GREENBURN PROJECT:

BRAEHEAD FARM

2 YEAR MONITORING REPORT: EAST DIVERSION

FINAL

FEBRUARY 2015

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DEFINING TOMORROW'S ENVIRONMENTS

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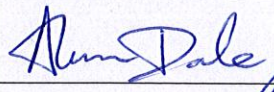
SIGNED:	
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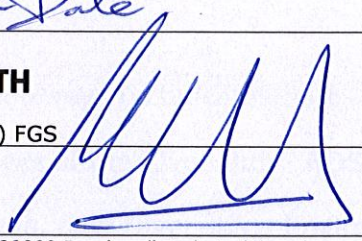
SIGNED:	
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6217/RNMP/01 **–** Photo Locations River Diversion East

1. INTRODUCTION

1.1 Background

Kier Minerals Ltd. holds an engineering licence under the Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR), authorisation number CAR/L/1090278, for the purpose of engineering work on the River Nith (East Diversion, Braehead) as part of the Braehead Farm extension to the Greenburn surface mining operations near New Cumnock, East Ayrshire.

Condition 3.2.1 of the licence requires the responsible person to submit a monitoring plan to the Scottish Environment Protection Agency (SEPA). This was submitted to SEPA in February 2013.

Condition 3.2.3 requires 1 report to be submitted two years after the completion date and 1 report five years after the completion date.

This report forms the submission of the two year monitoring report as per Condition 3.2.3 of the engineering licence.

2. MONITORING LOCATION

2.1 Location

The location of the realignment is shown in Drawing 6217/RNMP/01.

Reference points as per the licence are detailed in Table 2.1 below.

Table 2.1: Realignment Location

NGR	Name/ Reference	Associated Waters	Activity
NS 5779 1321 to NS 5805 1324	Point A and B	River Nith	Permanent Realignment

3. ENVIRONMENTAL MONITORING

3.1 Macro-Invertebrate Survey

The macro-invertebrate surveys were undertaken by the Centre for River Ecosystem Science (CRESS) during October 2012 and October 2014. The report has been included as Appendix A, a summary of the report findings are presented below.

Invertebrates were collected from upstream, downstream and within realigned sections of stream. The diversity of macro-invertebrate fauna present (66 species from 48 different families) is consistent with a small tributary in good ecological condition. The taxa identified at the site indicate that water quality is good. None of the species identified are of specific conservation concern as listed in the Scottish Invertebrate Species Knowledge Dossiers. It is possible to say with a reasonable degree of confidence that no species of conservation concern are found at the site, but that the site has conservation value with regard to the provision of habitat space in good ecological condition.

3.2 NDSFB Electrofishing Survey

An annual electrofishing survey is undertaken at the Greenburn site by the Nith District Salmon Fishery Board to monitor the health of the River Nith. During 2013 and 2014 additional locations were added, to monitor the east river diversion.

Both reports are included in Appendix B and the main points are summarised below:

2013

- Salmonid species of fish migrated through the diversion channel.
- Salmonid species of fish successfully spawned upstream, within and downstream of the diversion channel.
- Parr aged salmonids have taken up residency within the diversion channel.
- Silt remains within the substrate of the diversion channel and this is likely to reduce over time.
- Non salmonid fish have taken up residency within the diversion channel, although it is anticipated that the diversity and numbers of these species will increase as habitats evolve.
- Maturing riparian vegetation is likely to promote higher densities of all fish species.

2014

- Salmonid species of fish migrated through the diversion channel.
- Salmonid species of fish successfully spawned upstream, within and downstream of the diversion channel.
- Parr aged salmonids have taken up residency within the diversion channel.
- Silt remains within the substrate of the diversion channel but is much reduced form that found in 2013.
- Maturing riparian vegetation is likely to promote higher densities of all fish species.
- The sites surveyed at Greenburn contain comparable densities of fish to other similar sites located throughout the River Nith system.

3.3 River Habitat Survey

As part of the Greenburn site's wider ecological surveys, in 2013 and 2014 a River Habitat Survey (RHS) was undertaken by Environ UK Ltd to monitor the river diversion. Extracts of the reports relevant to east river diversion have been provided as Appendix C and are summarised below.

2013

The River Habitat Survey of the River Nith East Diversion revealed that whilst it is an extremely recently constructed and wholly man-made channel, it has developed extremely well.

A total of nine riffles, four unvegetated point bars and one vegetated point bar were recorded during the survey. These features, particularly the bars, are taken to be good indicators of a natural flow having developed within the channel as they are only formed under the correct flow conditions for the River Nith in this location.

The general appearance of the section is noticeably similar to the appearance of the channel section that was replaced with little outward evidence that it is not a natural channel.

2014

The east diversion was surveyed on 19th August 2014. The survey followed the standard method3.

The second River Habitat Survey of the River Nith East Diversion following the initial survey in 2013, revealed that the diversion has developed extremely well.

A total of nine riffles, three unvegetated point bars, no vegetated point bars and no pools were recorded during the survey. This compares with nine riffles and four unvegetated point bars in the 2013 survey suggesting that the diversion section has established well. At least one of the point bars is noticeably larger than in 2013.

The general appearance of the section is noticeably similar to the appearance of the channel section that it replaced, with little observable evidence that it is not a natural channel.

Both river diversions have developed well and are developing extremely natural looking appearances with the RHS not highlighting any obvious problems with either section.

4. VISUAL MONITORING

4.1 Photographic Records

In addition to the above environmental monitoring photographs were taken at various locations along the diversion and are presented in Appendix D. The locations of the photos are detailed below and presented in Drawing Ref: 6217/RNMP/01.

1: NS 5778 1323.
2: NS 5781 1322.
3: NS 5786 1322.
4: NS 5786 1325.
5: NS 5787 1334.
6: NS 5794 1335.
7: NS 5801 1328.
8: NS 5804 1326.

In addition to the above photo locations, areas of natural erosional and point bars have formed along sections of the diversion channel. These are shown in Appendix D and will continue to be monitored.

5. SUMMARY

The environmental monitoring undertaken at the site has shown that the River Nith east diversion undertaken in August 2012 has developed well over the last two years. The macroinvertebrate survey showed the diversion channel to be consistent with a small tributary in good ecological condition and the electrofishing results also supports this. The RHS documented features such as bars which had developed naturally within the channel are good indicators of a natural flow having developed within the channel.

LEGEND

1 → Photo Location & View point

Area of Tree Planting

Former River Channel Location

Title

GREENBURN PROJECT
BRAEHEAD FARM
PHOTO LOCATIONS
RIVER DIVERSION EAST

PDF - A3LX River Nith East Monitoring Plan
Survey - RIVER NITH DIV & TREE PLANTING

Drawn By	Checked by
AD	CT
Date	**Scale**
18-Dec-2013	1:2500 @ A3
Drawing No.	**Rev.**
6217/RNMP/01	-

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APPENDIX A: Macroinvertebrate Survey, Technical Report - CRESS, Nov 2014

RESS | Centre for River EcoSystem Science

A survey of the macroinvertebrate fauna in stream habitats of the River Nith

2 Year Report: East Diversion River Nith

November 2014

To:
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Kier

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UNIVERSITY OF STIRLING

This report should be referenced as: Perfect, C. and Law, A., (2014) *A survey of the macroinvertebrate fauna in stream habitats of the River Nith*. 2 Year Report: East Diversion River Nith. Centre for River Ecosystem Science, University of Stirling.

Contents

1. Non-technical Summary

Surveys of the macroinvertebrate communities in the River Nith were undertaken in November 2012 and October 2014. The survey of benthic macroinvertebrate communities is an established method for assessing the health of stream ecosystems. Macroinvertebrate families differ in lifecycle, feeding and life history strategies and therefore differ in their tolerance of chemical and morphological pressures. As a result, community level responses to a range of pressures are detectable. This is a distinct advantage compared to use of single indicator species.

