Technical Appendix 8.6 - FISH SURVEY REPORT for the proposed Millmoor Wind Farm

Survey work carried out by The *Tweed* Foundation for Direct Ecology Ltd

Electro-fishing and aquatic macroinvertebrate surveys carried out on the 27th and 28th June 2023

Habitat survey carried out on 25th May, 8th June, 31st July 2023

Report completed on the 27th October 2023

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The Tweed Foundation — for the good of the river

Declaration

This report has been prepared by The Tweed Foundation for Direct Ecology Ltd and has been based on information provided by Direct Ecology Ltd and the accepted tender. All information is correct to the best of our knowledge and collected following the standards and specifications detailed in the tender document.

Organisation

The Tweed Foundation (TF) is a charitable company limited by guarantee (SC366380) and a registered Scottish Charity (SC 011055) that has been in operation since 1987 and covers the Tweed and Eye district. TF has been involved in scoping and monitoring schemes for all wind farms in the Tweed District that have watercourses that contain fish. Examples of larger projects that TF have worked on (pre, construction and post construction monitoring) include Crystal Rig, Clyde (working in partnership with The Clyde Foundation) and Fallago Rig Wind Farms.

Contributors

James Hunt (BSc, MSc). The Tweed Foundation. Electro-fishing team leader, habitat surveyor and report writer.

Suzanne Taylor (BSc). The Tweed Foundation. Macro-invertebrate processing, habitat surveyor and analysis.

Contents

INTRODUCTION

The proposed Millmoor Rig Wind Farm development (Proposed Development) is situated in the headwaters of the Jed Water, a tributary of the Teviot which is a sub-catchment of the Tweed District (Map 1). The Tweed Foundation (Fisheries Trust for the Tweed District) was commissioned by Direct Ecology Ltd to undertake a fish, macro-invertebrate and habitat survey to inform the Further Environmental Information Report for the Proposed Development.

While fish surveys are a general requirement of all wind farm proposals where fish populations are likely to be found, an added consideration is that the River Tweed and primary tributaries (including the Jed Water) are an Site of Special Scientific Interest (SSSI) and Special Area of Conservation (SAC) for Atlantic salmon and lamprey. In a wider context Atlantic salmon (*Salmo salar*) is an internationally important fish species which is listed under Annex II and V of the European Habitats Directive (1992) (only in freshwater), and Appendix III of the Bern Convention (1979) (only in freshwater). Atlantic salmon is also a species of conservation concern on a UK level. Brown trout / sea trout (*Salmo trutta*) are a UK Biodiversity Action Plan species.

The Tweed also supports important adult salmon and sea trout fisheries with juvenile nursery areas found within the boundary of the survey area. These fisheries generate important income to the local economy and depend on healthy nursery areas to maximise in-river production.

Small numbers of European eel are also present in local watercourses. There continue to be concerns across Europe over low eel stocks. It is currently unknown why there has been such a rapid decline but it is thought to be linked to over-exploitation, inland habitat loss, climate and ocean current changes, disease and pollution. The European Eel Regulations (EC) No 1100/2007 aim to establish measures to recover eel stocks. One such measure was the production of Eel Management Plans for the Scotland River Basin[1] and the Solway Tweed River Basin[2] Districts, in 2008 and 2010 respectively. Fishing or taking eels is illegal (unless licensed) under The Freshwater Fish Conservation (Prohibition on Fishing for Eels) (Scotland) Regulations 2008. The European eel is also a UKBAP priority species.

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[1] Scottish Government (2008), Scotland River Basin Eel Management Plan http://www.gov.scot/Resource/Doc/1063/0076523.pdf

[2] Defra (2010), Eel Management Plans for the United Kingdom, Solway Tweed River Basin District http://webarchive.nationalarchives.gov.uk/20130402151656/http://archive.defra.gov.uk/foodfarm/fisheries/documents/fisheries/emp/solway.pdf

METHOD

Electro-fishing

There are different methods of electro-fishing that can be utilised for fisheries surveys and monitoring, each of which have advantages and disadvantages regarding the accuracy and precision of results and the number of sites that can be sampled per day. Quantitative methods for a delineated section of river (normally represented as number per 100m^2), typically involve electro-fishing the section one, two or three times to produce a density estimate. A three run method provides the highest level of accuracy and precision (with confidence limits) but is the most time consuming and labour intensive method. Index methods also exist that involve electro-fishing for a set period of time and are much quicker, but produce less accurate results. For wind farm fish monitoring, geographical coverage is important in order to sample the different sized watercourses and habitats at the site while attaining a reasonable level of accuracy for the results. A single run, semi-quantitative electro-fishing method was chosen as the most appropriate balance of attaining coverage and a reasonable level of accuracy.

Sampling was carried out in fast-flowing, relatively shallow areas, which are the preferred habitat of juvenile salmon and trout. Juvenile salmon are usually more common in main channels while trout, by contrast, dominate the smaller burns where adult trout spawn. Patches of fine sediment, if present, were also sampled to assess the distribution and abundance of larval lamprey. A summary of the life history stages of Atlantic salmon, trout and lamprey species is provided in Appendix 4.

Based on local knowledge from electro-fishing surveys in the local area, six sites were located in watercourses where the species most common in this area (trout, salmon and lamprey) were likely to be present. Five of the sites were located on the Jed Water and Black Burn, within the watershed of Proposed Development. The sixth site on the Carter Burn was sampled as a control site as there are no proposed turbines within the watershed of this tributary.

All site locations are displayed in Map 1and detailed in Appendix 1 (location and date). Samples were collected on the 27th and 28th June 2023.

All of the sites were photographed (Appendix 2) and accurately located using GPS (5 m accuracy). Effective monitoring relies on sampling exactly the same sections of river using an identical method to help reduce sampling error.

Macro-Invertebrate sampling and scoring

Six invertebrate samples were taken on the 25th May 2023 in proximity to each of the electrofishing sites. The samples were taken before any proposed construction work is carried out and therefore represents the condition of the Upper Jed Water before work has taken place.

The method used for freshwater invertebrate sampling was the standard Water Framework Directive (WFD) methodology which consists of three minutes of kick sampling followed by one minute of manual searching using a standard metal framed hand net of 25cm diameter with a 1mm mesh. The three-minute kick sample is split up proportionally based on the proportion of different habitats within the chosen sampling site. E.g. silt and mud, cobbles and pebbles, macrophytes. This methodology is used by both the Scottish Environment Protection Agency (SEPA) and the Environment Agency (EA) and is described in more detail in WFD UKTAG Biological Methods Rivers – Benthic Invertebrates.

After collection, samples were immediately preserved in 100% Isopropanol in labelled 1.5 litre plastic sample jars.

Invertebrate identification was carried out using a stereo microscope with variable magnification between x7 and x45. Identification was to family level (the level required for most biological indices, including WFD) for all invertebrate groups/types. Standard keys and guides were used for identification (Dobson et al 2012; Edington & Hilgrew 1981; Elliot, Humpesch & Macan 1988; Hynes 1977; and Wallace, Wallace & Philipson 2003).

The BMWP (Biological Monitoring Working Party) scoring system was used to give an index of water quality and river health. The system scores invertebrate families between 1 and 10 based on their based on their pollution tolerance, with the most sensitive receiving the highest score. The total score for all family's present and the average score per family present (ASPT) are then calculated, with high scores indicating high water quality. The scoring/rating of the results is a simplification of the BMWP system used by SEPA before the introduction of the Water Framework Directive (SEPA 2013) and is shown below in Table 1. Whilst both the ASPT and Combined Family Scores give a good indication of water quality, the ASPT is considered more reliable due to the slight variability in kick sampling results that can be due to different individuals undertaking the work.

One of the limitations of the BMWP scoring is that it is not abundance weighted. The WHPT (Walley Hawkes Paisley Trigg) ASPT index[7] is abundance weighted which improves the accuracy of the invertebrate assessment. The WHPT index was developed through the Water Framework Directive ('WFD', Directive 2000/60/EC) and from 2015 is used as the basis for river invertebrate status classification for Water Framework Directive (Environment Agency, 2019). It is important to note that the results presented are not true WFD status classifications as further environmental data must be collected and analysed using RIVPACS (River Invertebrate Prediction and Classification System) (Environment Agency, 2019).

The Proportion of Sediment Sensitive Invertebrates Index (PSI) was also used to gauge any potential impacts of sedimentation. The index works by giving scores to invertebrate families based on their tolerance to fine sediment, which is reflected in their abundance. The analysis focusses on the proportion of invertebrates in a sample that can only exist with minimal sedimentation.

Table 1. Simplified SEPA BMWP Colour Coded Scoring/Rating System.

Class	Description	ASPT	Combined Family Score	Comments
A1	Excellent	≥6.0	≥85	Sustainable salmonid fish population. Natural Ecosystem
A2	Good	≥5.0	≥70	Sustainable salmonid fish population. Ecosystem may be modified by human activity
B	Fair	≥4.2	≥50	Sustainable coarse fish population. Salmonids may be present. Impacted ecosystem.
C	Poor	≥3.0	≥15	Fish sporadically present. Impoverished ecosystem
D	Seriously Polluted	< 3.0	< 15	Cause of nuisance. Fauna absent or seriously restricted

Increased silt/sediment run off is a potential impact of numerous types of constructions, including windfarms (mainly due to run off from road networks crossing watercourses). The scoring system for the interpretation of PSI scores is shown in Table 2. The class scoring was added to aid the interpretation of the results and is not part of the PSI Index itself. The PSI index system is described in more detail in the 2011 paper by Extence et al (listed in the references).

Table 2. PSI Scoring/Rating System with Added Colour Coded Class Rating.

Class	PSI Score	River Bed Description
A1	81-100	Minimally sedimented / unsedimented
A2	61-80	Slightly sedimented
B	41-60	Moderately sedimented
C	21-40	Sedimented
D	0-20	Heavily Sedimented

Habitat survey

A habitat survey methodology was required to assess :-

1) Fish habitat, in particular different flow types that affect juvenile Salmonids (run-riffle, pool, glide).
2) Bank erosion points (as an indicator of bank stability).

3) Sediment presence (for lamprey habitat and as an indicator of increased sediment input).
4) Point source pollution points, particularly for sediment.
5) Riparian habitat features, in particular vegetation type.

The Hendry & Cragg-Hine walkover habitat survey methodology (Hendry & Cragg-Hine 1997) was selected as the most appropriate method for meeting these criteria. This method was also chosen as the recorded parameters are easily mapped in GIS format for visual display and the field survey work can be carried out relatively quickly.

The habitat survey covered all of the watercourses that are likely to contain fish in the wind farm boundary and a kilometre downstream of the boundary (Map 1). Similar to the electro-fishing and invertebrate sampling, habitat data from the Carter Burn acted as a control.

25 cm resolution aerial photography was used as a basemap for delineating lengths of instream habitat. Due to the relatively small size of watercourses and the time it would take to delineate areas of instream habitat, lengths of habitat units were recorded rather than areas.

Surveys for both watercourses were started at the most downstream point of the survey section. As well as instream habitat, the geographical location of features of interest including erosion points and sediment accumulations were recorded using GPS and pictures were taken of these. Watercourses were split up into sections according to discrete changes in riparian vegetation type.

