensure the effectiveness of the LWS in improving the physical and ecological complexity of the channel, the geomorphic context of the wider study reach has been taken into consideration. In particular, it is important to consider the interaction between flow, channel geometry (e.g. width, slope), bed particle size and the large wood itself, because these interactions are important in determining how sediment is stored in the vicinity of LWS and key to enhancing physical habitat complexity. If the LWS are not suitably scaled to the channel dimensions, particularly width, their influence on river processes (i.e. sediment erosion and deposition) may not be sufficient to induce the intended degree of physical and ecological enhancement to the channel.

Our experience has shown that, to have a tangible effect on geomorphic processes within river systems such as the Upper Spey, LWS must be constructed using multiple trees; typically, this would require up to five trees per structure, or possibly more, depending on the size of trees utilised. This ensures that the structures are of sufficient size to provide the cross-sectional area required to influence in-channel flow hydraulics; in particular, the vertical extent of a structure above the channel bed and the width of a structure presented to the prevailing flood flow direction are important. However, there is considerable variability in channel width throughout the surveyed reach; for example, the channel is considerably narrower (typically ~5–10 m) in sections where the flow has been split to form side channels, but channel width is ≥ 30 m in some of the widest sections of the surveyed reach. Accordingly, it is recommended that some flexibility be adopted and expert judgement be applied regarding the number and size of trees required for each structure. We propose assuming an average of 3 trees per structure for the purposes of forward planning.

To allow bar apex structures to protrude laterally into the channel to the extent required to influence geomorphic process, a minimum trunk length (including root plate) of 9–10 m is recommended. This would allow the LWS to extend about one quarter to one third of the way into the active channel while still allowing ~2 to 3 m of trunk length to be incorporated into the channel bank to stabilise the structure. Furthermore, the trees used should ideally be of sufficient size that the resultant structure is at least ~0.5 m above the adjacent bed; this would require trees with trunk diameter (measured just above the root plate) of ~0.5 m or more.

cbec has produced indicative design drawings for both bar apex and medial structures. These drawings are intended to guide the implementation of the LWS and are provided in Appendix B. Additionally, site-specific photorealistic visualisations have been produced to illustrate the implementation of the LWS within the Upper Spey. These are provided in Figure 4.1 and Figure 4.2**.**

To date, cbec has installed over two hundred large wood structures according to these specifications; none of these structures has ever travelled downstream, with only local adjustments to the structures observed in previous study areas. Accordingly, in our experience, if the structures are implemented according to the instructions provided, the risk of these structures mobilising and being transported downstream to cause damage elsewhere is considered to be very low.

Figure 4.1. Photorealistic visualisation of medial structure

Figure 4.2. Photorealistic visualisation of bar apex structure

APPENDIX A

LARGE WOOD STRUCTURE LOCATIONS

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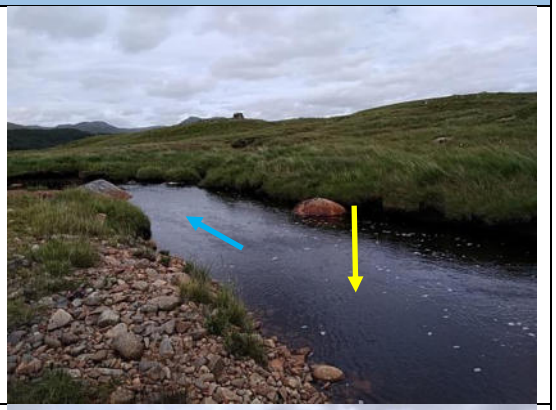
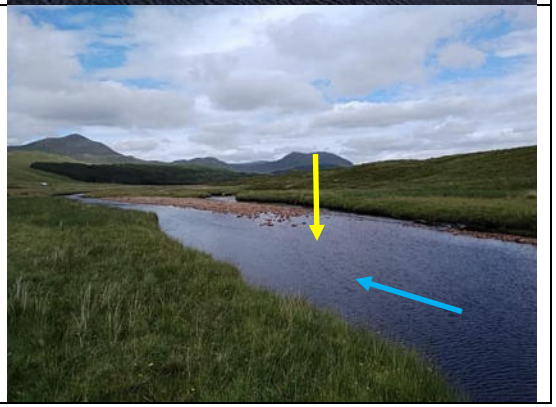
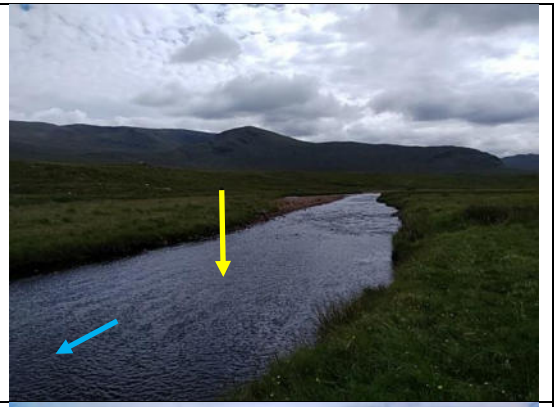
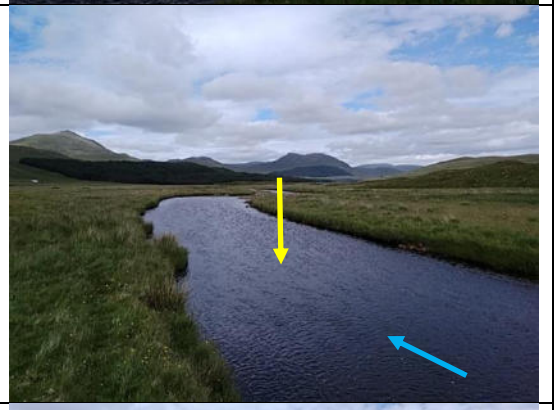
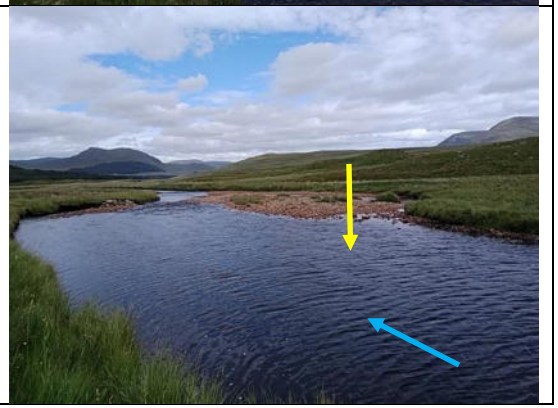
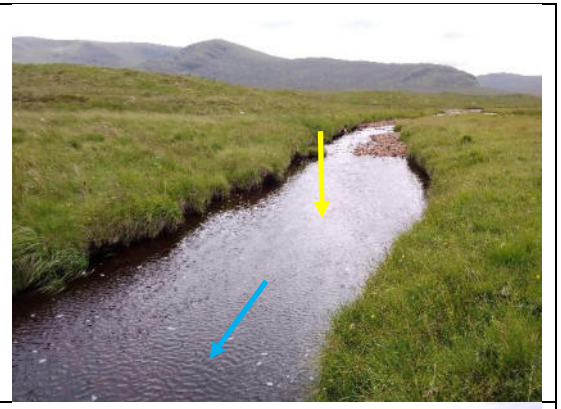
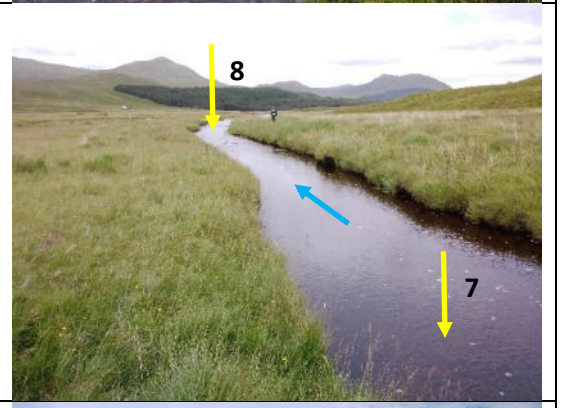
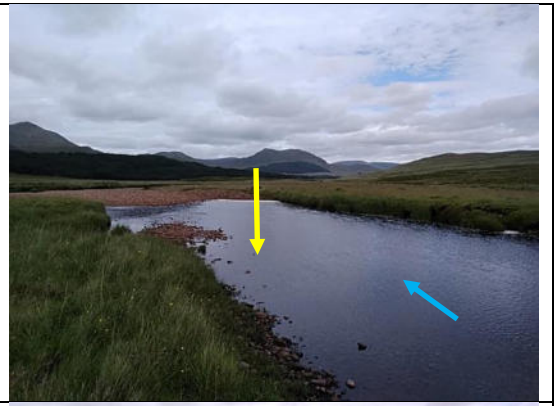
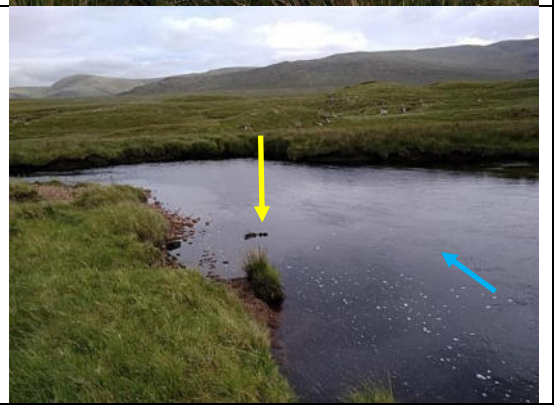
LARGE WOOD STRUCTURE LOCATIONS