Additionally a range of indices have been developed from existing knowledge of the ecology of the macroinvertebrate groups. These can be used to infer information on habitat diversity and water quality. Analysis of macroinvertebrate community data can therefore provide a picture of ecosystem condition, including any cumulative and synergistic effects. As such, this survey provides an insight into the health of the water bodies and records data against which future surveys can be compared.

Invertebrates were collected from upstream, downstream and within realigned sections of stream. The diversity of macroinvertebrate fauna present (66 species from 48 different families) is consistent with a small tributary in good ecological condition. The taxa identified at the site indicate that water quality is good. None of the species identified are of specific conservation concern as listed in the Scottish Invertebrate Species Knowledge Dossiers. It is possible to say with a reasonable degree of confidence that no species of conservation concern are found at the site, but that the site has conservation value with regard to the provision of habitat space in good ecological condition.

2. Introduction

CRESS were contracted to undertake invertebrate surveys at the site on the upper River Nith. CRESS has extensive experience of surveying freshwater habitats. Staff are active in the field of freshwater ecosystem research and have a wide knowledge base that includes previous survey work on other realignments on the River Nith undertaken since 2000.

The objective of this survey was to:

Undertake macroinvertebrate surveys on the River Nith to provide a baseline against which subsequent changes can be assessed.

3. Macroinvertebrate survey methods

3.1 Sample collection

Sampling

To achieve the project objective, a small invertebrate survey was undertaken comprising of collection and analysis of standard three minute kick-samples; 7 samples in 2012 and 13 samples in 2014. Samples were collected following standard FBA techniques.

Samples were collected using the standard technique for sampling stream benthos (ISO 7828). Sediment is disturbed by kicking the streambed and invertebrates are washed by the flow into a net positioned downstream. A sampling period of 3 minutes is spread across the stream habitats present. All habitats at the chosen sampling site in the river are sampled within a 3 minute period approximately in proportion to their abundance. This was achieved by combining nine discrete 20 second kicks located in proportion to the stream habitats present. The area surveyed for each 3 minute sample was approximately $1m^2$ in total. In addition, a manual search, lasting one minute, is performed and any invertebrates found attached to submerged plant stems, stones, logs or other solid surfaces are removed and placed in the net. Samples were preserved in industrial methylated spirits and stored in a cold room prior to sorting. Samples were collected on 28/11/12 and 15/10/14.

This approach is consistent with standard RIVPACS (River Prediction and Classification System) procedures; see EU STAR (2004). This is compliant with BS EN 27828:1994 (ISO78281985 *Methods of biological sampling: guidance on hand net sampling of aquatic benthic macroinvertebrates*), Associated RICT data for pH, conductivity and altitude was also collected, for the purposes of screening and to calculate reference scores for biological metrics.

Site map

Figure 0.1. *Map showing the locations of macroinvertebrate sites from the original realignment. Crown Copyright 2010 Ordnance Survey.*

Figure 0.2. *Map showing the locations of macroinvertebrate sites from the new realignment. Crown Copyright 2010 Ordnance Survey.*

3.2 Sample processing

Sorting protocol

Samples from all surveys were sorted in their entirety (the whole sample was sorted) and exhaustively (all individuals were removed). All individuals were identified under the microscope, with the exception of taxa represented by greater than 150 individuals in which case taxonomic identification of a subsample was confirmed by microscopic inspection.

Taxonomic identification

The majority of macroinvertebrates collected from stream sites were identified to species level. In some cases this was not possible either because (i) the individuals were at early instars and thereforetoo small for positive identification (most stream insects cast their exoskeleton as they grow, each growth stage is referred to as an instar – identification is often only possible for later instars), (ii) keys are not available, or (iii) identification to species is not expected e.g. Diptera and Oligochaeta. Identification was according to the FBA keys listed in the Appendices.

3.3 Site locations and descriptions

Table 0.1. Site code, grid reference and description for each of the sampling locations.

Site code	Grid reference	Habitat description
C1	NS 57713 13367	Predominantly riffle glide habitat with boulder cobble bed.
C2	NS 58240 13223	Predominantly riffle glide habitat with boulder cobble bed.
R1	NS 57866 13221	Predominantly riffle glide habitat with boulder cobble bed.
R2	NS 57925 13348	Predominantly riffle glide habitat with boulder cobble bed.
R3	NS 58022 13266	Predominantly riffle glide habitat with boulder cobble bed.
C3	NS 58124 13263	Riffle pool habitat. Cobble boulder bed.
C4	NS 58240 13223	Riffle pool habitat. Cobble boulder bed.
XC1	NS 56271 12925	Riffle glide habitat. Cobble boulder bed.
XC2	NS 56380 12910	Riffle glide habitat. Cobble boulder bed.
XD1	NS 56534 12991	Predominantly glide habitat with cobble gravel bed.
XD2	NS 56686 13086	Predominantly glide habitat with cobble gravel bed.
XC3	NS 56824 13196	Riffle glide habitat. Cobble boulder bed.
XC4	NS 56906 13231	Riffle glide habitat. Cobble boulder bed.

3.4 Data analysis

Indices are widely used to help summarise and aid the interpretation of ecological data. A group of indices has been selected from the considerable array that have been developed for this purpose. Those chosen provide an overall picture of the macroinvertebrate communities and habitat, encompassing a number of ecosystem elements – e.g. water quality, habitat diversity, productivity, species composition – which should be considered when assessing the health of stream systems.

The following diversity indices and biotic indices were calculated:

- Richness - Total number of taxa identified

- Abundance - Total number of individuals for each identified taxa
- Shannon's H' (index of taxonomic diversity)
- Biological Monitoring Working Party (BMWP) score
- Average BMWP Score Per Taxon (ASPT) score
- Non-metric multidimensional scaling (NMDS)

The merits of these indices are discussed in Appendix C

River Invertebrate Classification Tool (RICT)

The River Invertebrate Classification tool has been developed by SEPA to support the assessment of stream invertebrate communities. The tool incorporates RIVPACs IV, the latest predictive models developed by CEH and used in the calculation of Environmental Quality Indices (EQIs). These can be interpreted in terms of WFD ecological status classes. RICT uses geographical and habitat descriptors to predict an invertebrate community expected to occur in the absence of anthropogenic pressure. The observed fauna can then be compared to this reference baseline.

4. Results and discussion

Data from the surveys of macroinvertebrate communities present in the stream are presented below. Abundance values for individual taxa identified are given in Appendix D. The majority of individuals have been identified to species level allowing interpretation based on the known ecology and distribution of specific species.

The total number of taxa found across all samples was 66 species representing 48 different families. The sample richness (number of species) from realigned sections varies between samples and years, with the number of species found increasing from 2012 to 2014 (Figure 4.1). Variation in species richness from control samples were minor in comparison. Richness is a useful and easily interpretable indicator of the physical habitat diversity present and can be reduced by physical habitat degradation as well as physiochemical stress.