Digitised data, including all point photographs, was supplied to Direct Ecology as a project package that can be imported into ArcGis Pro.

Habitat surveys were carried out on the 25th May, 8th June and 31st July 2023 under low water conditions.

Standards

The electro-fishing team leader for this survey, James Hunt, has over 20 years electro-fishing experience and has undertaken training and refresher courses through The Scottish Fisheries Coordination Centre (www.sfcc.co.uk), following the agreed protocols[3]. Suzanne Taylor has attended a two day training course run by The SFCC for fish related habitat surveys and is an ARMI coordinator (www.riverflies.org/armi) for river fly sampling in the Tweed District.

[3] SFCC 2007. Electro-fishing team leader training manual. Fisheries management SVQ 3. Manage electrofishing operations

RESULTS

Electro-fishing

To provide some context to the results, the average densities of salmonid fishes at these locations were checked against the regional juvenile densities (fish/100m^2) bands for the East region (Table 2.)[4], which were used for the most recent SAC condition assessments, including the River Tweed SAC. The classified results are provided in Table 3.

Table 2. Quality bandings from the regional east model from Godfrey (2005)

Percentile	Salmon Fry	Salmon Parr	Trout Fry	Trout Parr
Zero density (%)	12.00	10.40	3.30	10.40
Min (Very Low)	0.69	0.69	0.85	0.30
20th percentile (Low)	6.89	3.05	4.31	1.86
40th percentile (Medium)	21.54	6.3	11.94	3.39
60th percentile (High)	43.38	10.16	26.21	7.46
80th percentile (Very High)	104.58	19.7	72.10	13.85
Max	497.70	51.42	292.95	151

Table 3. Classified densities (per 100 m^2) using the percentile categories in Table 1 for colour coding and the number of eels present. **'-' indicates not sampled**

Site Code	Salmon Fry	Salmon Parr	Trout Fry	Trout Parr	Eel (number)	Stone Loach	Three Spined Stickleback	Common Minnow
L01	237.6	0	72.7	0	0	4	0	0
L02	178.8	8.4	120.0	1.2	0	0	0	0
L03	15.6	2.6	62.6	31.3	0	0	0	0
L04	73.6	2.2	69.1	4.5	0	1	0	0
L05	64.0	6.2	78.8	3.7	0	0	1	0
L06	19.2	11.5	261.5	3.8	0	7	1	12

Salmon

The two sites furthest downstream, L01 and L02, had the highest Salmon fry results, both of which were categorised as 'Very High'. The next two sites moving upstream, L04 and L05, were classified as 'High'. The lowest salmon fry results were found in the smallest watercourses that were sampled, L03 and L06, both of which were categorised as 'Medium'.

[4] Godfrey, J.D. (2005). *Site condition monitoring of Atlantic salmon SACs*. Report by the SFCC to Scottish Natural Heritage, Contract F02AC608.

Salmon parr densities showed no relationship to fry, with all the results ranging from 'Zero' to 'High' categories.

Trout

All trout fry results were in the 'High' to 'Very High' categories, with no detectable spatial pattern related to the size of watercourse. Parr numbers were more variable, ranging from 'Zero' to 'Very High'.

Eels

No Eels were captured or seen at any of the sites that were sampled.

Other fish species

Stone loach, were present in low numbers at the two Jed Water sites (L01 and L04). Three spined stickleback were only detected at site L05, the furthest upstream site on the Jed Water. Common minnow were also only detected at one site, L06.

Lamprey

The Lamprey catch per unit effort results are presented in Table 4.

Table 4. Lamprey per unit of time (time in brackets**). '-' indicates no available habitat**

Site Code	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
L01	0 (1:40)	6 (3:30)	-	0	1.71	-
L02	3 (2:45)	0 (2:00)	6 (3:30)	1.09	0	1.71
L03	1 (2:50)	0 (1:10)	0 (3:20)	0.35	0	0
L04	2 (2:30)	0 (2:30)	0 (1:20)	0.80	0	0
L05	0 (1:40)	0 (1:00)	-	0	0	-
L06	-	-	-	-	-	-

Lamprey were absent at eight out of the thirteen locations that were sampled. For the remaining five sites, capture rates ranged from 0.35 per minute to 1.71 per minute.

Macro-invertebrates

The invertebrate sampling scores are presented in Table 5, based on the data contained in Appendix 5. Pollution-intolerant invertebrate families were present at all of the sample sites and as a result, all of the scores are in the highest categories for both ASPT and Combined Family Score.

From the PSI scores, five of the six sites are categorised as A2 which indicates the sites are slightly sedimented. Site L01 PSI score is categorised as A1 which indicates the site is minimally sedimented or unsedimented.

Table 5. Macro-invertebrate scores for BMWP, ASPT, combined family, WHPT and PSI

Site	BMWP ASPT Class	BMWP ASPT Description	Comb. Family Score Class	Comb. Family Score Description	WHPT N-Taxa	WHPT Score	WHPT ASPT	PSI Score	PSI Class	River Bed Description
L01	A1	Excellent	A1	Excellent	23	190.06	6.96	83	A1	Minimally sedimented / unsedimented
L02	A1	Excellent	A1	Excellent	20	168.57	7.08	80	A2	Slightly sedimented
L03	A1	Excellent	A1	Excellent	30	254.75	7.25	80	A2	Slightly sedimented
L04	A1	Excellent	A1	Excellent	27	219.99	6.89	70	A2	Slightly sedimented
L05	A1	Excellent	A1	Excellent	25	208.77	7.07	77	A2	Slightly sedimented
L06	A1	Excellent	A1	Excellent	19	149.32	6.52	68	A2	Slightly sedimented

Habitat surveys

The walkover habitat survey results are presented in Appendix 3 in a map format. For the entire extent of the survey, there was a regular, repeating change of run-riffle / pool-glide habitat units which is a typical feature of watercourses with moderate gradient. In steeper areas, the predominant flow type is run-riffle and in low gradient areas, mainly glide-pool is expected. A diversity of flow types is beneficial to the production of juvenile salmonids and other fish species, providing suitable rearing habitat for different stages of their life cycle. Although bedrock was present in certain areas, the predominant substate types were pebble, cobble and gravel, which provide cover for juvenile salmonids and suitable habitat for macro-invertebrates.

As noted for lamprey, accumulations of fine-sediment which were recorded as points of interest, were relatively uncommon and spread out rather than clustered in particular areas.

Riparian habitat quality was reasonable, with only small areas of overshading conifer in proximity to the watercourse. Harvesting of mature stands of conifer has taken place in the last few years within 500 m of the watercourse in a number of areas, with no evidence of any detrimental impact to the river through siltation or pollution. There was a reasonable coverage of replanting with broadleaf trees within 50 metres of the watercourse, but very little of it was planted on the riverbank, presumably to minimise the risk of losing saplings when the river floods.

The most common riparian habitats within 25 m of the bankside were tall herbs and grassland, followed by conifer plantation. Established riparian broadleaf tree cover was almost non-existent, with the only continuous coverage to be found on the upper section of the Black Burn, which was planted by the Tweed Foundation around 30 years ago.

DISCUSSION OF RESULTS

Salmon

Adult salmon typically spawn in the main channel of the Tweed, the Teviot and the principal tributaries which include the Jed Water. The watercourses within the Proposed Development site are at the upper range of their distribution, with the number of spawners varying from year to year based on flow conditions at the time of spawning. The two sites furthest downstream, L01 and L02, had the highest densities of fry, which probably reflects a higher numbers of spawners in the local area. Sites further upstream (L04 and L05) and in smaller watercourses (L03 and L06) had lower densities of fry, which probably reflect a lower number of spawners in 2022. The Peden Burn site (L06), for example, is probably so small that spawning did not take place in this watercourse; the small number of fry present are likely to be migrants from the Jed Water.

Parr are known to be move much further downstream and upstream after their first year of rearing and an unknown proportion will smolt after one year to migrate to their feeding grounds; these fish will therefore not be present to sample when electro-fishing, therefore having a strong influence on their densities. The variable parr densities are therefore consistent with results from other Tweed tributaries.

Trout

All of the watercourses within the Proposed Development site are suited to trout spawning and rearing of juvenile fry. Consistent with results from other parts of the catchment, fry numbers were classified as 'High' to 'Very High', reflecting good levels of spawning by adult sea trout and brown trout in Autumn 2022 and good instream habitat. Similar to salmon parr, trout parr are more prone to small and large scale movements to the main river and out to sea. Larger trout are also typically found in slower flowing, deeper water with good instream cover, which was not sampled.

Lamprey

Also consistent with surveys from other upland areas, patches of fine sediment that were suitable for sampling were scarce. Similar to trout, lamprey are also at the upper extent of their natural range.

The larval lamprey that were counted were most likely to be brook lamprey, rather than the migratory river and sea lamprey which are typically found further downstream in the main stem of the Tweed. Brook lamprey are the most common of the three types of lamprey and are found in most parts of the catchment, often in very high numbers.

Eels

The absence of eels at any of the sites is consistent with results from other parts of the catchment at the top of tributaries. In the lower parts of the river, eels are quite common but become increasingly rare moving up the main river and tributaries.

Macro-invertebrates

The top rated scores for BMWP, ASPT and Combined scores at all of the sites is indicative of high water quality in the local area. Without any housing or farming in the local area, any form of pollution or habitat degradation which could potentially reduce the scores is unlikely.

Habitat

The overall assessment of the lead surveyor (James Hunt) is the instream habitat quality (based on substrate and flow units) is very good, based on 1) good quality, well distribute spawning substrate 2) a mixture of uncompacted substrate sizes, particularly pebble and cobble, which provide cover for fry and parr.

There was a general absence of riparian tree cover, which in turn leads to a reduction in habitat diversity through the absence of large woody debris and tree roots which provide cover from predators and influence water flow. Tree cover is also essential for shading the river, helping to keep the river cool in hot summers and is a current focus for habitat management (noted in conclusions).

CONCLUSIONS

The combination of electro-fishing and macro-invertebrate monitoring sites with a walkover habitat survey provide a comprehensive assessment of the local fish populations and the quality of the local environment for fish production. Should construction go ahead, the collected data will form the backbone of a baseline monitoring scheme.

Standard guidelines for construction work will minimise any damage to the local river environment. Some fisheries related considerations are provided in Appendix 6. Given that all fish are migratory to varying degrees, it is of particular importance that any new road culverts are properly designed to allow the free passage of fish.

The habitat survey also provides some interesting insights into potential habitat improvement through riparian tree planting. At present, forestry managers are planting broadleaf trees well away from the bankside to minimise the risk of tree loss from floods. Tree planting along the riverbank is the primary management tool to help reduce increasing summer water temperatures by shading the river, with extensive scientific research currently being carried out by the Marine Directorate and The Tweed Foundation (www.gov.scot/publications/scotland-river-temperature-monitoring-network-srtmn/). The establishment of riparian trees in the Upper Black Burn through low cost willow planting is important evidence that riparian tree cover can be established.