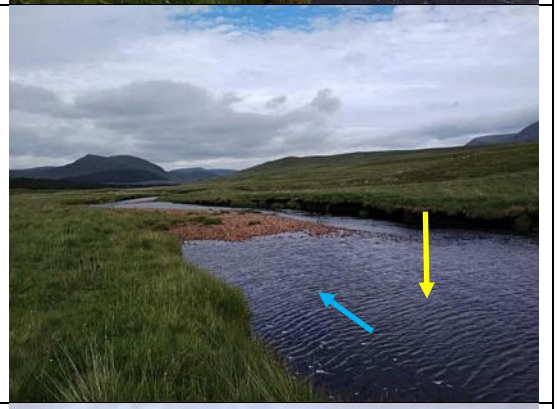
The following table provides a comprehensive breakdown of the large wood structure (LWS) positions proposed within reaches 1 to 4 of the Upper Spey and additional geomorphically beneficial locations identified between the study areas. This appendix builds on the summary provided in Section 3 of the 'Habitat enhancement for the Upper River Spey' (cbec [Draft], 2022), and should be read as a supporting document to this main report.

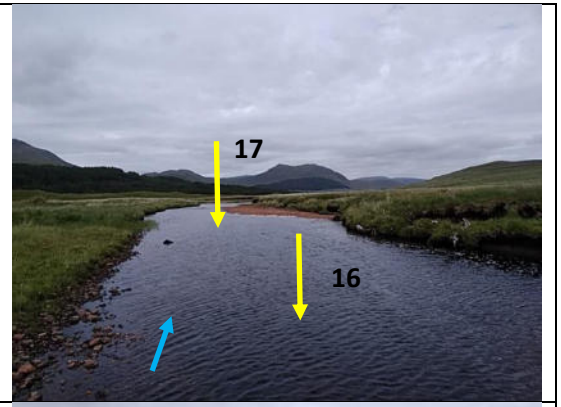
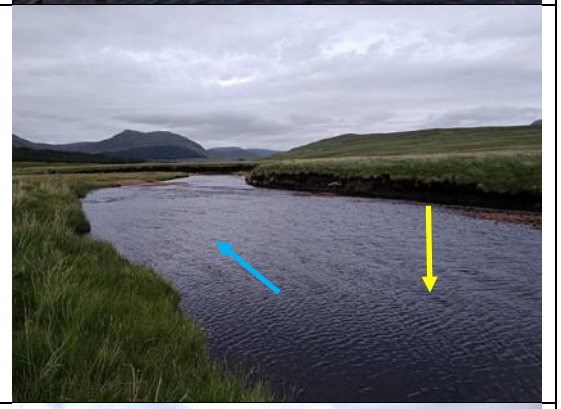
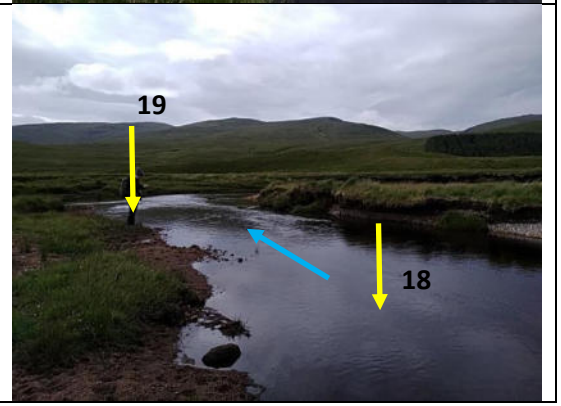
Structure Number	Grid Reference	Type	Priority	Habitat	Comments	Location Yellow arrow = LWS Position Blue arrow = Flow Direction
Reach 1						
1	NN 43471 94224	Medial	Low	Fry	Good habitat diversity upstream and downstream already. Potential spawning area nearby.	
2	NN 43489 94271	Right Bar Apex	High	Glide	Logistics of construction potentially difficult but otherwise good location, boulders nearby for ballast. Encourage growth of proto-bar feature.	
3	NN 43490 94281	Medial	Medium	Glide	Potential to extend alluvial bar form downstream and add additional habitat diversity.	

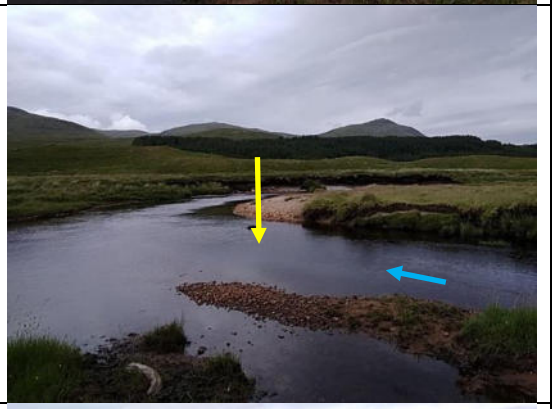
4	NN 43525 94359	Medial	High	Mixed juvenile	Long glide section suitable for 2 medial LWS (structures 4 & 5). River left channel around island.	
5	NN 43540 94385	Medial	High	Mixed juvenile	Homogeneous section, some small boulders on bed. Long glide section suitable for 2 medial LWS (structures 4 & 5). River left channel around island.	
6	NN 43564 94403	Right Bar Apex	Low	Mixed juvenile	Just upstream of more diverse section. River left channel around island.	

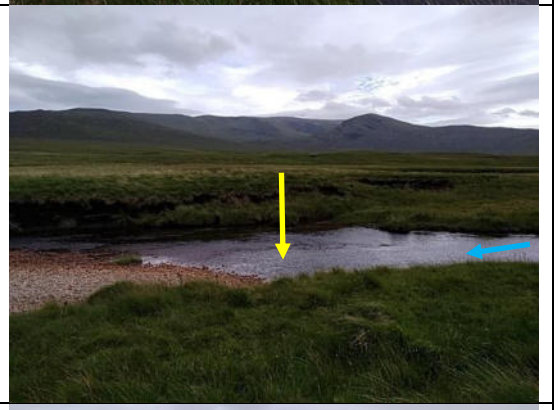
7	NN 43551 94353	Medial	High	Fry/Glide	Widest section of glide between two riffles. River right channel around island.	
8	NN 43577 94393	Medial	High	Fry/Glide	River right channel around island. Potential to add channel heterogeneity between two riffles at downstream end of island. Potential spawning area nearby.	
9	NN 43645 94453	Medial	Medium	Glide	Short homogeneous section with more diverse habitat upstream and downstream. Potential to enhance existing habitat and provide in-channel cover.	