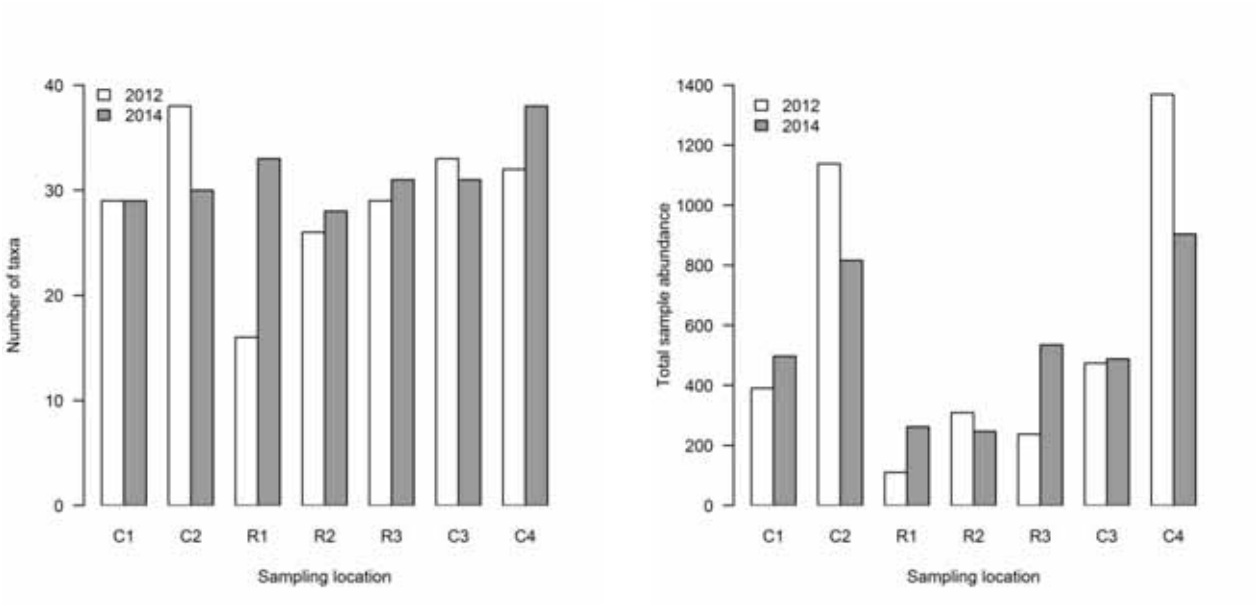

Figure 4.1 Graph showing the sample richness (left) and abundance (right) at each of the macroinvertebrate survey sites.

Samples from the new diversion are more species richness rich further downstream, but realigned sections display negligible differences from control samples (Figure 4.2).

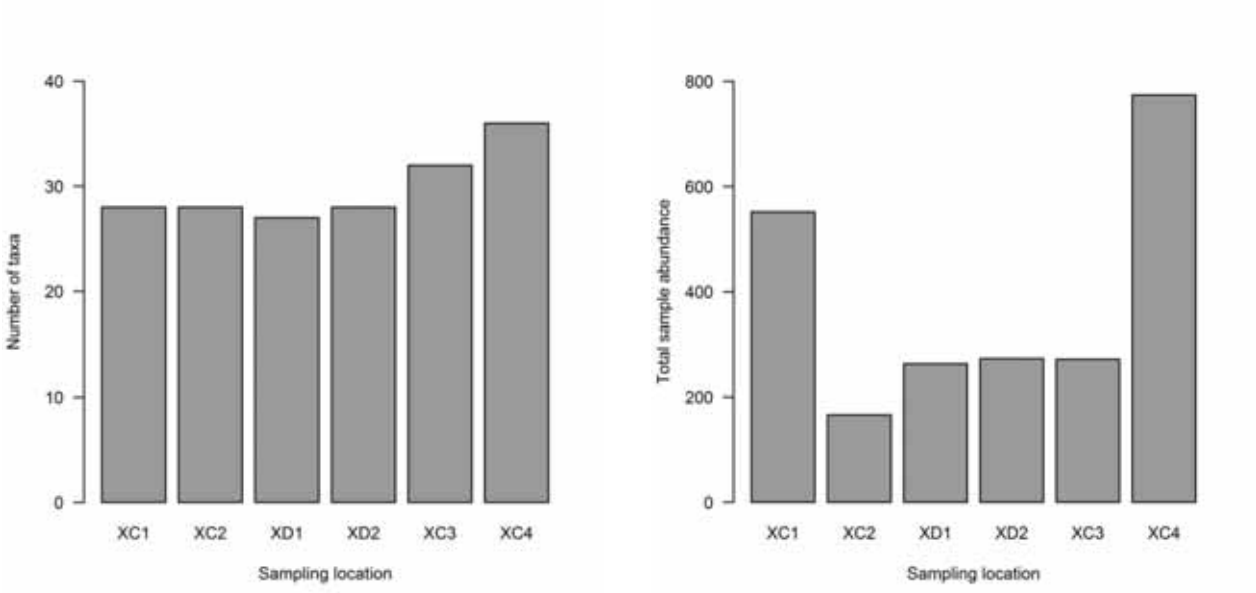

Figure 4.2 Graph showing the sample richness (left) and abundance (right) at each of the macroinvertebrate survey sites from the new diversion.

The community structure of each sample is summarised using Shannon's index of diversity (Figure 4.3), displaying a negligible, consistent differences between control and realigned habitats. This is as expected for sites in such close proximity.

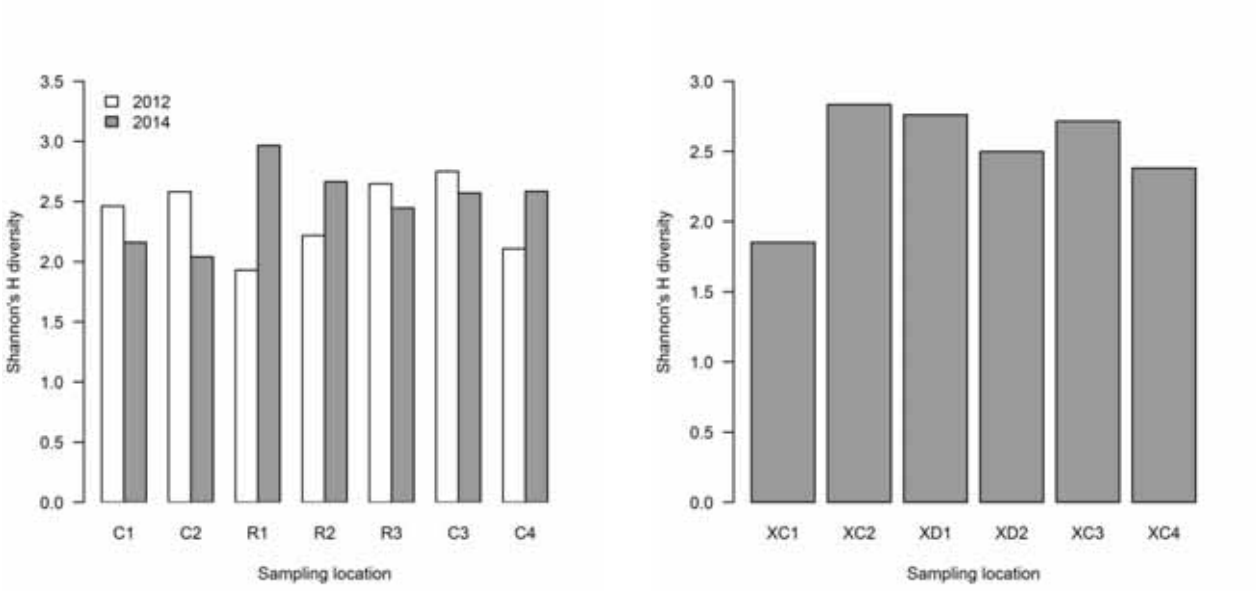

Figure 4.2 Graphs comparing Shannon diversity index H' scores for each of the macroinvertebrate sampling locations.

The BWMP score (Figure 4.4) for the old channel realignment shows few pronounced changes in BMWP between 2012-2014, with the exception of sample R1 which displays a large increase in score having been the lowest scoring site in 2012. Scores from the new aligned channel were greater downstream, most likely related to the greater species richness at these sites.