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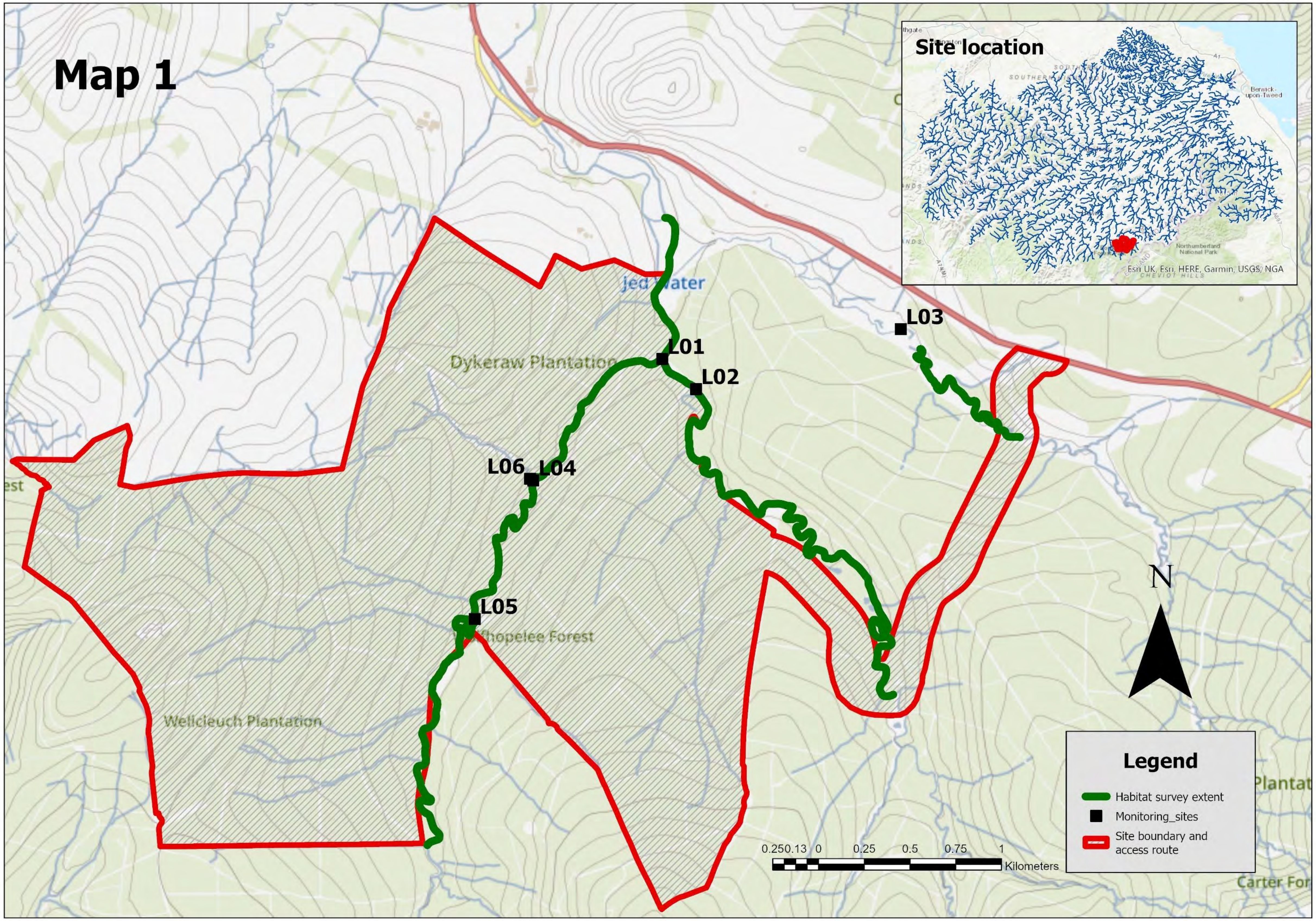
Map 1. Site location and layout



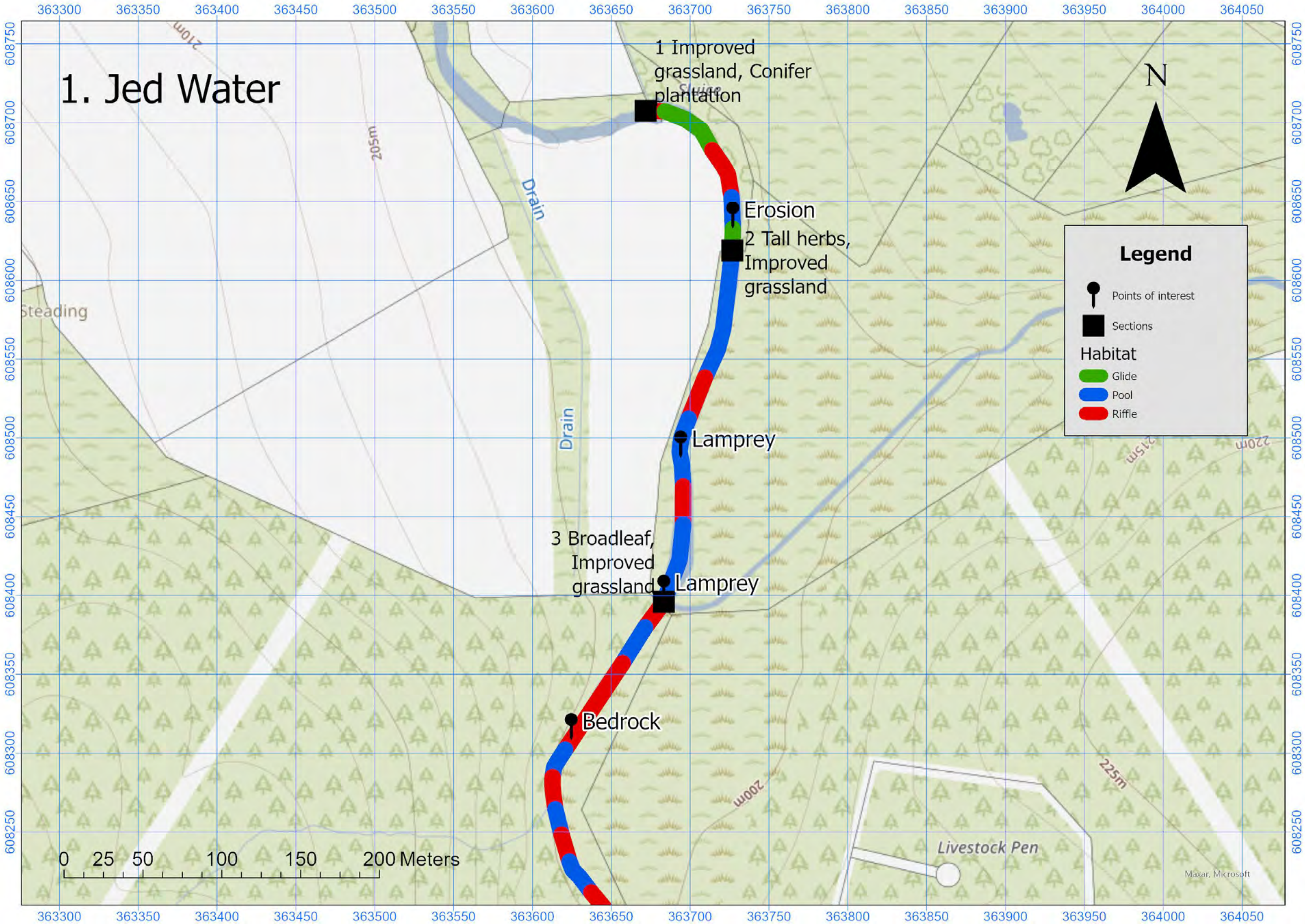
Appendix 1. Electro-fishing and macro-invertebrate sampling site details

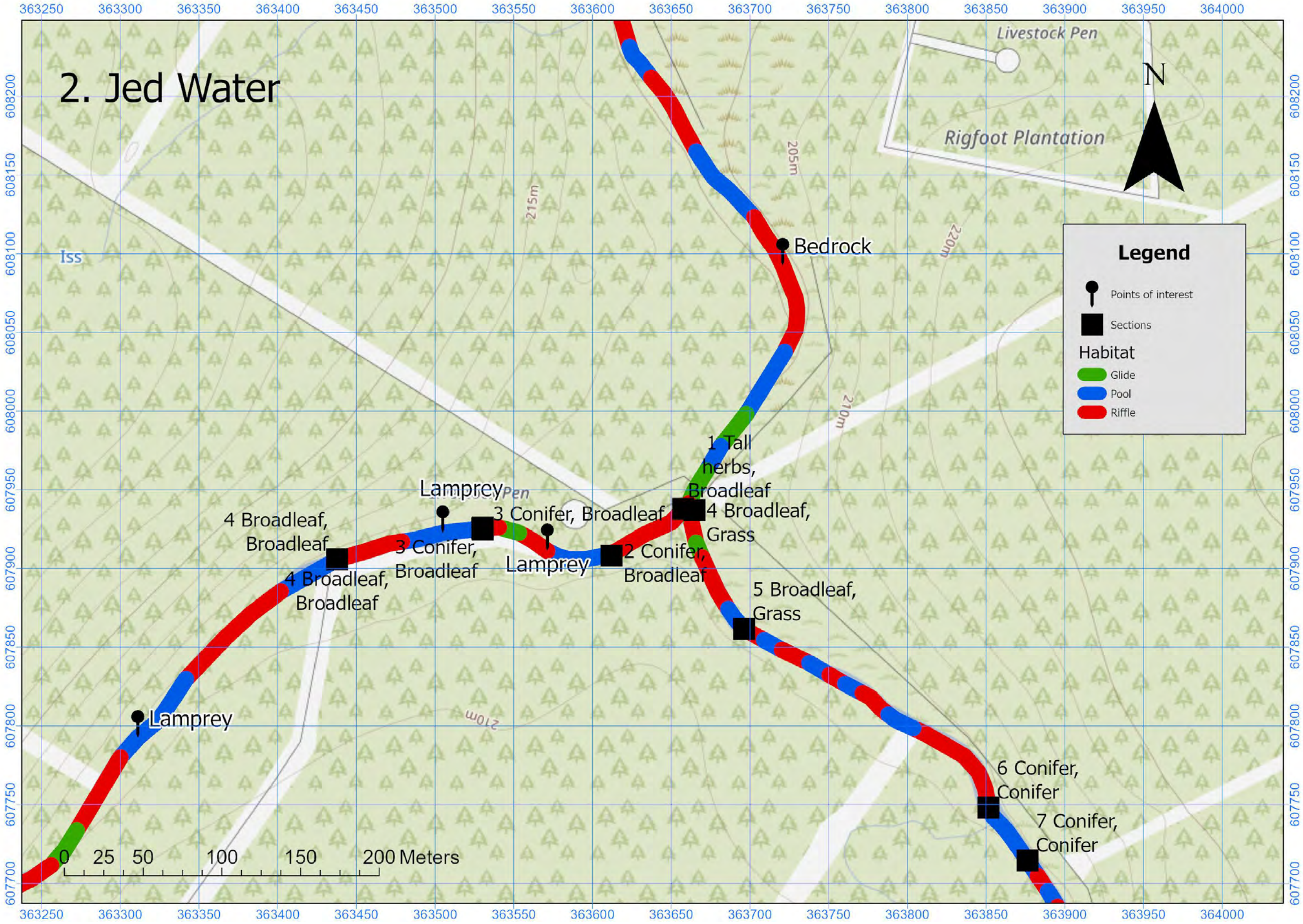
Site Code	Easting	Northing	Date	Order 3	Order 4	Electro-fishing Reach (m)	Electro-fishing Area (m2)
L01	363656	607936	27/06/2023	Jed Water		20	77
L02	363841	607771	27/06/2023	Jed Water	Black Burn	20	83
L03	364960	608099	27/06/2023	Jed Water	Carter Burn	25	38
L04	362951	607272	28/06/2023	Jed Water		20	90
L05	362632	606515	28/06/2023	Jed Water		25	81
L06	362934	607281	28/06/2023	Jed Water	Peden Burn	20	