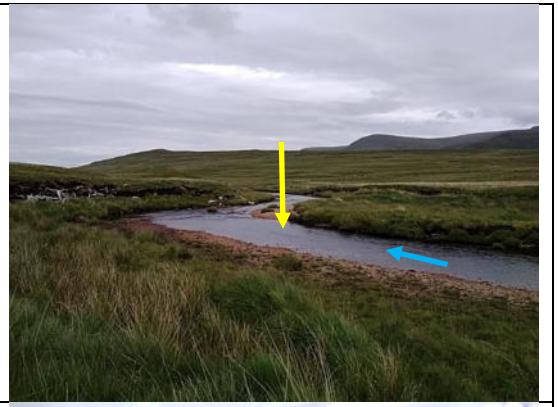
10	NN 43658 94475	Left Bar Apex	Low	Glide	Location is very close to existing well-developed alluvial bar form, hence lower priority rating.	
11	NN 43705 94531	Medial	Medium	Glide	Potential to enhance existing habitat where channel is relatively wide and provide in-channel cover. Existing deposition occurring around large chunks of bank material in channel.	
12	NN 43791 94509	Left Bar Apex	Low	Pool	Potential to enhance deposition along inside of bend and enhance pool formation along opposite bank, but habitat diversity upstream and downstream already good. Potential spawning area downstream.	

13	NN 43891 94589	Medial	Medium	Glide	Existing good habitat but potential for adding diversity in wider section of channel and provision of in-channel cover. Potential spawning area between structures 13 & 14.	
14	NN 43936 94562	Medial	Medium	Pool	Wider channel coming out of pool; potential to provide in-channel cover and increase habitat diversity upstream of existing deposition.	
15	NN 44031 94608	Right Bar Apex	Medium	Glide	Existing good habitat diversity upstream and downstream, but potential to enhance deposition along right bank. Potential spawning area downstream.	

16	NN 44100 94631	Medial	Low	Glide	Assigned low priority as located between two areas of potential spawning. Substrate coated with algae. Care should be taken not to disturb any spawning areas.	
17	NN 44176 94702	Medial	Medium	Fry	Good potential for increased habitat diversity and provision of in-channel cover but near known areas of spawning. Care should be taken not to disturb any spawning areas.	
18	NN 44264 94790	Medial	High	Glide	Slow moving silty section so potential for structures to improve habitat diversity and provide clean substrate.	

19	NN 44254 94792	Left Bar Apex	High	Glide	Potential to combine with structure 20 to create opposite bank bar apex LWS. Known spawning areas nearby. Backwater channel forming to left bank floodplain here.	
20	NN 44252 94808	Right Bar Apex	Medium	Glide	Potential to combine with structure 19 to create opposite bank bar apex LWS. Potential spawning areas nearby.	
21	NN 44245 94824	Medial	High	Fry/Mixed juvenile	Homogeneous section with substrate covered by algae and silt; good potential for habitat enhancement. Potential spawning areas nearby.	

22	NN 44273 94844	Medial	High	Glide	Some boulders present in channel could be used to help stabilise structure.	
23	NN 44304 94849	Left Bar Apex	Low	Fry	Area with existing good habitat and possible spawning but opportunity to enhance deposition along apex and provide in-channel cover. Small boulders present in channel could be used to stabilise.	
24	NN 44335 94853	Medial	Medium	Glide	Existing alluvial deposition in this reach but potential to enhance complexity within channel and provide in-channel cover.	

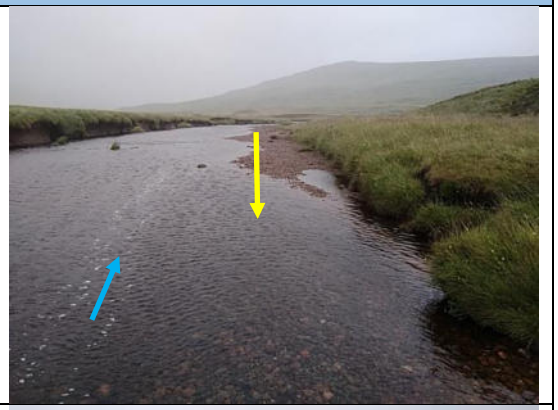
25	NN 44349 94850	Right Bar Apex	Medium	Fry	Potential to enhance existing deposition and provide in-channel cover. Potential spawning area just downstream.	
26	NN 44406 94840	Medial	High	Glide	Good potential to provide habitat diversity and in-channel cover in short homogeneous section.	
27	NN 44425 94842	Left Bar Apex	High	Glide	Good potential to provide habitat diversity and in-channel cover in short homogeneous section.	

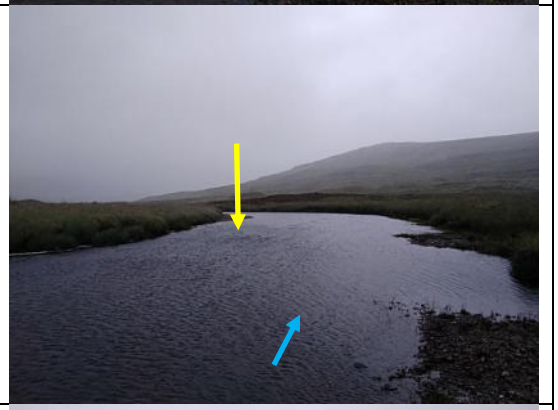
28	NN 44452 94837	Left Bar Apex	High	Glide	Good potential to enhance proto-alluvial bar form and use existing boulders in channel for ballast. Potential spawning area nearby.	
29	NN 44465 94836	Left Bar Apex	High	Glide	Good potential to enhance proto-alluvial bar form. Boulders present in channel can be used for ballast. Potential spawning area nearby.	
30	NN 44489 94838	Right Bar Apex	Medium	Mixed juvenile	Existing habitat diversity nearby could be enhanced and existing boulders used for ballast.	

Between Reaches 1 & 2						
31	NN 44575 94921	Medial	Low	Pool	Short homogeneous section with potential to provide in-channel cover. Potential spawning areas upstream and downstream.	
32	NN 44618 94955	Medial	High	Deep juvenile	Good potential for increasing habitat diversity and provision of in-channel cover.	
33	NN 44641 94962	Right Bar Apex	Medium	Glide	Good potential for increasing habitat diversity and provision of in-channel cover.	

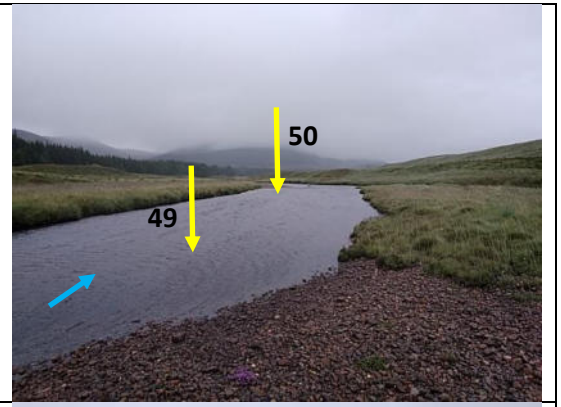
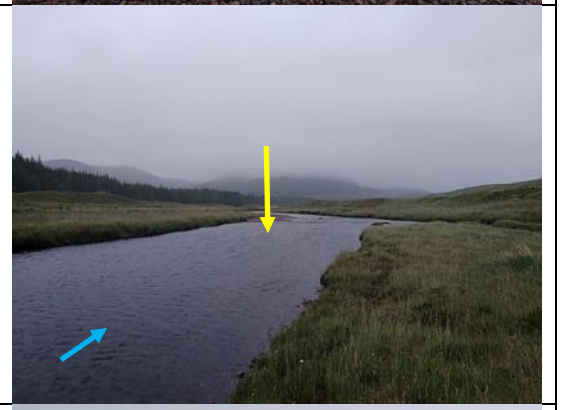
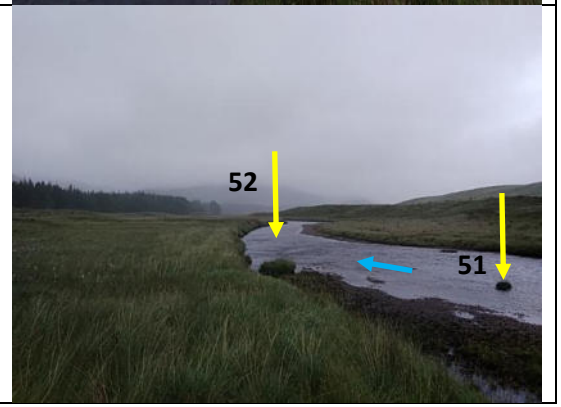
34	NN 44694 94995	Left Bar Apex	Low	Mixed juvenile	Potential to enhance existing habitat diversity. Potential spawning area between structures 34 & 35.	
35	NN 44726 95049	Right Bar Apex	Low	Pool	Potential to enhance existing habitat diversity but fencing likely to pose constraint. Potential spawning area between structures 34 & 35.	
36	NN 44932 95107	Left Bar Apex	Medium	Mixed juvenile	Potential to enhance existing diversity. Potential spawning area nearby.	