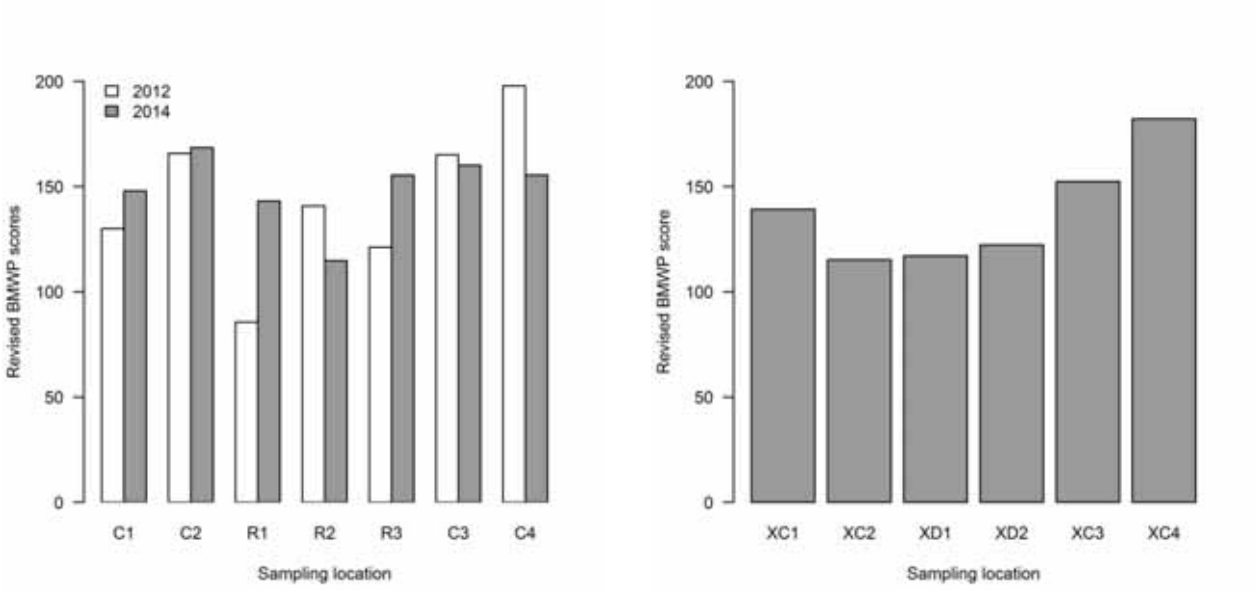

Figure 3.4 Graphs comparing BMWP scores for each of the macroinvertebrate sampling locations.

ASPT scores correct for differences in richness and display negligible differences between realigned sections, years, or upstream and downstream position (Figure 4.5).

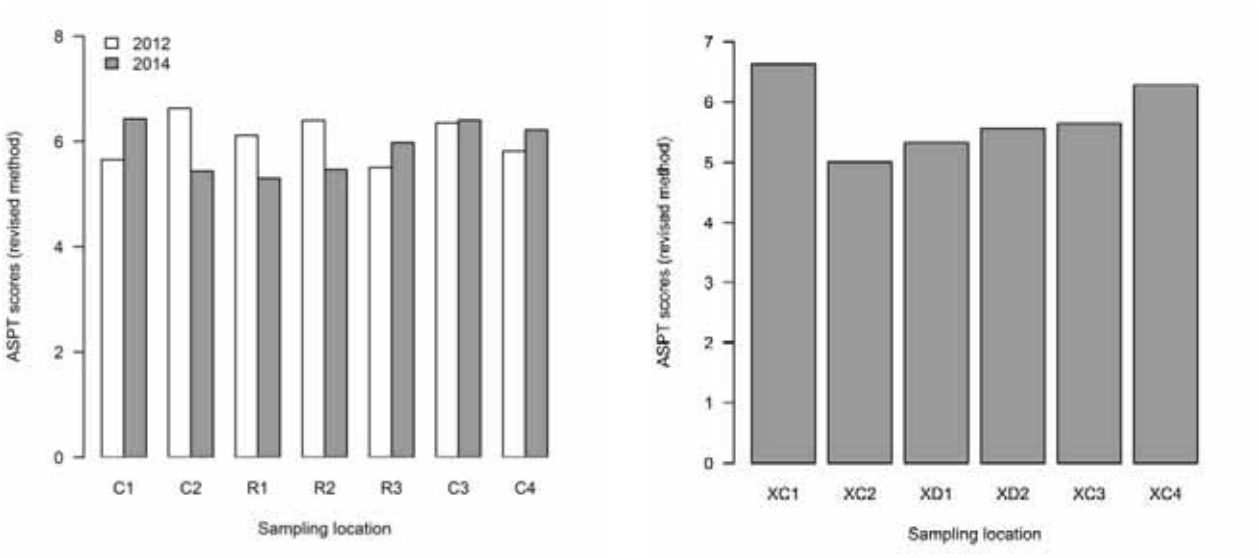

Figure 4.5 Graphs comparing ASPT scores for each of the macroinvertebrate sampling locations.

The clearest, within year differences in species composition occurred between 2012 samples where control and realigned samples differed. Samples from these same habitats in 2014 had a more similar species composition as indicated by plotted points being positioned closer together.

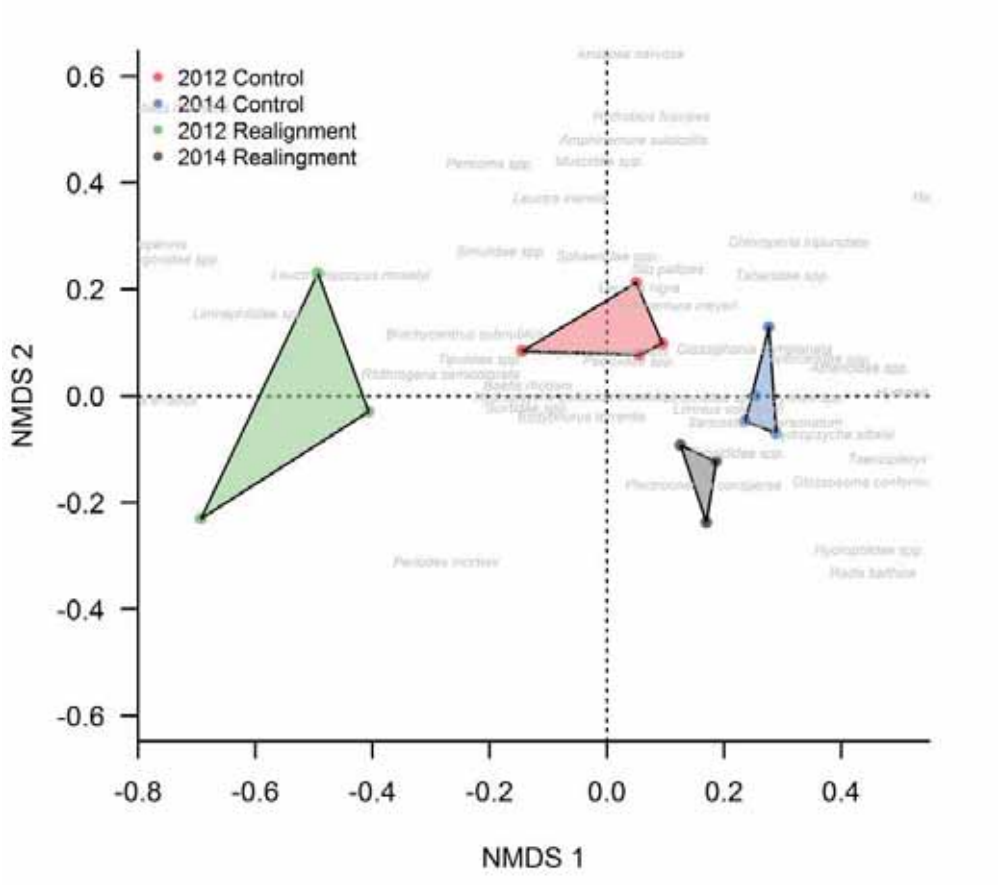

Figure 5.5 Non-metric multidimensional scaling ordination (NMDS) of macroinvertebrate composition, based on a Bray-Curtis dissimilarity matrix with species overlaid.