Appendix 2. Electro-fishing site photos

L01	L02
	
L03	L04
	
L05	L06
	

Appendix 3. Habitat survey




2. Jed Water
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
N
Livestock Pen
Rigfoot Plantation
Iss
Bedrock
Lamprey
Lamprey
Lamprey
1 Tall herbs, Broadleaf
2 Conifer, Broadleaf
3 Conifer, Broadleaf
3 Conifer, Broadleaf
4 Broadleaf, Broadleaf
4 Broadleaf, Broadleaf
4 Broadleaf, Grass
5 Broadleaf, Grass
6 Conifer, Conifer
7 Conifer, Conifer
205m
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363250 363300 363350 363400 363450 363500 363550 363600 363650 363700 363750 363800 363850 363900 363950 364000
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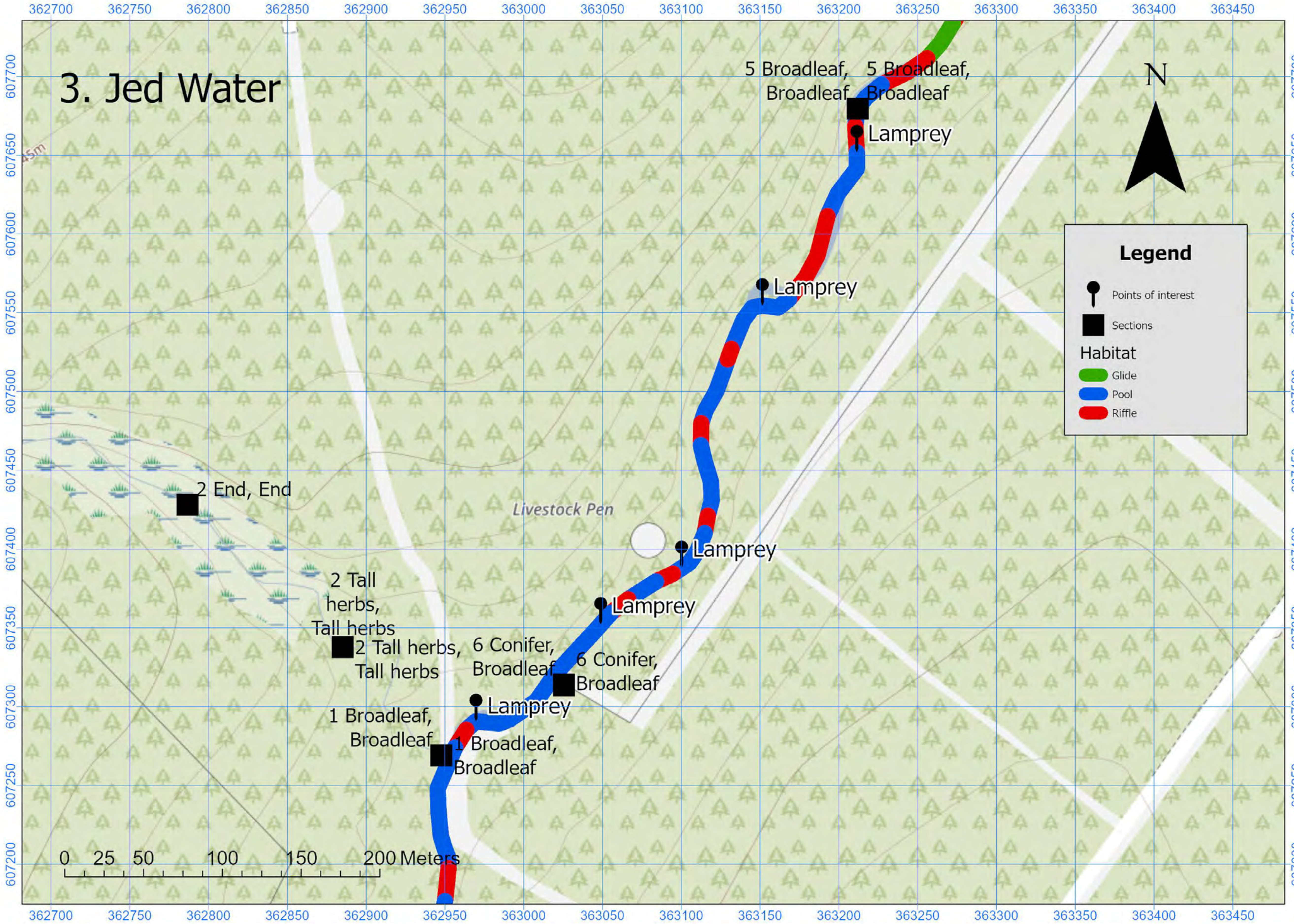
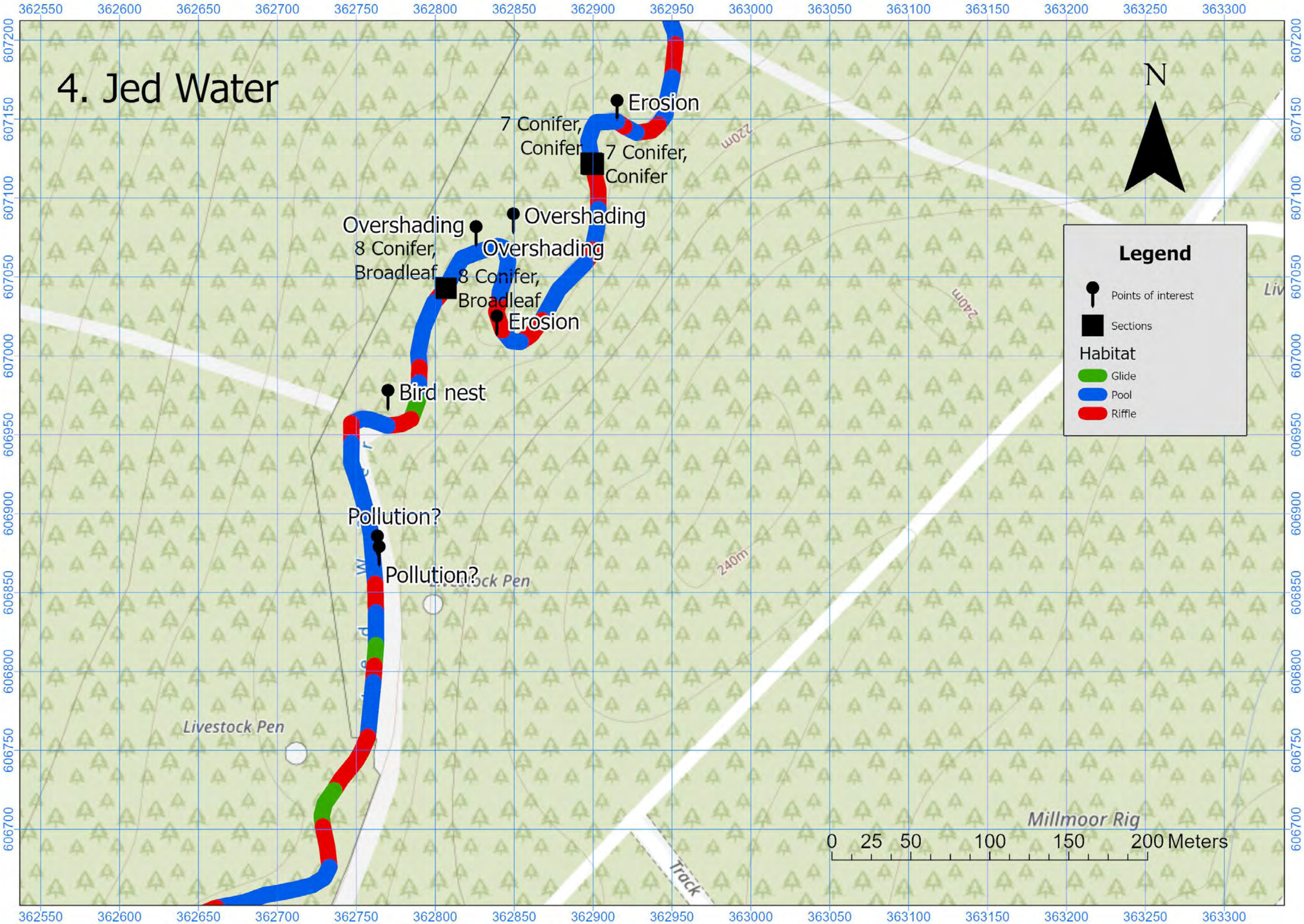
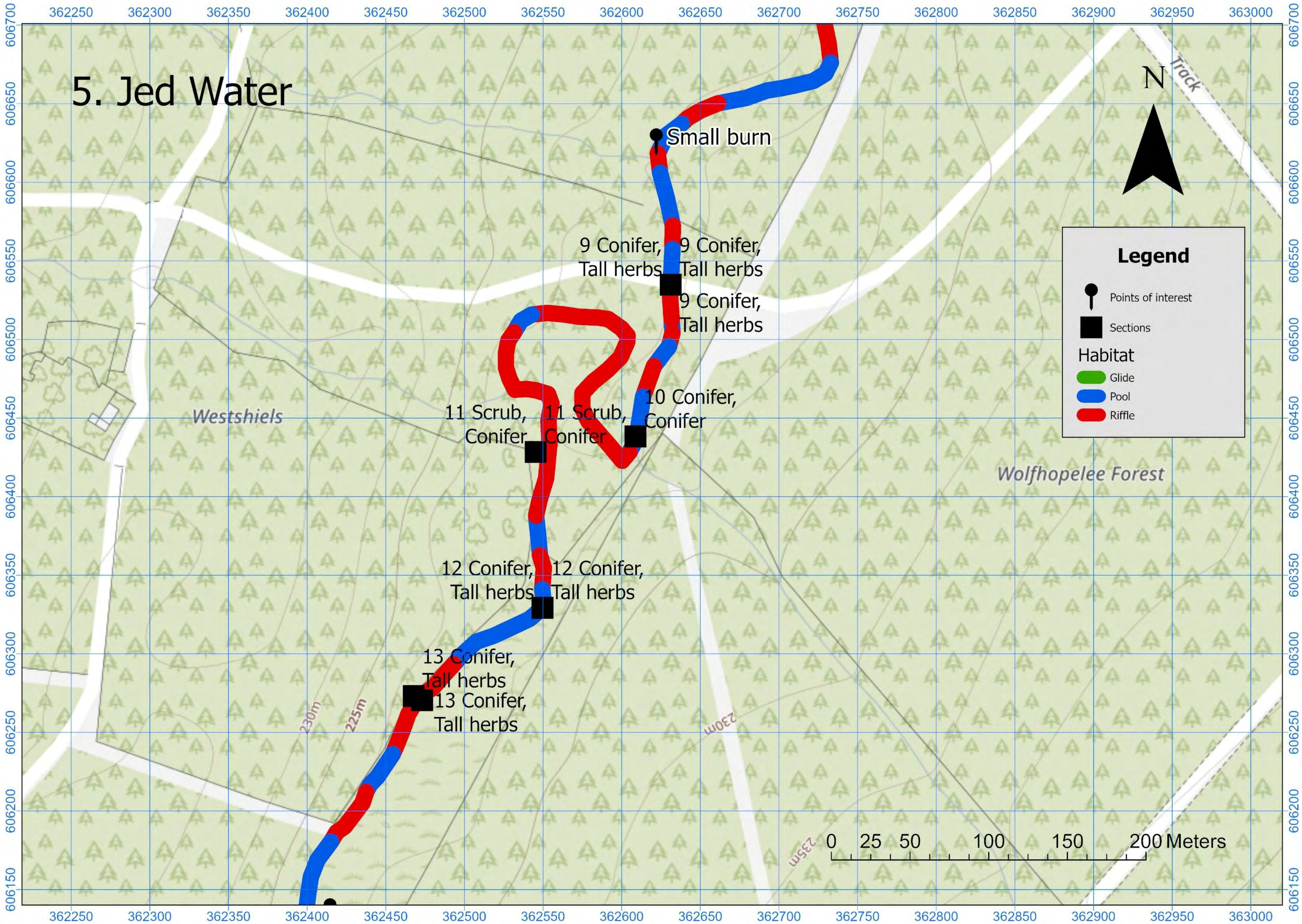
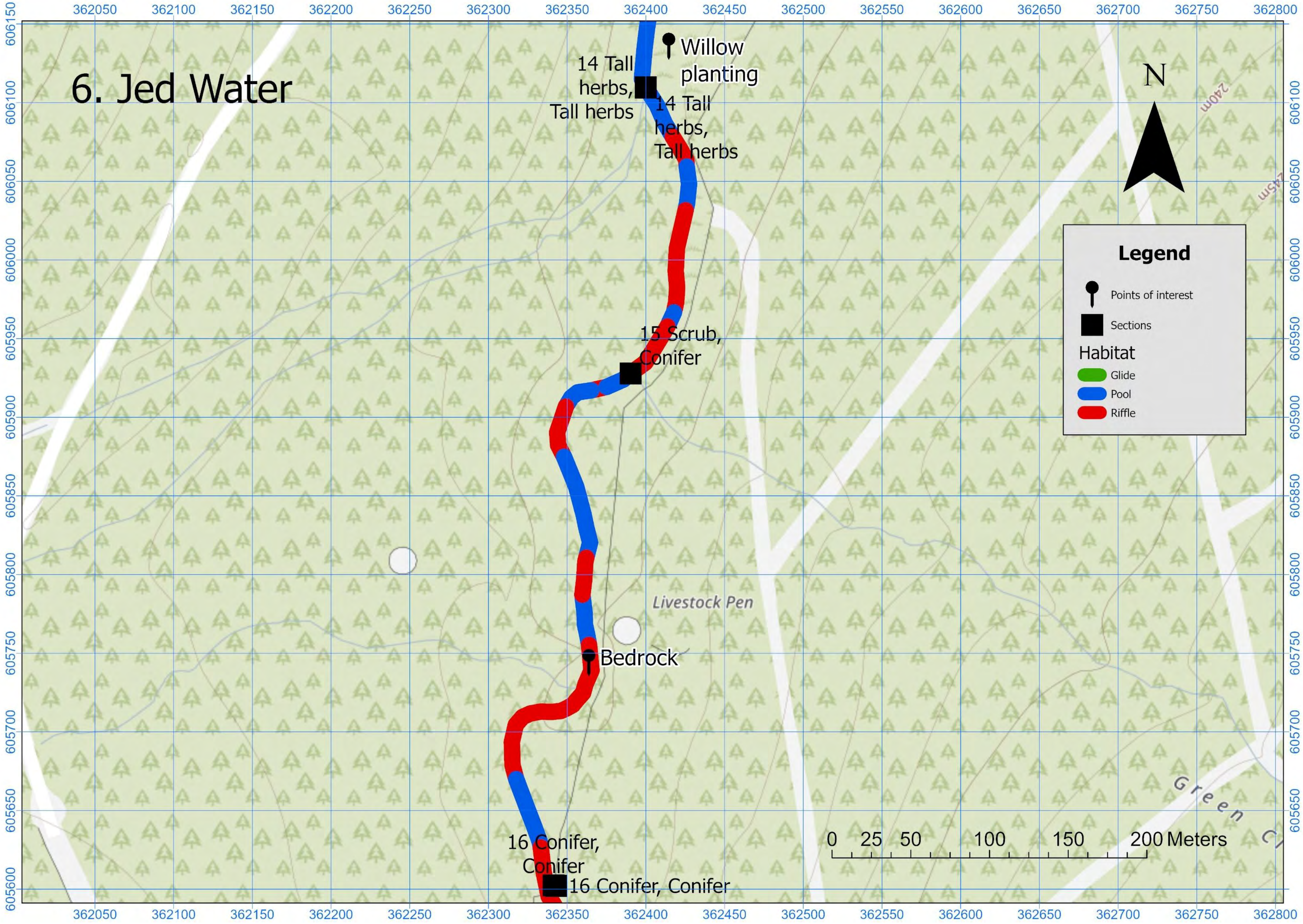