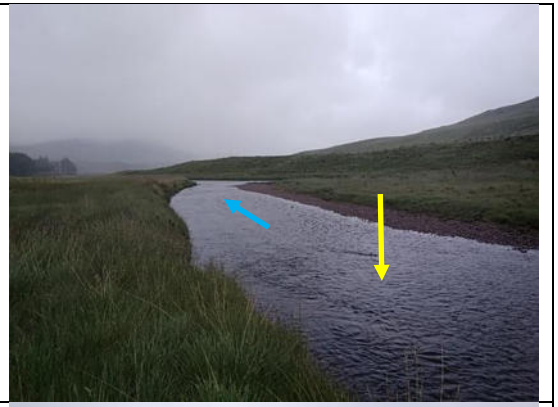
37	NN 44955 95118	Left Bar Apex	High	Mixed juvenile	Good potential to enhance existing habitat diversity and provide in-channel cover.	
38	NN 44975 95123	Medial	High	Mixed juvenile	Good potential to enhance existing habitat diversity in relatively homogeneous section. Potential spawning areas just downstream.	
39	NN 45064 95171	Right Bar Apex	Low	Glide	Existing habitat diversity nearby but potential to enhance.	

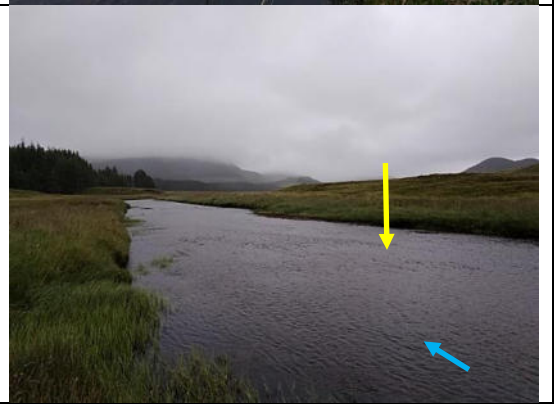
Reach 2						
40	NN 45089 95173	Right Bar Apex	Medium	Glide	Potential to enhance existing alluvial deposition along right bank. Potential spawning area nearby.	
41	NN 45112 95175	Medial	Low	Glide	Existing alluvial deposition here but potential to provide additional in-channel diversity and cover. Potential spawning area nearby.	
42	NN 45159 95164	Medial	Medium	Pool	Some deposition already occurring here but potential to provide additional habitat diversity and in-channel cover. Some small boulders present in channel.	

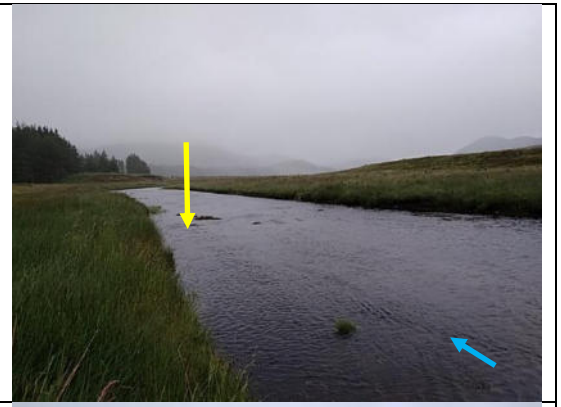
43	NN 45184 95153	Medial	High	Glide	Good potential for improved habitat diversity in homogeneous section.	
44	NN 45222 95147	Left Bar Apex	High	Glide	Good potential for improved habitat diversity in homogeneous section.	
45	NN 45269 95162	Right Bar Apex	High	Deep juvenile	Good potential for improved habitat diversity in relatively homogeneous section.	

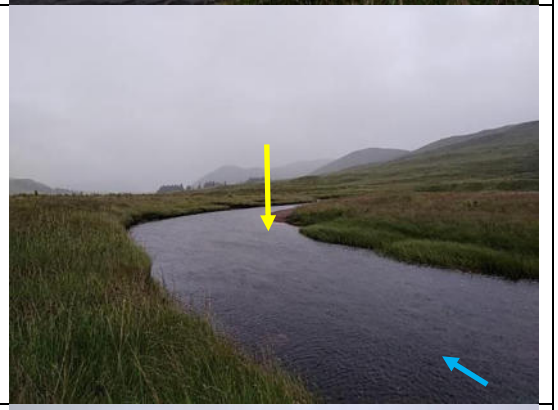
46	NN 45292 95187	Medial	High	Pool	Good potential for improved habitat diversity in homogeneous section.	
47	NN 45326 95201	Medial	High	Glide	Good potential for improved habitat diversity in homogeneous section.	
48	NN 45348 95199	Right Bar Apex	Medium	Glide	Lower priority than medial structures upstream but still good potential for enhancing diversity. Potential spawning area downstream.	

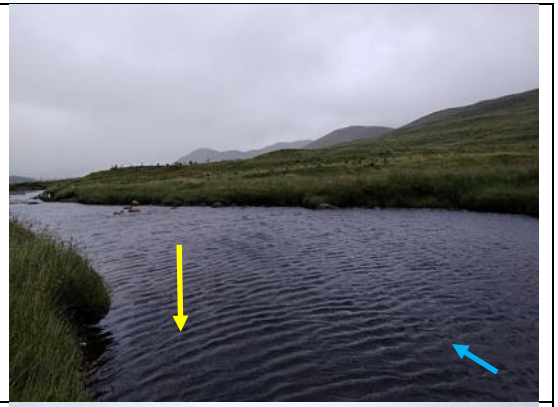
49	NN 45453 95231	Medial	Medium	Fry	Existing diverse habitat present upstream but potential to enhance. Several potential spawning areas nearby as indicated on habitat maps.	
50	NN 45482 95248	Left Bar Apex	Low	Glide	Deposition already occurring here but potential to enhance. Several potential spawning areas nearby on habitat maps.	
51	NN 45551 95275	Medial	Medium	Glide	Potential to enhance diversity in relatively homogeneous section. Potential spawning nearby.	

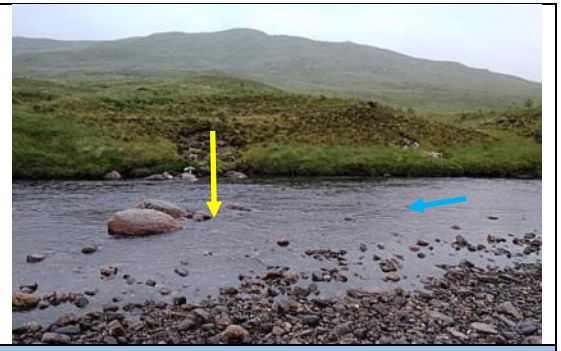
52	NN 45591 95317	Medial	Low	Glide	Potential to enhance diversity and in-channel cover in relatively homogeneous section. Potential spawning area downstream.	
53	NN 45672 95345	Medial	High	Glide	Good potential to enhance diversity in homogeneous section. Located just downstream of backwater channel.	
54	NN 45691 95368	Left Bar Apex	High	Glide	Good potential to enhance existing alluvial deposition in relatively homogeneous section.	