Number of taxa, BMWP and ASPT scores calculated for the downstream site are broadly consistent with those predicted with the SEPA River Invertebrate Classification Tool (RICT) for both realigned and control sections (Table 4.1). Ecological Quality Indices for NTAXA are consistently close to or above unity (median 1.11), with the exception of one site (R1 in 2012), indicating that at least the expected number of taxa are usually sampled. In terms of ASPT the median EQI across all samples in both years was 0.95, which falls close to the boundary between high and good ecological status indicating that any impairment to composition is generally small.

Table 4.1 Observed (based on sampling) and expected (predicted by RICT) biological indices scores for the habitats on the River Nith

Sampling location	Year	NTAXA		BMWP		ASPT	
		Observed	Expected	Observed	Expected	Observed	Expected
C1	2012	29	25	130.0	179.7	5.65	6.24
C1	2014	29	27	147.9	186.7	6.43	6.18
C2	2012	38	29	168.5	180.5	5.44	6.00
C2	2014	30	27	165.7	187.7	6.63	6.17
C3	2012	33	28	165.1	191.4	6.35	6.20
C3	2014	31	28	160.1	191.7	6.4	6.18
C4	2012	32	28	155.5	189.4	6.22	6.20
C4	2014	38	28	197.8	191.2	5.82	6.17
R1	2012	16	29	85.6	182.0	6.11	6.00
R1	2014	33	28	143.1	190.2	5.3	6.15
R2	2012	26	28	114.8	186.4	5.47	6.15
R2	2014	28	28	140.8	189.2	6.4	6.15
R3	2012	29	28	121.1	191.8	5.5	6.20
R3	2014	31	28	155.4	191.1	5.98	6.20
XC1	2014	28	29	139.2	194.6	6.63	6.12
XC2	2014	28	27	115.2	188.5	5.01	6.17
XC3	2014	32	27	152.4	187.5	5.64	6.19
XC4	2014	36	27	182.2	187.0	6.28	6.16
XD1	2014	27	29	117	191.6	5.32	6.11
XD2	2014	28	28	122.3	190.4	5.56	6.17

5. Conclusions

Summary of findings

Invertebrates were collected from control and realigned sections of the upper River Nith from 2012 and 2014. The diversity of macroinvertebrates present (66 species from 48 different families) is consistent with a small upland river in good ecological condition. There is evidence that over two years the fauna of the realignment has converged considerably towards that of control sites. The taxa identified at the site indicate that water quality is good. None of the species identified are of specific conservation concern as listed in the Scottish Invertebrate Species Knowledge Dossiers. It is possible to say with a reasonable degree of confidence that no species of conservation concern are found at

the site, but that the site has conservation value with regard to the provision of habitat space in good ecological condition.

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Appendices

Appendix A - BMWP scores for individual taxa

Table A. *BMWP Scores for all scoring taxonomic families*

Common Name	Family	Original BMWP Score	Revised BMWP Score	Common Name	Family	Original BMWP Score	Revised BMWP Score
Flatworms	Planariidae	5	4.2	Bugs	Mesoveliidae *	5	4.7
	Dendrocoelidae	5	3.1		Hydrometridae	5	5.3
Snails	Neritidae	6	7.5		Gerridae	5	4.7
	Viviparidae	6	6.3		Nepidae	5	4.3
	Valvatidae	3	2.8		Naucoridae	5	4.3
	Hydrobiidae	3	3.9		Aphelocheiridae	10	8.9
	Lymnaeidae	3	3		Notonectidae	5	3.8
	Physidae	3	1.8		Pleidae	5	3.9
	Planorbidae	3	2.9		Corixidae	5	3.7
Limpets and mussels	Ancylidae	6	5.6	Beetles	Haliplidae	5	4
	Unionidae	6	5.2		Hygrobiidae	5	2.6
	Sphaeriidae	3	3.6		Dytiscidae	5	4.8
Worms	Oligochaeta	1	3.5		Gyrinidae	5	7.8
Leeches	Piscicolidae	4	5		Hydrophilidae	5	5.1
	Glossiphoniidae	3	3.1		Clambidae	5	
	Hirudididae	3	0		Scirtidae	5	6.5
	Erpobdellidae	3	2.8		Dryopidae	5	6.5
Crustaceans	Asellidae	3	2.1		Elmidae	5	6.4
	Corophiidae	6	6.1		Chrysomelidae *	5	4.2
	Gammaridae	6	4.5		Curculionidae *	5	4
	Astacidae	8	9	Alderflies	Sialidae	4	4.5
Mayflies	Siphlonuridae	10	11	Caddisflies	Rhyacophilidae	7	8.3
	Baetidae	4	5.3		Philopotamidae	8	10.6
	Heptageniidae	10	9.8		Polycentropidae	7	8.6
	Leptophlebiidae	10	8.9		Psychomyiidae	8	6.9
	Ephemerellidae	10	7.7		Hydropsychidae	5	6.6
	Potamanthidae	10	7.6		Hydroptilidae	6	6.7
	Ephemeridae	10	9.3		Phryganeidae	10	7
	Caenidae	7	7.1		Limnephilidae	7	6.9
Stoneflies	Taeniopterygidae	10	10.8		Molannidae	10	8.9
	Nemouridae	7	9.1		Beraeidae	10	9
	Leuctridae	10	9.9		Odontoceridae	10	10.9
	Capniidae	10	10		Leptoceridae	10	7.8
	Perlodidae	10	10.7		Goeridae	10	9.9
	Perlidae	10	12.5		Lepidostomatidae	10	10.4
	Chloroperlidae	10	12.4		Brachycentridae	10	9.4
Damselflies	Platycnemidae	6	5.1		Sericostomatidae	10	9.2
	Coenagriidae	6	3.5	True flies	Tipulidae	5	5.5
	Lestidae	8	5.4		Chironomidae	2	3.7
	Calopterygidae	8	6.4		Simuliidae	5	5.8
Dragonflies	Gomphidae	8					
	Cordulegasteridae	8	8.6				
	Aeshnidae	8	6.1				
	Corduliidae	8					
	Libellulidae	8	5				

Appendix B - Photos of sampling sites

Table B *Photos of the sampling sites showing a general view of the stream site (right) and close up of the stream bed (left). Photographs shown were taken May 2012.*

Appendix C - Information on indices

Richness and Abundance

Although richness (number of different taxa) and abundance (number of individuals) can vary considerably depending on the habitat being surveyed, when compared to equivalent habitats these are useful as general and easily interpretable indicators of stream health. The indices also have some meaningful ecological significance. A higher richness score is taken to indicate a greater number of ecological 'niches' are available as would be the case in a physically complex habitat with a range of environmental conditions. A higher abundance score implies a larger area of habitat is available or that conditions are particularly suited to the family in question. Since an increase in habitat complexity and diversity would result in the space and resources available to each individual family decreasing, these indices are often inversely related to each other, especially when abundance is given as an average abundance per taxon.