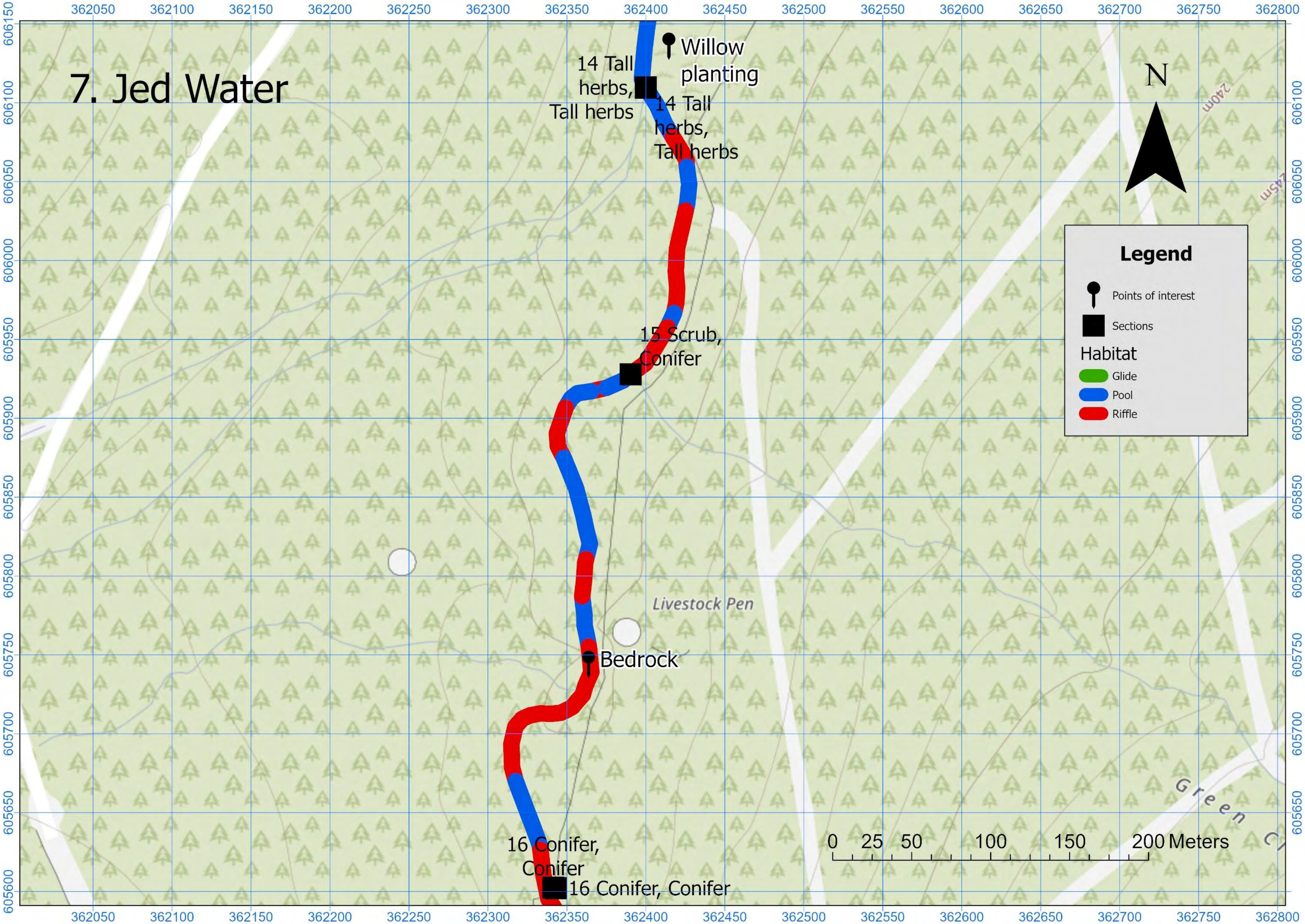
3. Jed Water
N
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
5 Broadleaf, Broadleaf
5 Broadleaf, Broadleaf
Lamprey
Lamprey
Livestock Pen
2 End, End
Lamprey
Lamprey
2 Tall herbs, Tall herbs
2 Tall herbs, Tall herbs
6 Conifer, Broadleaf
6 Conifer, Broadleaf
Lamprey
1 Broadleaf, Broadleaf
1 Broadleaf, Broadleaf
0 25 50 100 150 200 Meters