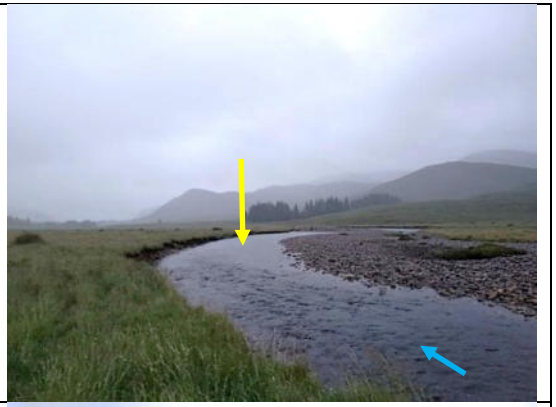
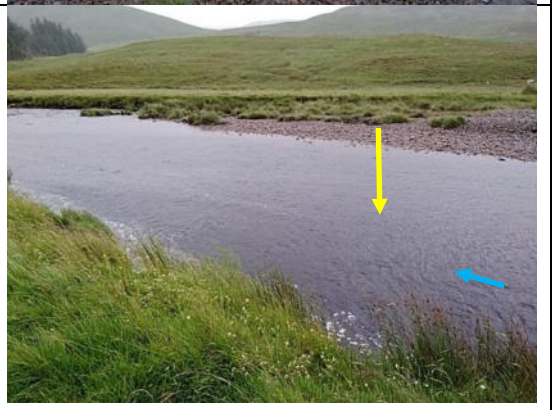
55	NN 45731 95401	Medial	High	Glide	Good potential to enhance diversity in homogeneous section.	
56	NN 45753 95428	Left Bar Apex	Medium	Glide	Existing deposition observed along left bank (submerged). Potential spawning area between structures 56 & 57.	
57	NN 45801 95449	Right Bar Apex	High	Glide	Good potential to enhance diversity in relatively homogeneous section. Potential spawning area between structures 56 & 57.	

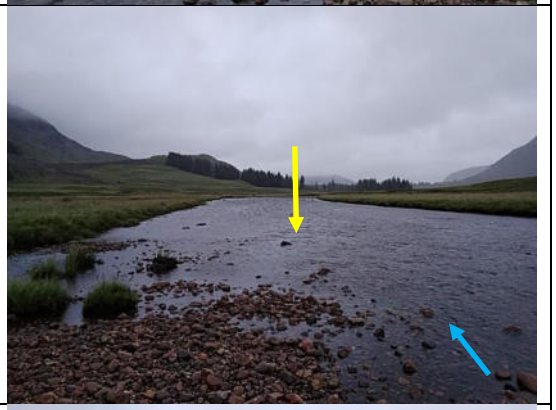
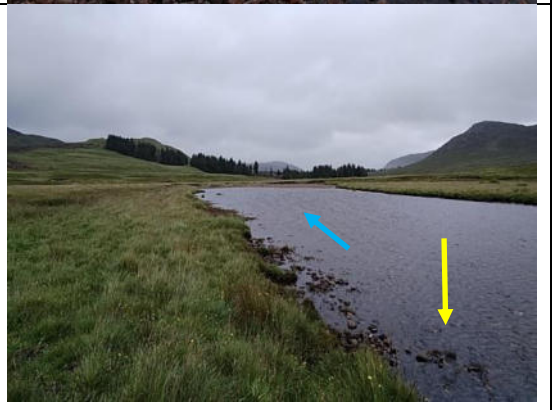
58	NN 45824 95488	Left Bar Apex	High	Glide	Good potential to enhance diversity in relatively homogeneous section. Potential spawning area nearby.	
59	NN 45861 95501	Medial	Medium	Fry	Good potential to enhance diversity in relatively homogeneous section. Potential spawning area nearby.	
60	NN 45912 95532	Right Bar Apex	High	Fry	Good potential to enhance diversity and provide in-channel cover in relatively homogeneous section. Potential spawning area.	

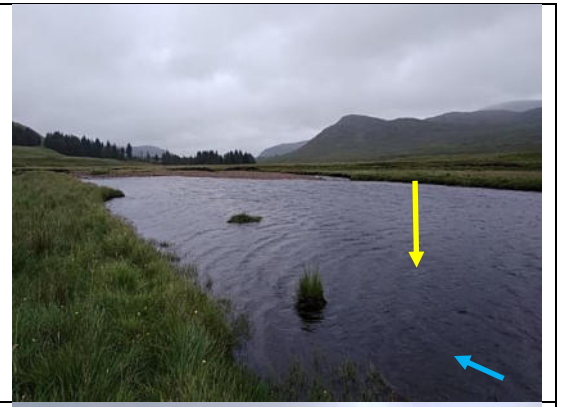
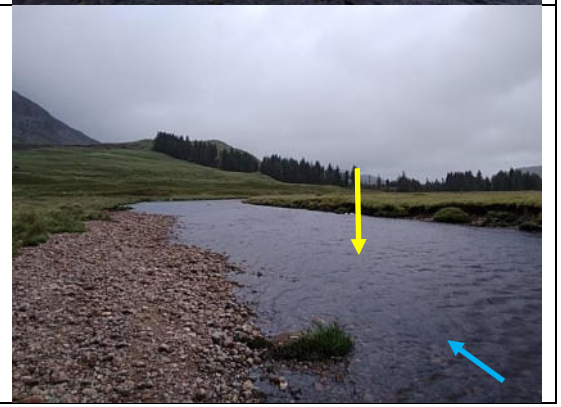
61	NN 45954 95539	Medial	Medium	Fry	Good potential to enhance diversity in relatively homogeneous section. Potential spawning area.	
62	NN 45985 95532	Right Bar Apex	Medium	Mixed juvenile	Good potential to enhance diversity in relatively homogeneous section.	
63	NN 46035 95498	Medial	High	Glide	Good potential to enhance diversity in relatively homogeneous section at downstream end of alluvial bar form in wider section.	

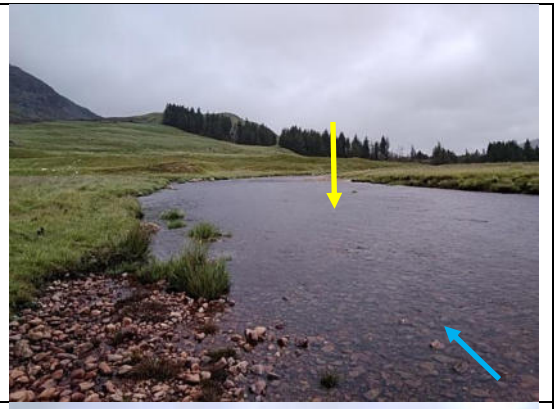
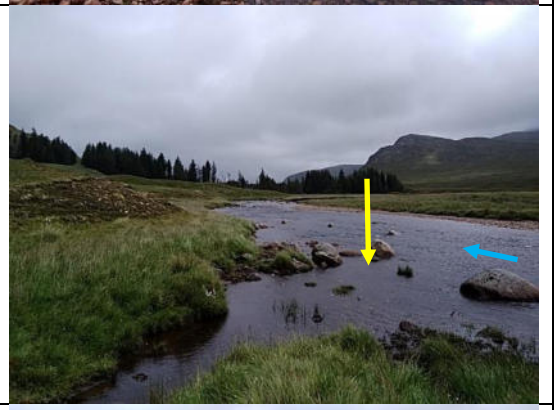
64	NN 46060 95490	Left Bar Apex	High	Pool	Good potential to enhance diversity in relatively homogeneous section, utilising existing area of deposition.	
65	NN 46085 95485	Right Bar Apex	Medium	Mixed juvenile	Enhance existing area of deposition and utilise boulders in channel for ballast.	
66	NN 46136 95505	Medial	Low	Glide	Potential to enhance existing habitat diversity and provide in-channel cover. Boulders present locally in channel for ballast.	

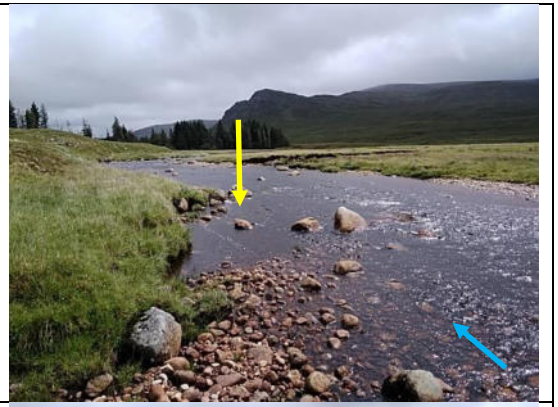
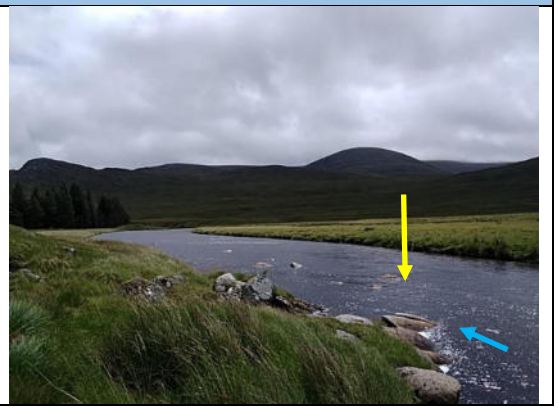
67	NN 46226 95503	Medial	Low	Mixed juvenile	Already diverse habitat but potential to provide in-channel cover. Utilise existing boulders to stabilise.	
Between Reaches 2 & 3						
68	NN 46262 95535	Medial	High	Pool	Good potential to enhance existing habitat diversity and provide in-channel cover.	
69	NN 46340 95623	Medial	High	Mixed juvenile	Good potential to enhance existing habitat diversity and provide in-channel cover.	