Biological Monitoring Working Party (BMWP) score and Average Score Per Taxon (ASPT)

This method has been developed for stream samples and is based on the principle that different aquatic invertebrates have different tolerances to pollutants. Mayfly and Stonefly families generally have a low tolerance of pollution so tend to score high, whereas more tolerant species such as Oligochete worms and Dipterans (true-flies) such as Chironomidae are given low scores. The BMWP score equals the sum of the tolerance scores of all macroinvertebrate families in the sample. As a result the score reflects the sensitivity of the community to pollution. High community sensitivity (high BMWP score) is taken to indicate pollutants and pollution events in the stream occur at a low level, resulting in better water quality. A table of the standard tolerance scores has been included in Appendix A. This includes both the original scores developed in the 1980s and the revised scores developed when the index was recently modernised. It is best practise to use the revised scores. Original scores are also presented as they are more familiar to many people. Also presented are the categories and interpretation of the BMWP final score.

Table C *BMWP quality categories and their interpretation*

BMWP score	Category	Interpretation
0-10	Very poor	Heavily polluted
11-40	Poor	Polluted or impacted
41-70	Moderate	Moderately impacted
71-100	Good	Clean but slightly impacted
> 100	Very good	Unpolluted, unimpacted

The BMWP score can also be given as an Average Score Per Taxon (ASPT). The ASPT score indicates the average pollution sensitivity of the macroinvertebrate community. This means that the community richness (number of families) does not influence the final score. The score is therefore more resistant to variation in sampling effort and is able to differentiate between communities that have a few (high scoring) highly sensitive families and those with many (low scoring) pollution tolerant

families. The ASPT score equals the tolerance score (BMWP) divided by the number of families represented. A low ASPT score is obtained from streams that are heavily polluted and dominated by pollution-tolerant organisms.

Shannon's H (Diversity)

Although the ecological basis for diversity indices related to family abundance models remains uncertain, they have proved to be a useful tool in ecology for summarising community composition data into a single value allowing quick comparisons to be made between different samples. One of the most widely applied indices of this type is Shannon's H. High values of this index are achieved by communities in which many families contribute to the total number of individuals. Communities that contain very few taxa, or are dominated by large abundances of just a few families, are scored low by the index. As a result the index can be taken to indicate whether communities are supported by a complex and balanced habitat. The formula to calculate Shannon's H is shown below:

Equation 1 – Shannon's – –

Where H = Shannon's diversity index, S= number of taxa (e.g. families or species), n= the total number of individuals identified, n_i= the number of individuals in the sample belonging to the i^{th} taxon.

Non-metric multidimensional scaling

Non-metric multidimensional scaling (NMDS) is a means of visualizing the level of similarity of individual samples of a dataset, based on an underlying distance matrix (Bray-Curtis in this report). Therefore variance in composition of samples within and between years or treatments can be visually examined e.g. points plotted close together on plots have a similar species richness and abundance, whereas points plotted further apart encompass distinct species assemblages.

Appendix D - Species abundance tables for the sampling dates

Year	Sample	Section	Family	BMWP revised	Species	Abundance
2012	C1	Control	Planorbidae	2.9	*Ancylus fluviatilis*	1
2012	C1	Control	Baetidae	5.3	*Baetis muticus*	13
2012	C1	Control	Baetidae	5.3	*Baetis rhodani*	85
2012	C1	Control	Chironomidae	3.7	*Chironomidae spp.*	3
2012	C1	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	12
2012	C1	Control	Elmidae	6.4	*Elmis aenea*	10
2012	C1	Control	Empididae		*Empididae spp.*	1
2012	C1	Control	Gammaridae	4.5	*Gammarus pulex*	104
2012	C1	Control	Gyrinidae	7.8	*Gyrinus spp.*	1
2012	C1	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	18
2012	C1	Control	Leuctridae	9.9	*Leuctra hippopus.moselyi*	1
2012	C1	Control	Leuctridae	9.9	*Leuctra inermis*	6
2012	C1	Control	Limnephilidae	6.9	*Limnephilidae spp.*	13
2012	C1	Control	Elmidae	6.4	*Limnius volckmari*	7
2012	C1	Control	Limoniidae		*Limoniidae spp.*	1
2012	C1	Control	Lymnaeidae	3	*Lymnaea truncata*	27
2012	C1	Control	Muscidae		*Muscidae spp.*	2
2012	C1	Control	Nemouridae	9.1	*Nemoura cambrica.erratica*	1
2012	C1	Control	Oligochaeta	3.5	*Oligochaeta spp.*	2
2012	C1	Control	Elmidae	6.4	*Oulimnius spp.*	5
2012	C1	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	3
2012	C1	Control	Psychodidae		*Pericoma spp.*	1
2012	C1	Control	Perlidae	12.5	*Perla bipunctata*	7
2012	C1	Control	Polycentropodidae	8.6	*Plectrocnemia conspersa*	1
2012	C1	Control	Nemouridae	9.1	*Protonemura meyeri*	25
2012	C1	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	22
2012	C1	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	15
2012	C1	Control	Scirtidae	6.5	*Scirtidae spp.*	2
2012	C1	Control	Simulidae	5.8	*Simulidae spp.*	1
2014	C1	Control	Baetidae	5.3	*Baetis muticus*	1
2014	C1	Control	Baetidae	5.3	*Baetis rhodani*	17
2014	C1	Control	Ceratopogonidae		*Ceratopogonidae spp.*	1
2014	C1	Control	Chironomidae	3.7	*Chironomidae spp.*	9
2014	C1	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	11
2014	C1	Control	Elmidae	6.4	*Elmis aenea*	35
2014	C1	Control	Empididae		*Empididae spp.*	2
2014	C1	Control	Gammaridae	4.5	*Gammarus pulex*	82
2014	C1	Control	Glossosomatidae	7	*Glossosoma conformis.boltoni*	6
2014	C1	Control	Gyrinidae	7.8	*Gyrinus spp.*	8
2014	C1	Control	Hydraenidae		*Hydraena spp.*	2
2014	C1	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	9
2014	C1	Control	Hydropsychidae	6.6	*Hydropsyche siltalai*	27

2014	C1	Control	Hydroptilidae	6.7	*Hydroptilidae spp.*	3
2014	C1	Control	Perlodidae	10.7	*Isoperla grammatica*	3
2014	C1	Control	Elmidae	6.4	*Limnius volckmari*	3
2014	C1	Control	Lymnaeidae	3	*Lymnaea truncata*	200
2014	C1	Control	Oligochaeta	3.5	*Oligochaeta spp.*	46
2014	C1	Control	Elmidae	6.4	*Oulimnius spp.*	2
2014	C1	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	2
2014	C1	Control	Perlidae	12.5	*Perla bipunctata*	3
2014	C1	Control	Polycentropodidae	8.6	*Plectrocnemia conspersa*	2
2014	C1	Control	Nemouridae	9.1	*Protonemura meyeri*	13
2014	C1	Control	Lymnaeidae	3	*Radix balthica*	2
2014	C1	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	1
2014	C1	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	2
2014	C1	Control	Sericostomatidae	9.2	*Sericostoma personatum*	1
2014	C1	Control	Taeniopterygidae	10.8	*Taeniopteryx nebulosa*	3
2014	C1	Control	Tipulidae	5.5	*Tipulidae spp.*	1
2012	C2	Control	Nemouridae	9.1	*Amphinemura sulcicollis*	2
2012	C2	Control	Limnephilidae	6.9	*Anabolia nervosa*	2
2012	C2	Control	Planorbidae	2.9	*Ancylus fluviatilis*	5
2012	C2	Control	Baetidae	5.3	*Baetis muticus*	11
2012	C2	Control	Baetidae	5.3	*Baetis rhodani*	75
2012	C2	Control	Chironomidae	3.7	*Chironomidae spp.*	35
2012	C2	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	26
2012	C2	Control	Elmidae	6.4	*Elmis aenea*	28
2012	C2	Control	Empididae		*Empididae spp.*	1
2012	C2	Control	Gammaridae	4.5	*Gammarus pulex*	300
2012	C2	Control	Glossiphoniidae	3.1	*Glossiphonia complanata*	1
2012	C2	Control	Gyrinidae	7.8	*Gyrinus spp.*	6
2012	C2	Control	Hydrophilidae	5.1	*Hydrobius fuscipes*	3
2012	C2	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	102
2012	C2	Control	Perlodidae	10.7	*Isoperla grammatica*	8
2012	C2	Control	Leptoceridae	7.8	*Leptoceridae spp.*	2
2012	C2	Control	Leuctridae	9.9	*Leuctra inermis*	9
2012	C2	Control	Limnephilidae	6.9	*Limnephilidae spp.*	8
2012	C2	Control	Elmidae	6.4	*Limnius volckmari*	45
2012	C2	Control	Limoniidae		*Limoniidae spp.*	8
2012	C2	Control	Lymnaeidae	3	*Lymnaea truncata*	200
2012	C2	Control	Muscidae		*Muscidae spp.*	3
2012	C2	Control	Oligochaeta	3.5	*Oligochaeta spp.*	48
2012	C2	Control	Elmidae	6.4	*Oulimnius spp.*	40
2012	C2	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	9
2012	C2	Control	Pediciidae		*Pediciidae spp.*	2
2012	C2	Control	Psychodidae		*Pericoma spp.*	1
2012	C2	Control	Perlidae	12.5	*Perla bipunctata*	2