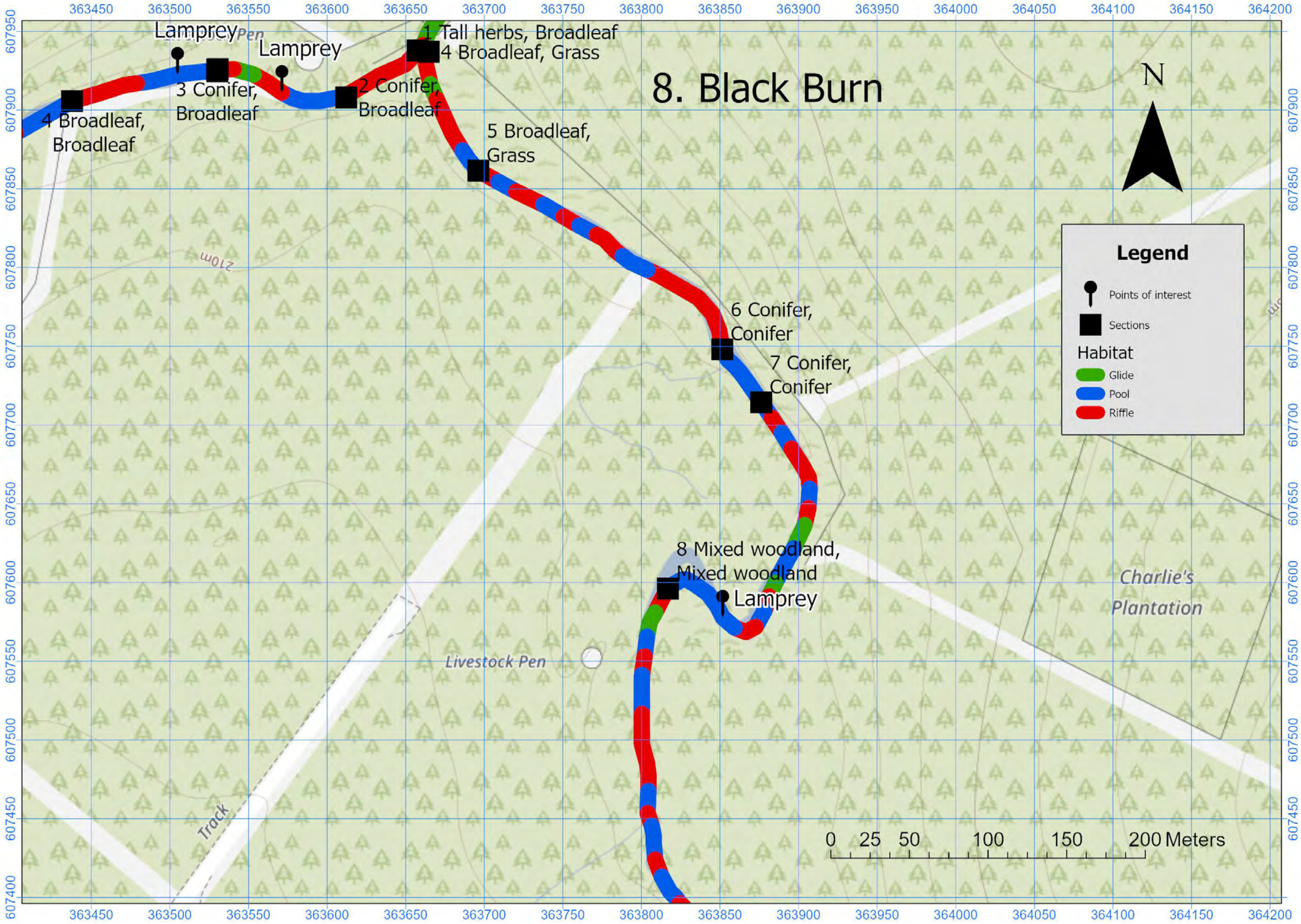

4. Jed Water
N
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
Erosion
7 Conifer, Conifer
7 Conifer, Conifer
Overshading
Overshading
Overshading
8 Conifer, Broadleaf
8 Conifer, Broadleaf
Erosion
Bird nest
Pollution?
Pollution?
Livestock Pen
Livestock Pen
Millmoor Rig
Track
220m
240m
240m
0 25 50 100 150 200 Meters
362550 362600 362650 362700 362750 362800 362850 362900 362950 363000 363050 363100 363150 363200 363250 363300
607200 607150 607100 607050 607000 606950 606900 606850 606800 606750 606700


5. Jed Water
Small burn
9 Conifer, Tall herbs
9 Conifer, Tall herbs
9 Conifer, Tall herbs
10 Conifer, Conifer
11 Scrub, Conifer
11 Scrub, Conifer
12 Conifer, Tall herbs
12 Conifer, Tall herbs
13 Conifer, Tall herbs
13 Conifer, Tall herbs
Westshiels
Wolfhopelee Forest
Track
N
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
0 25 50 100 150 200 Meters
230m
225m
235m

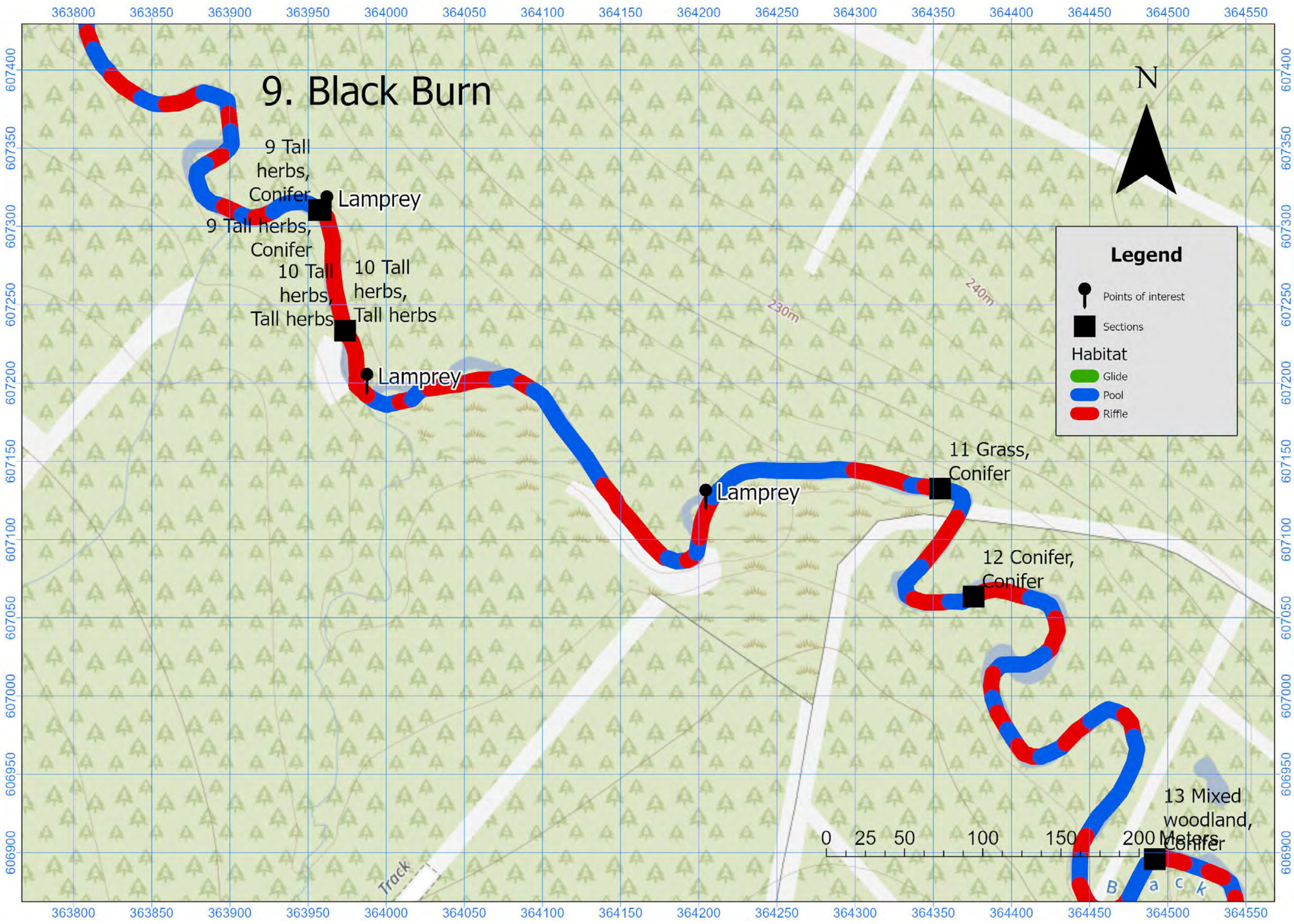


6. Jed Water
Willow planting
14 Tall herbs, Tall herbs
14 Tall herbs, Tall herbs
15 Scrub, Conifer
Livestock Pen
Bedrock
16 Conifer, Conifer
16 Conifer, Conifer
N
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
0 25 50 100 150 200 Meters
240m
245m
Green Cl

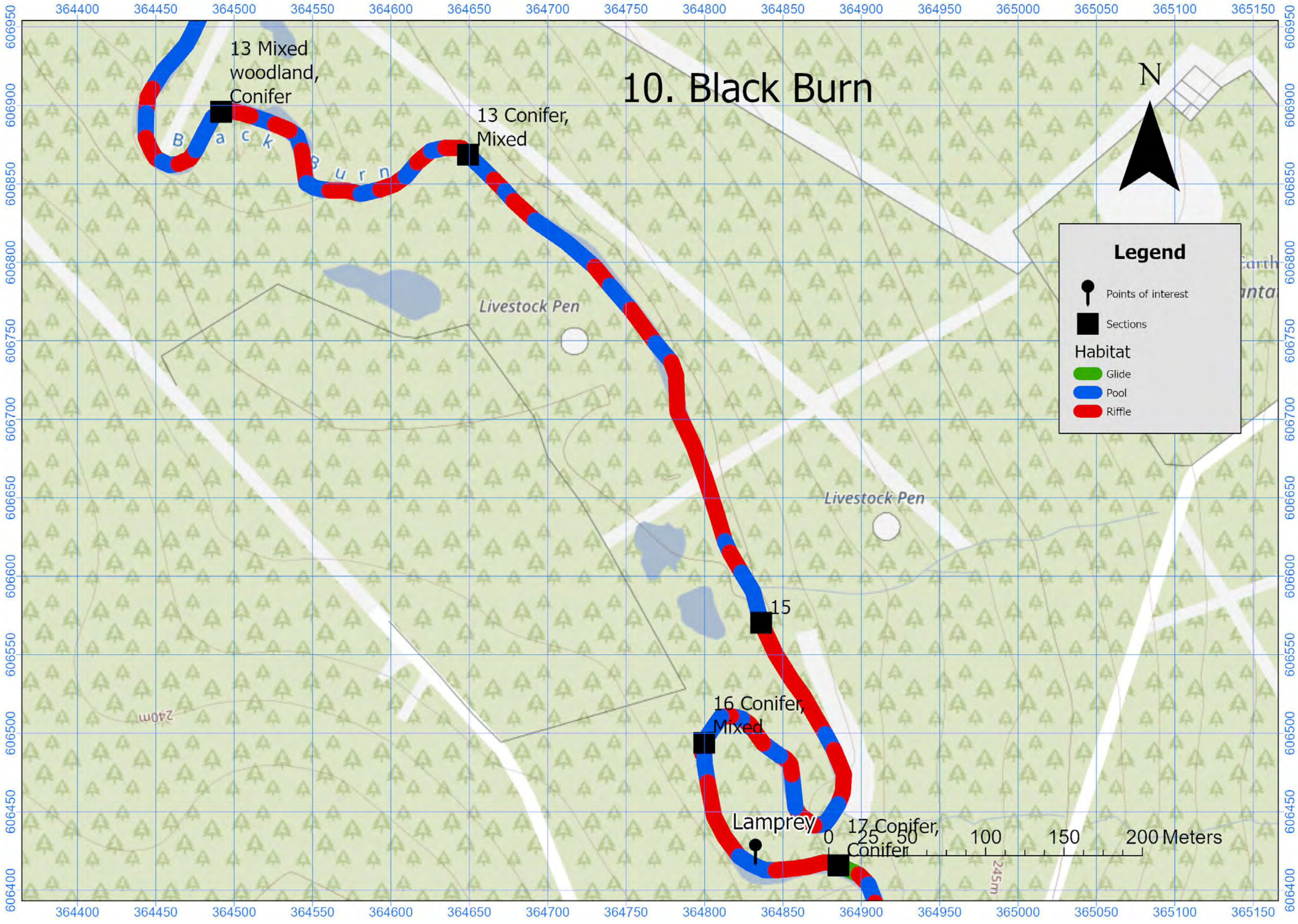

7. Jed Water
Willow planting
14 Tall herbs, Tall herbs
14 Tall herbs, Tall herbs
15 Scrub, Conifer
Livestock Pen
Bedrock
16 Conifer, Conifer
16 Conifer, Conifer
N
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
0 25 50 100 150 200 Meters
Green Cl
240m
245m
362050 362100 362150 362200 362250 362300 362350 362400 362450 362500 362550 362600 362650 362700 362750 362800
606150 606100 606050 606000 605950 605900 605850 605800 605750 605700 605650 605600