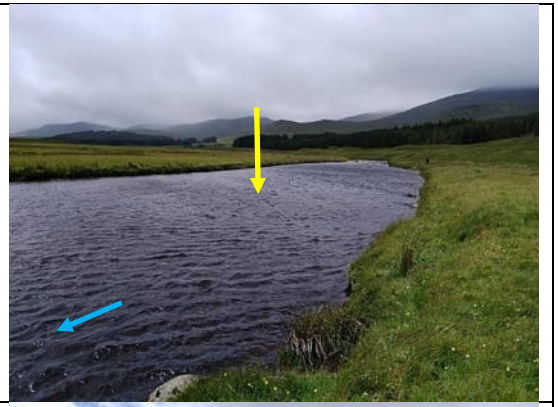
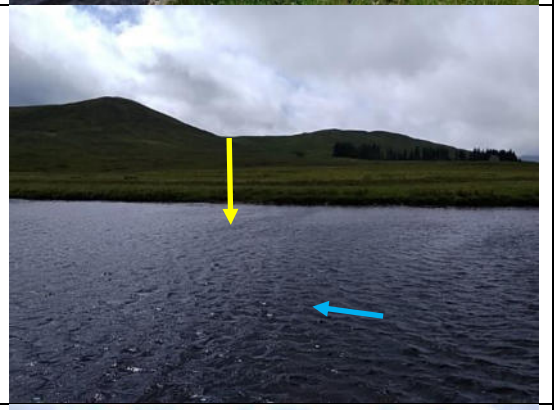
70	NN 46601 95678	Medial	Low	Pool	Potential to provide in-channel cover.	
71	NN 46698 95588	Medial	Medium	Mixed juvenile/Deep juvenile	Existing deposition and habitat diversity but potential to enhance in-channel processes in wider section and provide in-channel cover. Area of potential spawning upstream.	
72	NN 46876 95532	Medial	High	Pool	Existing deposition but potential to enhance in-channel processes in wider section and provide in-channel cover. Potential spawning area.	

Reach 3						
73	NN 47197 95581	Medial	Medium	Glide	Existing alluvial deposition here but potential to enhance existing diversity and provide in-channel cover.	
74	NN 47266 95594	Medial	High	Fry	Good potential to enhance habitat diversity downstream of existing alluvial deposition.	
75	NN 47302 95613	Left Bar Apex	Medium	Glide	Utilise area of proto-alluvial bar form along left bank in homogeneous section.	

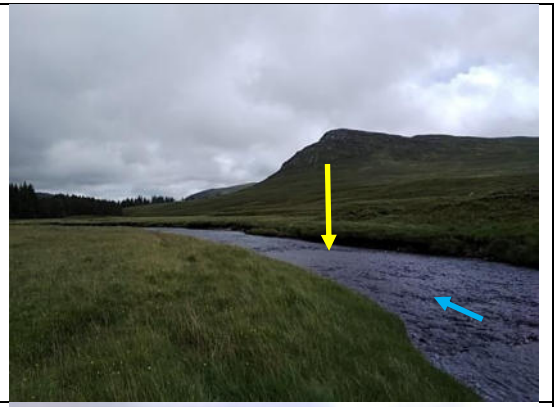
76	NN 47340 95606	Medial	High	Glide	Good potential to add diversity in homogeneous section of channel.	
77	NN 47475 95599	Medial	Medium	Fry	Potential to add habitat diversity in side channel. Potential spawning area nearby.	
78	NN 47523 95628	Medial	Medium	Glide	Existing alluvial deposition here but potential to enhance in-channel processes and provide in-channel cover.	

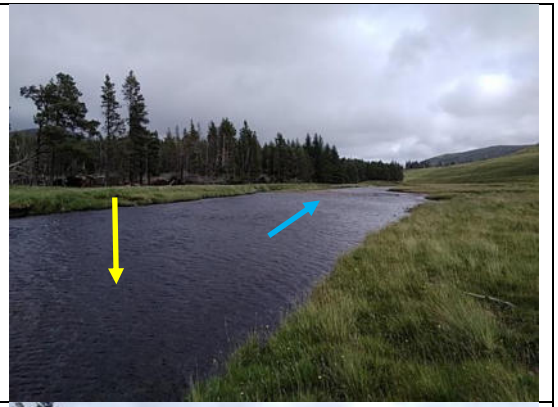
79	NN 47567 95650	Medial	High	Fry	Good potential to provide heterogeneity in channel. Boulders nearby for ballast. Potential spawning area nearby.	
80	NN 47617 95671	Left Bar Apex	Medium	Fry	Existing habitat diversity upstream and downstream of location, but good boulders present to anchor and development of proto-alluvial bar feature can be enhanced.	
81	NN 47632 95657	Medial	Medium	Fry	Good potential to enhance existing deposition and provide greater in-channel heterogeneity and cover.	

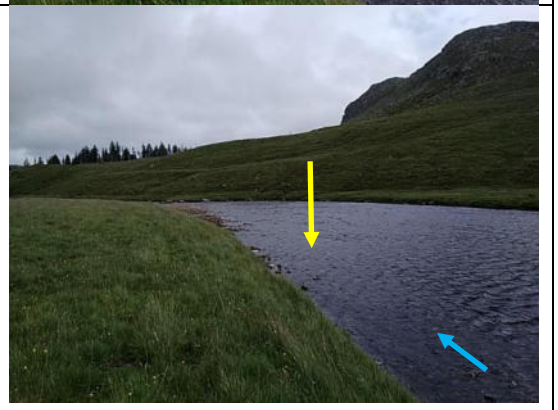
82	NN 47676 95658	Left Bar Apex	Medium	Fry	Potential to enhance existing deposition and use existing boulders to anchor. Located just downstream of drain. Access/installation may be difficult.	
83	NN 47684 95648	Medial	High	Mixed juvenile	Good potential to add heterogeneity and use existing boulders.	
Between Reaches 3 & 4						
84	NN 47780 95590	Medial	High	Mixed juvenile	Potential for several LWS in long, straight, relatively homogeneous section (structures 84, 85, 86 & 87).	

85	NN 47822 95543	Medial	High	Pool	Good potential to introduce heterogeneity.	
86	NN 47835 95508	Right Bar Apex	Low	Glide	Potential to introduce heterogeneity and utilise proto-alluvial bar form but lower priority than medial structures nearby.	
87	NN 47868 95499	Medial	High	Glide	Good potential to introduce heterogeneity.	

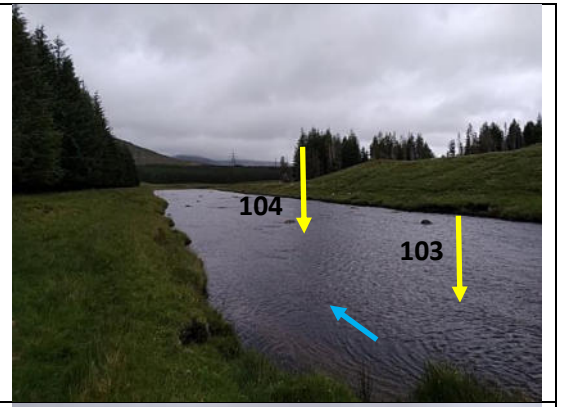
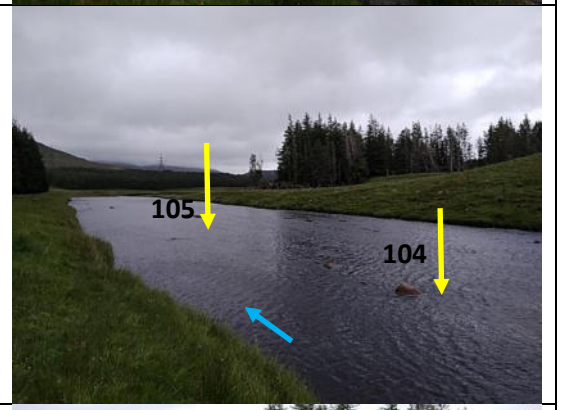
88	NN 47917 95424	Left Bar Apex	High	Glide	Good potential to enhance proto-alluvial bar form.	
89	NN 47984 95412	Medial	High	Pool	Potential for several LWS here and downstream.	
90	NN 48079 95373	Medial	High	Pool	Wide channel, potential to enhance heterogeneity between riffles. Channel on left side of island.	