2012	C2	Control	Polycentropodidae	8.6	*Plectrocnemia conspersa*	2
2012	C2	Control	Limnephilidae	6.9	*Potamophylax latipennis*	2
2012	C2	Control	Nemouridae	9.1	*Protonemura meyeri*	76
2012	C2	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	38
2012	C2	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	14
2012	C2	Control	Sericostomatidae	9.2	*Sericostoma personatum*	5
2012	C2	Control	Simulidae	5.8	*Simulidae spp.*	9
2012	C2	Control	Sphaeriidae	3.6	*Sphaeriidae spp.*	2
2012	C2	Control	Tabanidae		*Tabanidae spp.*	6
2012	C2	Control	Tipulidae	5.5	*Tipulidae spp.*	2
2014	C2	Control	Baetidae	5.3	*Baetis muticus*	31
2014	C2	Control	Baetidae	5.3	*Baetis rhodani*	20
2014	C2	Control	Chironomidae	3.7	*Chironomidae spp.*	22
2014	C2	Control	Chloroperlidae	12.4	*Chloroperla torrentium*	1
2014	C2	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	9
2014	C2	Control	Elmidae	6.4	*Elmis aenea*	45
2014	C2	Control	Empididae		*Empididae spp.*	3
2014	C2	Control	Gammaridae	4.5	*Gammarus pulex*	114
2014	C2	Control	Glossiphoniidae	3.1	*Glossiphonia complanata*	1
2014	C2	Control	Glossosomatidae	7	*Glossosoma conformis.boltoni*	15
2014	C2	Control	Gyrinidae	7.8	*Gyrinus spp.*	5
2014	C2	Control	Hydraenidae		*Hydraena spp.*	1
2014	C2	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	7
2014	C2	Control	Hydroptilidae	6.7	*Hydroptilidae spp.*	2
2014	C2	Control	Perlodidae	10.7	*Isoperla grammatica*	13
2014	C2	Control	Leptoceridae	7.8	*Leptoceridae spp.*	1
2014	C2	Control	Elmidae	6.4	*Limnius volckmari*	14
2014	C2	Control	Limoniidae		*Limoniidae spp.*	3
2014	C2	Control	Lymnaeidae	3	*Lymnaea truncata*	400
2014	C2	Control	Oligochaeta	3.5	*Oligochaeta spp.*	36
2014	C2	Control	Elmidae	6.4	*Oulimnius spp.*	8
2014	C2	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	4
2014	C2	Control	Perlidae	12.5	*Perla bipunctata*	2
2014	C2	Control	Polycentropodidae	8.6	*Plectrocnemia conspersa*	3
2014	C2	Control	Nemouridae	9.1	*Protonemura meyeri*	28
2014	C2	Control	Lymnaeidae	3	*Radix balthica*	1
2014	C2	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	5
2014	C2	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	11
2014	C2	Control	Sericostomatidae	9.2	*Sericostoma personatum*	8
2014	C2	Control	Taeniopterygidae	10.8	*Taeniopteryx nebulosa*	3
2012	C3	Control	Nemouridae	9.1	*Amphinemura sulcicollis*	1
2012	C3	Control	Planorbidae	2.9	*Ancylus fluviatilis*	6
2012	C3	Control	Baetidae	5.3	*Baetis muticus*	2
2012	C3	Control	Baetidae	5.3	*Baetis rhodani*	56

2012	C3	Control	Chironomidae	3.7	*Chironomidae spp.*	20
2012	C3	Control	Chloroperlidae	12.4	*Chloroperla tripunctata*	1
2012	C3	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	7
2012	C3	Control	Elmidae	6.4	*Elmis aenea*	21
2012	C3	Control	Empididae		*Empididae spp.*	5
2012	C3	Control	Gammaridae	4.5	*Gammarus pulex*	23
2012	C3	Control	Glossiphoniidae	3.1	*Glossiphonia complanata*	1
2012	C3	Control	Gyrinidae	7.8	*Gyrinus spp.*	5
2012	C3	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	51
2012	C3	Control	Hydropsychidae	6.6	*Hydropsyche siltalai*	5
2012	C3	Control	Perlodidae	10.7	*Isoperla grammatica*	3
2012	C3	Control	Leuctridae	9.9	*Leuctra inermis*	2
2012	C3	Control	Leuctridae	9.9	*Leuctra nigra*	1
2012	C3	Control	Limnephilidae	6.9	*Limnephilidae spp.*	1
2012	C3	Control	Elmidae	6.4	*Limnius volckmari*	91
2012	C3	Control	Limoniidae		*Limoniidae spp.*	8
2012	C3	Control	Lymnaeidae	3	*Lymnaea truncata*	53
2012	C3	Control	Oligochaeta	3.5	*Oligochaeta spp.*	9
2012	C3	Control	Elmidae	6.4	*Oulimnius spp.*	31
2012	C3	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	3
2012	C3	Control	Pediciidae		*Pediciidae spp.*	6
2012	C3	Control	Perlidae	12.5	*Perla bipunctata*	3
2012	C3	Control	Polycentropodidae	8.6	*Plectrocnemia conspersa*	1
2012	C3	Control	Nemouridae	9.1	*Protonemura meyeri*	20
2012	C3	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	9
2012	C3	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	24
2012	C3	Control	Goeridae	9.9	*Silo pallipes*	1
2012	C3	Control	Simulidae	5.8	*Simulidae spp.*	3
2012	C3	Control	Tipulidae	5.5	*Tipulidae spp.*	1
2014	C3	Control	Baetidae	5.3	*Baetis muticus*	3
2014	C3	Control	Baetidae	5.3	*Baetis rhodani*	9
2014	C3	Control	Chironomidae	3.7	*Chironomidae spp.*	20
2014	C3	Control	Chloroperlidae	12.4	*Chloroperla torrentium*	1
2014	C3	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	13
2014	C3	Control	Elmidae	6.4	*Elmis aenea*	35
2014	C3	Control	Empididae		*Empididae spp.*	2
2014	C3	Control	Gammaridae	4.5	*Gammarus pulex*	21
2014	C3	Control	Glossiphoniidae	3.1	*Glossiphonia complanata*	1
2014	C3	Control	Glossosomatidae	7	*Glossosoma conformis.boltoni*	13
2014	C3	Control	Gyrinidae	7.8	*Gyrinus spp.*	13
2014	C3	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	28
2014	C3	Control	Hydropsychidae	6.6	*Hydropsyche siltalai*	17
2014	C3	Control	Hydroptilidae	6.7	*Hydroptilidae spp.*	5
2014	C3	Control	Perlodidae	10.7	*Isoperla grammatica*	3