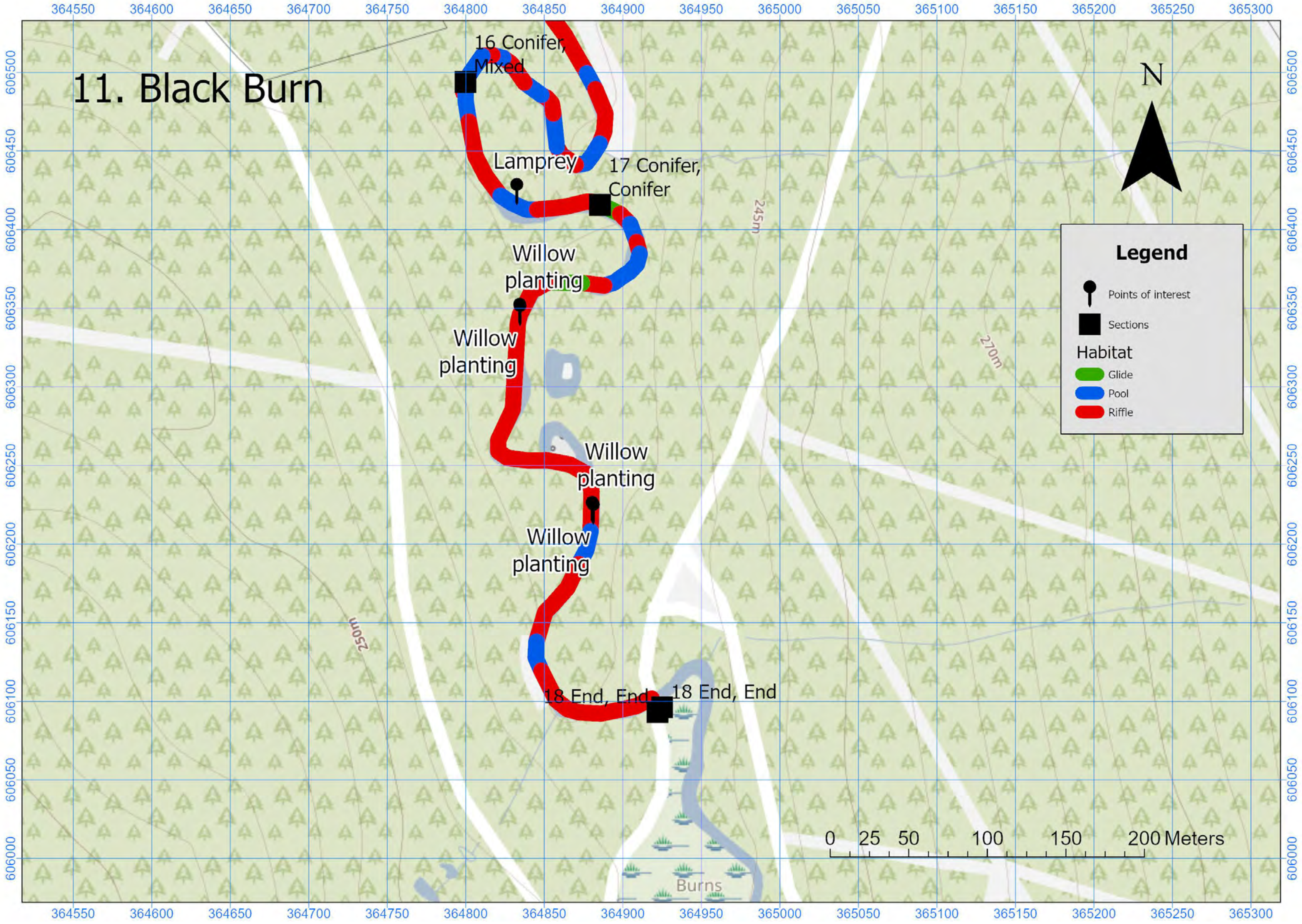


8. Black Burn
N
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
1 Tall herbs, Broadleaf
4 Broadleaf, Grass
2 Conifer, Broadleaf
3 Conifer, Broadleaf
4 Broadleaf, Broadleaf
5 Broadleaf, Grass
6 Conifer, Conifer
7 Conifer, Conifer
8 Mixed woodland, Mixed woodland
Lamprey
Lamprey
Lamprey
Livestock Pen
Charlie's Plantation
Track
210m
0 25 50 100 150 200 Meters
363450 363500 363550 363600 363650 363700 363750 363800 363850 363900 363950 364000 364050 364100 364150 364200
607950 607900 607850 607800 607750 607700 607650 607600 607550 607500 607450 607400

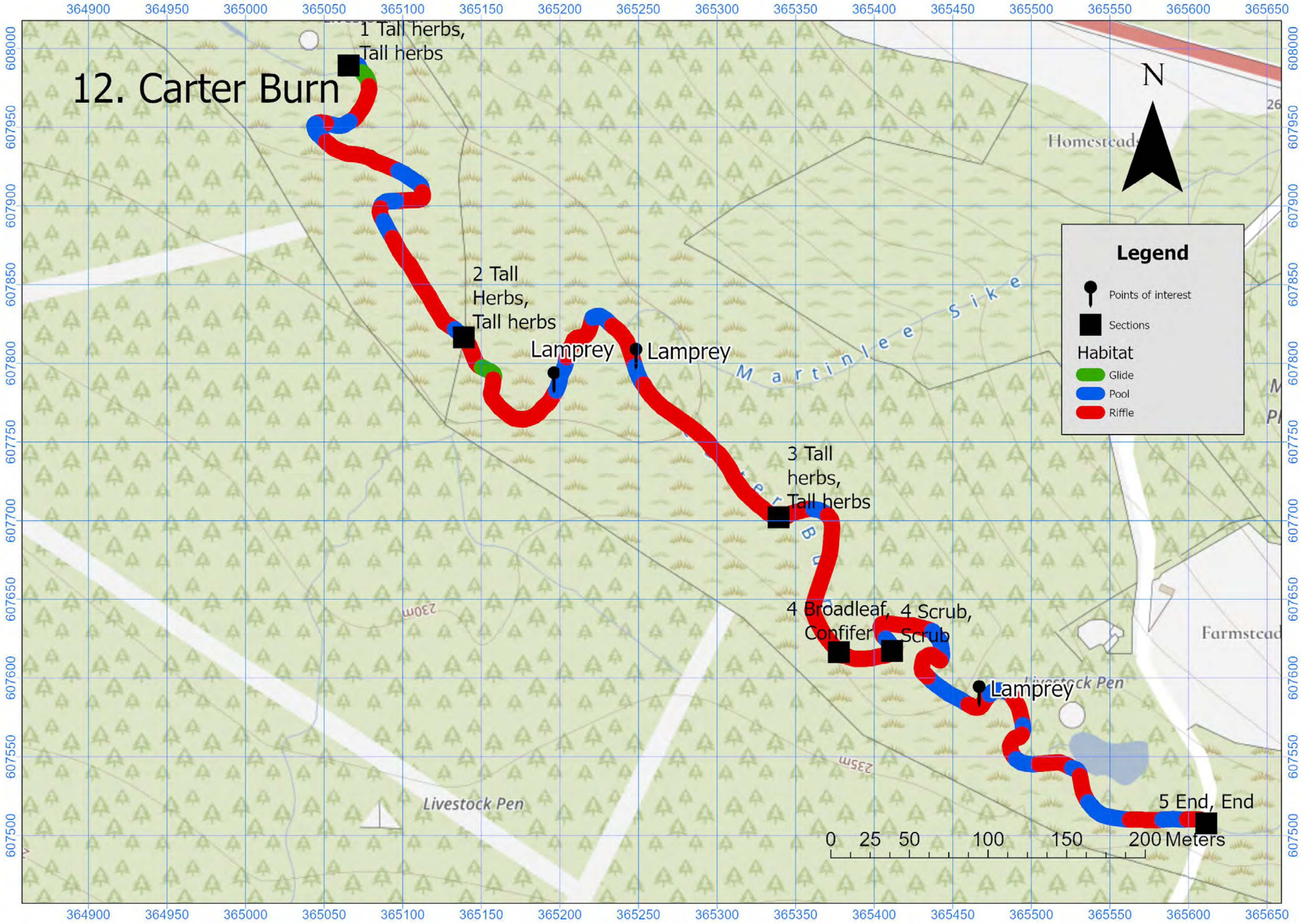


9. Black Burn
N
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
9 Tall herbs, Conifer
Lamprey
9 Tall herbs, Conifer
10 Tall herbs, Tall herbs
10 Tall herbs, Tall herbs
Lamprey
230m
240m
11 Grass, Conifer
Lamprey
12 Conifer, Conifer
13 Mixed woodland, Conifer
0 25 50 100 150 200 Meters
Track
363800 363850 363900 363950 364000 364050 364100 364150 364200 364250 364300 364350 364400 364450 364500 364550
607400 607350 607300 607250 607200 607150 607100 607050 607000 606950 606900


10. Black Burn
N
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
13 Mixed woodland, Conifer
13 Conifer, Mixed
15
16 Conifer, Mixed
17 Conifer, Conifer
Lamprey
Black Burn
Livestock Pen
Livestock Pen
240m
245m
0 25 50 100 150 200 Meters
364400 364450 364500 364550 364600 364650 364700 364750 364800 364850 364900 364950 365000 365050 365100 365150
606400 606450 606500 606550 606600 606650 606700 606750 606800 606850 606900 606950



11. Black Burn
16 Conifer, Mixed
Lamprey
17 Conifer, Conifer
Willow planting
Willow planting
Willow planting
Willow planting
18 End, End
18 End, End
Burns
245m
270m
250m
N
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
0 25 50 100 150 200 Meters
364550 364600 364650 364700 364750 364800 364850 364900 364950 365000 365050 365100 365150 365200 365250 365300
606500 606450 606400 606350 606300 606250 606200 606150 606100 606050 606000


12. Carter Burn
1 Tall herbs, Tall herbs
2 Tall Herbs, Tall herbs
3 Tall herbs, Tall herbs
4 Broadleaf, Conifer
4 Scrub, Scrub
5 End, End
Lamprey
Lamprey
Lamprey
Legend
Points of interest
Sections
Habitat
Glide
Pool
Riffle
N
0 25 50 100 150 200 Meters
Martinlee Sike
Homesteads
Farmstead
Livestock Pen
Livestock Pen
230m
235m
364900 364950 365000 365050 365100 365150 365200 365250 365300 365350 365400 365450 365500 365550 365600 365650
608000 607950 607900 607850 607800 607750 607700 607650 607600 607550 607500

Appendix 4. The life cycle of Salmon and Trout and Lamprey

To understand the results provided on the following pages, a brief guide to the life cycle of Salmon and Trout is provided:-

The Fry are "the young of the year" that are spawned in the Autumn and emerge out of the gravel around April / May. By summer these fish are 5 to 7 cm in length and are typically found in shallow, fast flowing water.