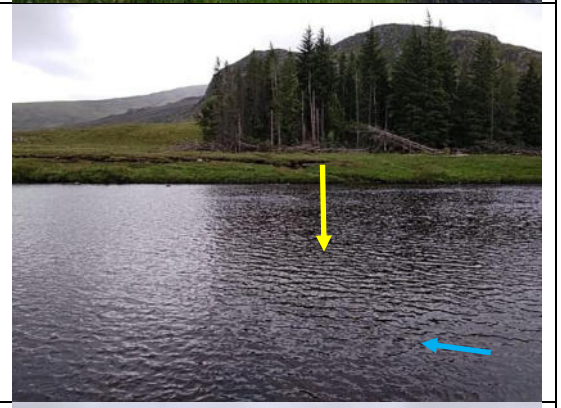
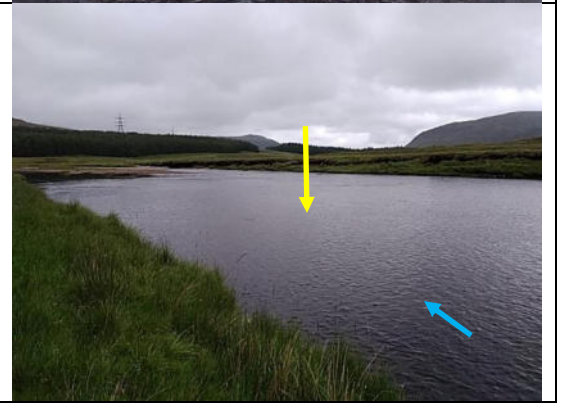
91	NN 48144 95357	Medial	Low	Fry	Channel on left side of island. Potential to enhance habitat diversity in short homogeneous section. Potential spawning area.	
92	NN 48159 95361	Left Bar Apex	High	Glide	Proto-alluvial bar form already present. Can be combined with, or implemented instead of, structure 91. Channel on left side of island.	
93	NN 48164 95421	Right Bar Apex	High	Glide	Good potential to enhance existing alluvial deposition. Channel on right side of island.	

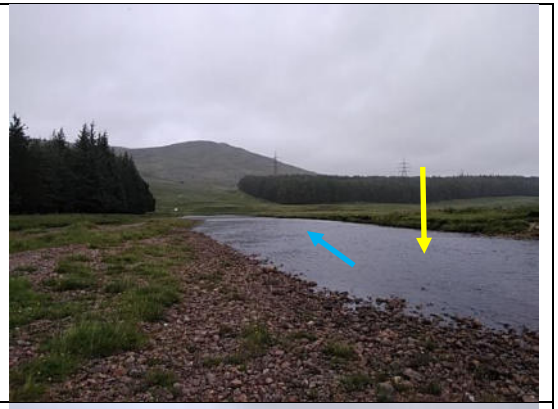
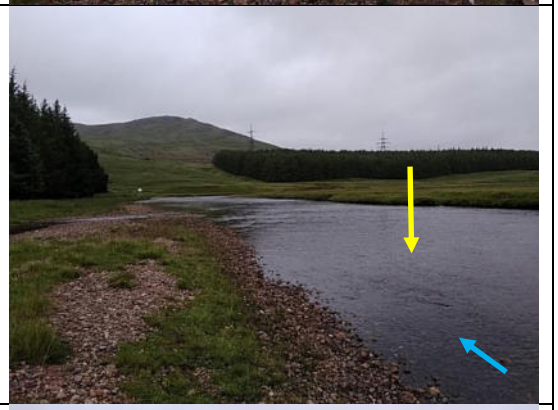
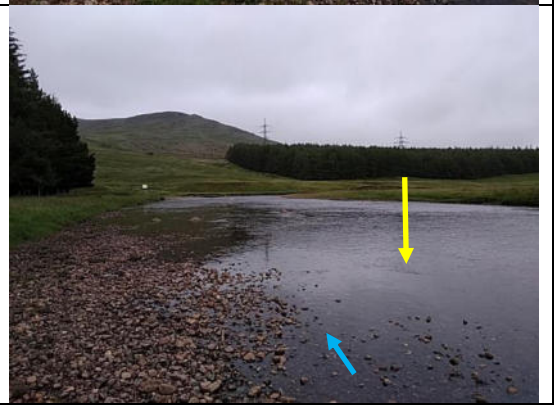
94	NN 48208 95419	Medial	High	Pool	Good potential to provide additional habitat diversity in wide, relatively homogeneous section. Channel on right side of island.	
95	NN 48326 95401	Left Bar Apex	High	Glide	Good potential to provide additional habitat diversity in wide, relatively homogeneous section.	
96	NN 48326 95375	Right Bar Apex	High	Mixed juvenile	Combine with structure 95 to provide opposite bank bar apex structures.	

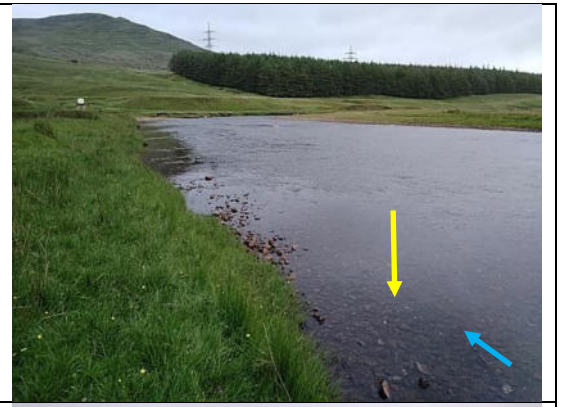
97	NN 48510 95306	Medial	Medium	Mixed juvenile	Existing habitat diversity downstream but potential to enhance and to provide in-channel cover.	
98	NN 48565 95261	Medial	High	Mixed juvenile	Good potential to introduce heterogeneity in wide, relatively featureless section.	
99	NN 48622 95248	Left Bar Apex	High	Mixed juvenile	Good potential to introduce heterogeneity in wide, relatively featureless section.	

Reach 4						
100	NN 48691 95246	Medial	High	Fry	Utilise existing boulders in channel to anchor/stabilise.	
101	NN 48699 95262	Left Bar Apex	High	Mixed juvenile	Proto-alluvial bar feature. Locate upstream of large boulder in bank and use boulders in channel as ballast.	
102	NN 48724 95270	Medial	Medium	Deep juvenile	Potential to enhance existing habitat and utilise existing boulders to stabilise.	

103	NN 48805 95305	Medial	High	Deep juvenile	Potential to combine structures 103, 104, 105, 106, 107 & 108 to introduce heterogeneity to long, relatively featureless stretch.	
104	NN 48860 95331	Medial	High	Glide	Potential to combine structures 103, 104, 105, 106, 107 & 108 to introduce heterogeneity to long, relatively featureless stretch.	
105	NN 48908 95357	Medial	High	Glide	Potential to combine structures 103, 104, 105, 106, 107 & 108 to introduce heterogeneity to long, relatively featureless stretch.	

106	NN 48934 95381	Medial	High	Glide	Potential to combine structures 103, 104, 105, 106, 107 & 108 to introduce heterogeneity to long, relatively featureless stretch.	
107	NN 48998 95401	Medial	Medium	Glide	Potential to combine structures 103, 104, 105, 106, 107 & 108 to introduce heterogeneity to long, relatively featureless stretch.	
108	NN 49043 95425	Medial	High	Glide	Potential to combine structures 103, 104, 105, 106, 107 & 108 to introduce heterogeneity to long, relatively featureless stretch. Locate this structure upstream of riffle section.	

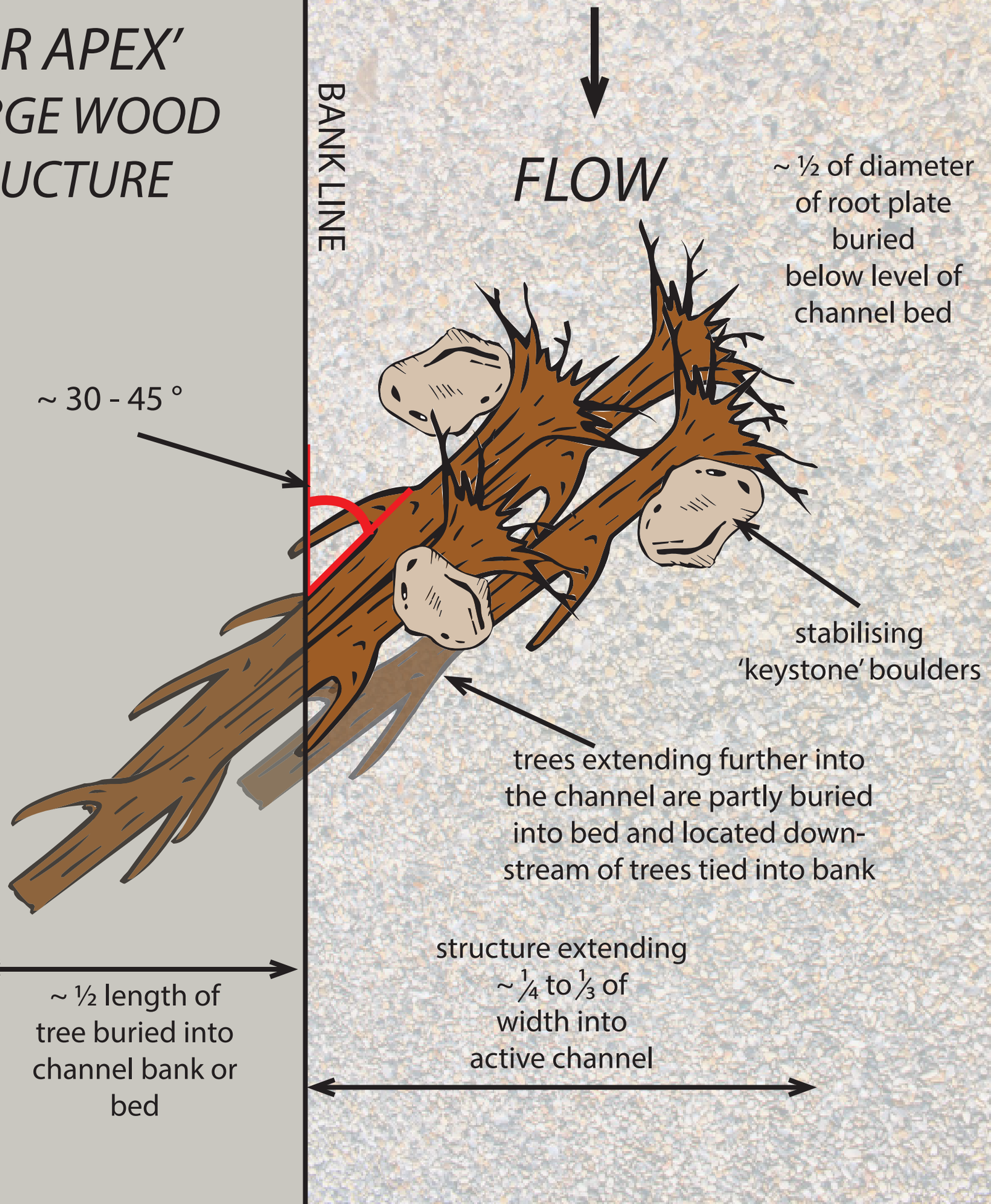
109	NN 49156 95483	Medial	Medium	Fry	Existing deposition here but potential to enhance in-channel diversity and provide in-channel cover.	
110	NN 49201 95522	Medial	Medium	Fry	Existing deposition here but potential to enhance in-channel diversity and provide in-channel cover. Potential spawning area.	
111	NN 49232 95562	Medial	Medium	Mixed juvenile	Existing deposition here but potential to enhance in-channel diversity and provide in-channel cover.	

112	NN 49239 95591	Left Bar Apex	High	Glide	Enhance proto-alluvial bar feature and provide diversity in relatively homogeneous section.	
113	NN 49275 95584	Right Bar Apex	Medium	Glide	Locate upstream of ford.	
114	NN 49274 95601	Medial	High	Deep juvenile	Locate upstream of ford.	

APPENDIX B

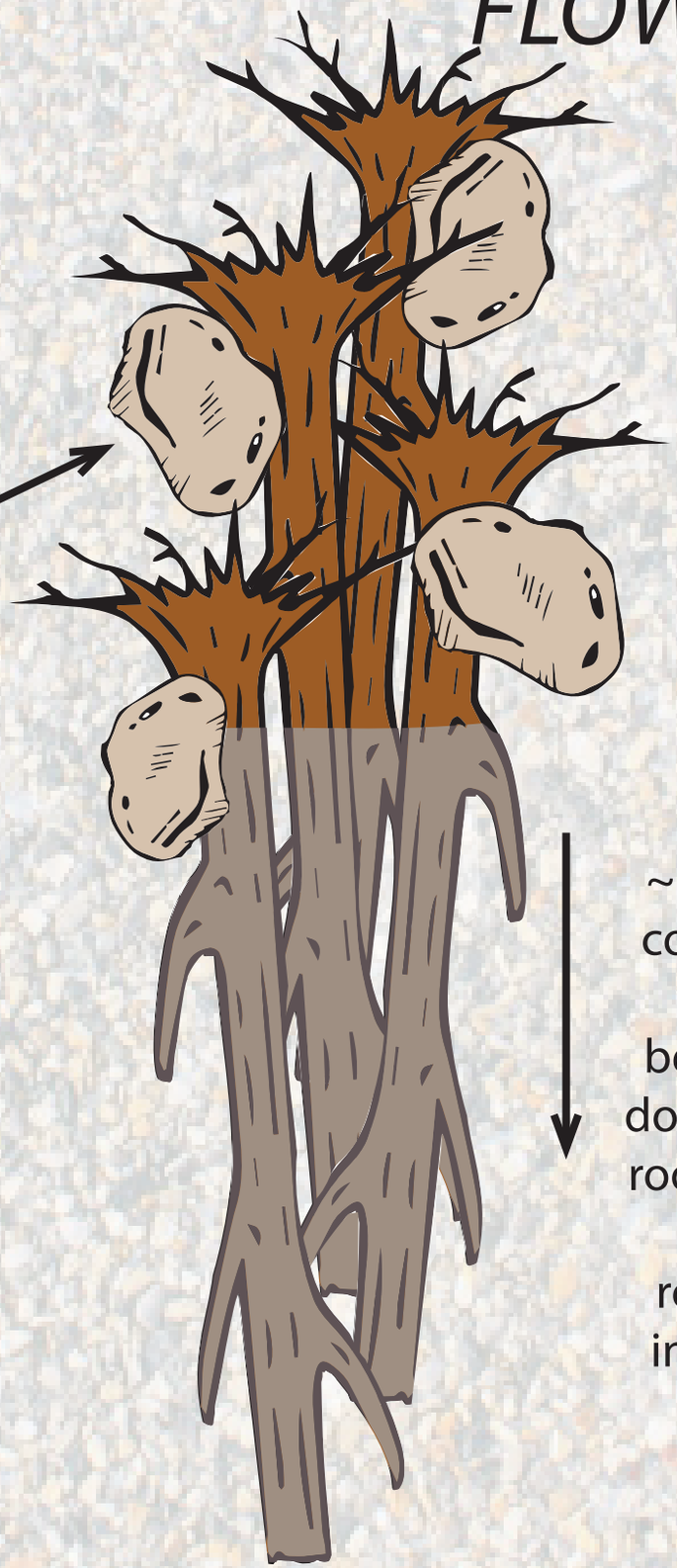
INDICATIVE DESIGN DRAWINGS

'BAR APEX' LARGE WOOD STRUCTURE



'MEDIAL' LARGE WOOD STRUCTURE

FLOW



stabilising 'keystone' boulders

~ ½ length of tree completely buried within channel bed - trees angled down into bed from root plate to crown.
~ ½ diameter root plate buried into channel bed.