(picture – a Salmon fry recently emerged)

Parr are fish that have spent one or more winters in the stream. Features of Salmon parr that can be used to distinguish them from Trout parr include distinctive parr marks along the flank, a black spot on the gill cover, a more forked tail and generally an absence of red in the tail and adipose fin. Both Salmon and Trout Parr tend to be found in slightly deeper water than Fry, which includes glide and pool habitat units, particularly when there is bankside cover to hide under from predators.

(picture – Salmon Parr (top), Trout Parr (bottom))

Most Salmon Parr leave the river in the Spring as Smolts at a length of around 12 cm (generally after two winters in the river). Trout Parr on the other hand either drop down into the main river to become adult Brown Trout or become Smolts in spring time and go to sea to become Sea Trout.

(picture – Salmon smolt)

Adult Salmon and Sea Trout typically return from the sea after 1 or 2 winters, although some Sea Trout may return after the first summer.

(picture – adult Salmon (top), adult Sea Trout (bottom))

The Tweed system has 3 types of Lamprey – Brook, River and Sea.

Brook Lamprey will remain resident in the area that they are spawned and seldom grow any larger than the individual shown in the picture (about 12-14 cm). River Lamprey migrate down to the Estuary and coast and the Sea Lamprey (see picture left) out to sea to feed before returning to the river. River and Sea Lamprey larvae are typically found in the middle and lower reaches of the Tweed and it would be very unlikely to find them in the proposed wind farm area. Young lamprey (Ammocoetes) only live in silt, mud or fine sand

Appendix 5. Macro-invertebrate results

Family	BMWP Score	Sample Site					
		Jed Water L01	Black Burn L02	Jed Water L04	Jed Water L05	Peden's Cleuch L06	Carter Burn Control
Bithyniidae	3	7			3	1	
Lymnaeidae	3		5	1			
Planorbidae	3			1			
Ancylidae	6	2					2
Oligochaeta	1	1		1		1	1
Gammaridae	6	23	6	39	46	17	380
Baetidae	4	46	26	56	39	4	89
Heptageniidae	10	42	23	46	34	19	24
Leptophlebiidae	10				2	50	4
Ephemeridae	10	4		3	3	2	6
Ephemerellidae	10	104	170	1119	474	6	287
Caenidae	7		1	42	7	5	2
Nemouridae	7	1	2	19	6		7
Leuctridae	10						2
Capniidae	10						1
Perlodidae	10	6	1	23	19		8
Perlidae	10	7	2	15	7		1
Chloroperlidae	10					2	
Haliplidae	5				1		
Dytiscidae	5	11	27	47	24	10	26
Gyrinidae	5			1			
Hydraenidae	5		15	14		2	13
Elmidae	5	125	70	172	183	26	574
Sialidae	4					2	
Rhyacophilidae	7	2	1	2	7		10
Hydroptilidae	6	77	191	561	17	1	121
Psychomyiidae	8	19	12	3	1		
Polycentropodidae	7			5			
Hydropsychidae	5	7	4	30	47	1	24
Limnephilidae	7	4		11	5	1	20
Sericostomatidae	10	5	1		1		2
Odontoceridae	10	4		2	1	2	17
Tipulidae (incl. Cylindrotomidae, Limoniidae & Pediciidae)	5	6	8	6	1		7
Psychodidae	0						1
Ceratopogonidae	0						1
Simuliidae	5	1	1	4	13		2
Chironomidae	2	10	21	118	35	4	185
Tabanidae	0			2			3
Muscidae	0				1		1
N - Taxa		23	20	27	25	19	30
Combined Family Score		152	130	156	167	120	183
BMWP ASPT		6.61	6.50	6.50	6.96	6.32	7.04
WHPT Score		190.06	168.57	219.99	208.77	149.32	254.75
WHPT ASPT		6.96	7.08	6.89	7.07	6.52	7.25
PSI Score		82.5	80	70	77	68	80

Appendix 6. Management of local fish populations

Under the scenario that the Proposed Development is consented, management of factors that could influence local fish populations will be required and are summarised below. Following SEPA guidelines and consultation with local Fisheries Trusts will generally mitigate the potential issues. It is unlikely, as long as adequate mitigation measures are in place, that Proposed Development should impact significantly on the surrounding fish populations or their habitats.

Magnitude of Effects

The magnitude of effects on the fish populations is described below (see Table 4). For example, in the worst-case scenario, large scale mortality to fish populations may be caused or important instream habitat, such as spawning gravels, irreversibly damaged. Fish movement may also be disturbed and this may have the effect of limiting the full use of available habitat or their health may be affected. Some effects may influence fish populations to limit their feeding times, indirectly encourage them to move downstream into already overpopulated areas, or cause areas of spawning habitat to become unused. However, effects such as disturbance may only be short term.

Table 1. Scale of potential effects from construction and ongoing maintenance operations

Magnitude of Potential Effects	Definition
High	Direct mortality of fish species including the egg stage. Total loss of food resource. Irreversible damage to instream/riparian habitats, in particular, salmonid spawning areas. Blocking migratory fish movements. Long-term displacement of fish populations.
Moderate	Reduction in level of food resource. Limited damage to instream/riparian habitats. Hindering migratory fish movements. Short-term displacement of fish populations. Changes to hydrology.
Low	Detectable but minor, short-term changes to fish populations, water quality and instream habitat. Water quality standards reduced slightly but not enough to impact upon fish populations present.
Negligible	Unquantifiable change to fish populations, water quality or instream habitat.

Likely significant effects are discussed briefly below:

Obstruction to fish migration

The most common issue encountered in the River Tweed catchment is the construction of road crossings on small watercourses that do not require a SEPA licence and therefore do not receive proper scrutiny. These are typically piped culverts, often with a lip at the downstream side that form a complete barrier to fish migration. When building any crossing point over a watercourse it is important to ensure free passage to fish both in an upstream and downstream direction. Some fish species (including salmon, trout, eels and lampreys) undertake migration as an essential part of the lifecycle. To interfere with the free passage of migratory salmonids is illegal (see Salmon (Fish Passes and Screens) (Scotland) Regulations 1994).

To ensure the free passage of fish at river crossings, the River Crossings and Migratory Fish: Design Guidance (2000) must be adhered to (available on the Scottish Executive website http://www.scotland.gov.uk/consultations/transport/rcmf-00.asp). During the construction phase, it must be ensured that no hanging culverts are installed and that fish passes which are passable to parr, are installed where necessary. The Salmon (Fish Passes and Screens) (Scotland) Regulations 1994 must be adhered to.

Elevated Levels of Suspended Silt

The construction of the required new road network, upgrading of existing roads and the excavation of turbine bases will require extensive works. These works could result in large areas of disturbed ground and spoil heaps which will lack a layer of protective stabilising vegetation and thus, could be washed into surrounding watercourses. Therefore, the main potential impact to the freshwater environment from these works will be raised levels of suspended silt within the water column.

The effect of this increased silt on fisheries can be extremely damaging. Direct effects on fish include respiration problems due to clogged gill rakers/gill filaments. The settlement of fine sediments on spawning gravels can reduce water flow and thus oxygen transfer to egg and alevin life stages of salmonids whilst they are buried in 'redds' (typically September – March). Spawning beds can be damaged by siltation at any time of year as gravels may become 'cemented' by the settling fine particles, causing problems when fish try to spawn the following autumn. In addition, raised turbidity levels may affect fish feeding through them not being able to see food items, mortality of the aquatic invertebrate population, reduced productivity and modifying substrate habitat by an infilling of the smaller voids used for shelter by small fish and aquatic invertebrates.

The most sensitive time of year for salmonids is between September and May. Spawning of trout may start as early as late September, with salmon starting roughly a month later but they may go on until early January. The eggs will develop in constructed 'redds' until they hatch as alevins. The alevins will remain hidden in the gravel, gaining nourishment from their yolk sac, until they swim up into the overhead water column between February and May, depending on water temperatures. The downstream migration of salmon and sea trout smolts will take place roughly between April and May annually and great care must be taken not to damage or hinder these important fish.

Excessive Erosion

Excessive levels of erosion are undesirable due to loss of riparian land and elevating the levels of suspended silt. The placing of instream and bankside structures such as watercourse crossings may cause both upstream and downstream erosion problems which can be exacerbated by flood events.

Water Pollution

When any substantial work programme is being undertaken with mechanical equipment near a watercourse, there is always the risk of pollution of nearby watercourses. In particular, oil and fuel, either leaking from faulty or damaged equipment or spillage during refuelling can enter watercourses and cause problems such as fish kills.

It must be highlighted that any pollution or silt input to a watercourse will have a downstream effect, but, depending on the type of event, may have diminishing effects as it travels further downstream due to the effect of dilution.

Instream and Riparian Habitat Loss

Instream habitat may be degraded through elevated levels of silt or from activity during the construction of crossing points. The placing of culverts may require the removal or redistribution of instream substrate. Riparian habitat could be lost or reduced when the road crosses a watercourse or the road runs closely alongside the watercourse. Furthermore, heavy machinery constructing crossing points working in the riparian area could, through manoeuvring, degrade the riparian habitat. This can cause erosion if not attended to.

Heavy machinery should avoid entering instream habitats where possible, as it may cause compaction of substrates, mortality of fish and degradation of the banksides and riparian habitat.

Maintenance of Crossing Points

It is essential to ensure that crossing points once constructed are carefully monitored and remedial works undertaken if necessary. Potential areas of concern include blocking of culverts by debris, excessive erosion around the crossing point structures and silt entering from roadside drainage channels.

Culvert blockages will not only cause problems for fish movement but may also cause upstream flooding which may cause additional problems with erosion and washing in of silt.

Forest Harvesting

It is recognised that the short-term release of nitrate that can follow the large-scale harvesting at some forest sites may pose an additional acidification threat within acid sensitive areas. The Forests and Water Guidelines Fourth Edition (2003) provides information (using a decision tree) on whether the forestry authorities require a site impact assessment before issuing a felling licence. Research suggests that effects of harvesting on burn acidity is hard to notice if 20 % or less of a catchment is felled over a three year period. Depending on the scale of tree felling proposed for the wind farm it may be necessary to undertake a site impact assessment to examine what the impacts on water chemistry would be.