2014	C3	Control	Leptoceridae	7.8	*Leptoceridae spp.*	1
2014	C3	Control	Elmidae	6.4	*Limnius volckmari*	61
2014	C3	Control	Limoniidae		*Limoniidae spp.*	8
2014	C3	Control	Lymnaeidae	3	*Lymnaea truncata*	150
2014	C3	Control	Oligochaeta	3.5	*Oligochaeta spp.*	3
2014	C3	Control	Elmidae	6.4	*Oulimnius spp.*	41
2014	C3	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	1
2014	C3	Control	Pediciidae		*Pediciidae spp.*	3
2014	C3	Control	Perlidae	12.5	*Perla bipunctata*	1
2014	C3	Control	Nemouridae	9.1	*Protonemura meyeri*	7
2014	C3	Control	Lymnaeidae	3	*Radix balthica*	6
2014	C3	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	7
2014	C3	Control	Sericostomatidae	9.2	*Sericostoma personatum*	9
2014	C3	Control	Simulidae	5.8	*Simulidae spp.*	1
2014	C3	Control	Taeniopterygidae	10.8	*Taeniopteryx nebulosa*	3
2014	C3	Control	Tipulidae	5.5	*Tipulidae spp.*	2
2012	C4	Control	Baetidae	5.3	*Baetis muticus*	1
2012	C4	Control	Baetidae	5.3	*Baetis rhodani*	64
2012	C4	Control	Limnephilidae	6.9	*Chaetopteryx villosa*	1
2012	C4	Control	Chironomidae	3.7	*Chironomidae spp.*	12
2012	C4	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	8
2012	C4	Control	Elmidae	6.4	*Elmis aenea*	49
2012	C4	Control	Empididae		*Empididae spp.*	6
2012	C4	Control	Gammaridae	4.5	*Gammarus pulex*	36
2012	C4	Control	Glossiphoniidae	3.1	*Glossiphonia complanata*	1
2012	C4	Control	Gyrinidae	7.8	*Gyrinus spp.*	5
2012	C4	Control	Hydrophilidae	5.1	*Hydrobius fuscipes*	1
2012	C4	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	116
2012	C4	Control	Hydropsychidae	6.6	*Hydropsyche siltalai*	57
2012	C4	Control	Perlodidae	10.7	*Isoperla grammatica*	1
2012	C4	Control	Leuctridae	9.9	*Leuctra inermis*	2
2012	C4	Control	Limnephilidae	6.9	*Limnephilidae spp.*	1
2012	C4	Control	Limnephilidae	6.9	*Limnephilus rhomicus*	1
2012	C4	Control	Elmidae	6.4	*Limnius volckmari*	207
2012	C4	Control	Limoniidae		*Limoniidae spp.*	29
2012	C4	Control	Lymnaeidae	3	*Lymnaea truncata*	600
2012	C4	Control	Oligochaeta	3.5	*Oligochaeta spp.*	18
2012	C4	Control	Elmidae	6.4	*Oulimnius spp.*	27
2012	C4	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	5
2012	C4	Control	Perlidae	12.5	*Perla bipunctata*	9
2012	C4	Control	Nemouridae	9.1	*Protonemura meyeri*	36
2012	C4	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	38
2012	C4	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	1
2012	C4	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	18

2012	C4	Control	Sericostomatidae	9.2	*Sericostoma personatum*	1
2012	C4	Control	Goeridae	9.9	*Silo pallipes*	1
2012	C4	Control	Simulidae	5.8	*Simulidae spp.*	12
2012	C4	Control	Tabanidae		*Tabanidae spp.*	2
2012	C4	Control	Tipulidae	5.5	*Tipulidae spp.*	3
2014	C4	Control	Athericidae		*Athericidae spp.*	3
2014	C4	Control	Baetidae	5.3	*Baetis muticus*	8
2014	C4	Control	Baetidae	5.3	*Baetis rhodani*	18
2014	C4	Control	Brachycentridae	9.4	*Brachycentrus subnubilus*	1
2014	C4	Control	Chironomidae	3.7	*Chironomidae spp.*	12
2014	C4	Control	Chloroperlidae	12.4	*Chloroperla tripunctata*	1
2014	C4	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	12
2014	C4	Control	Elmidae	6.4	*Elmis aenea*	53
2014	C4	Control	Empididae		*Empididae spp.*	1
2014	C4	Control	Gammaridae	4.5	*Gammarus pulex*	32
2014	C4	Control	Glossosomatidae	7	*Glossosoma conformis.boltoni*	50
2014	C4	Control	Gyrinidae	7.8	*Gyrinus spp.*	27
2014	C4	Control	Hapliplidae	4	*Haliplidae spp.*	4
2014	C4	Control	Hydraenidae		*Hydraena spp.*	4
2014	C4	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	90
2014	C4	Control	Hydropsychidae	6.6	*Hydropsyche siltalai*	39
2014	C4	Control	Hydroptilidae	6.7	*Hydroptilidae spp.*	1
2014	C4	Control	Perlodidae	10.7	*Isoperla grammatica*	3
2014	C4	Control	Leptoceridae	7.8	*Leptoceridae spp.*	1
2014	C4	Control	Limnephilidae	6.9	*Limnephilidae spp.*	2
2014	C4	Control	Elmidae	6.4	*Limnius volckmari*	86
2014	C4	Control	Limoniidae		*Limoniidae spp.*	28
2014	C4	Control	Lymnaeidae	3	*Lymnaea truncata*	300
2014	C4	Control	Muscidae		*Muscidae spp.*	1
2014	C4	Control	Oligochaeta	3.5	*Oligochaeta spp.*	14
2014	C4	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	2
2014	C4	Control	Pediciidae		*Pediciidae spp.*	4
2014	C4	Control	Perlidae	12.5	*Perla bipunctata*	28
2014	C4	Control	Polycentropodidae	8.6	*Plectrocnemia conspersa*	1
2014	C4	Control	Nemouridae	9.1	*Protonemura meyeri*	23
2014	C4	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	7
2014	C4	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	5
2014	C4	Control	Sericostomatidae	9.2	*Sericostoma personatum*	19
2014	C4	Control	Simulidae	5.8	*Simulidae spp.*	3
2014	C4	Control	Sphaeriidae	3.6	*Sphaeriidae spp.*	1
2014	C4	Control	Tabanidae		*Tabanidae spp.*	8
2014	C4	Control	Taeniopterygidae	10.8	*Taeniopteryx nebulosa*	6
2014	C4	Control	Tipulidae	5.5	*Tipulidae spp.*	6
2012	R1	Realignment	Baetidae	5.3	*Baetis rhodani*	20

2012	R1	Realignment	Chironomidae	3.7	*Chironomidae spp.*	4
2012	R1	Realignment	Heptageniidae	9.8	*Ecdyonurus torrentis*	3
2012	R1	Realignment	Elmidae	6.4	*Elmis aenea*	2
2012	R1	Realignment	Gammaridae	4.5	*Gammarus pulex*	6
2012	R1	Realignment	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	14
2012	R1	Realignment	Perlodidae	10.7	*Isoperla grammatica*	1
2012	R1	Realignment	Limnephilidae	6.9	*Limnephilidae spp.*	5
2012	R1	Realignment	Elmidae	6.4	*Limnius volckmari*	1
2012	R1	Realignment	Limoniidae		*Limoniidae spp.*	1
2012	R1	Realignment	Oligochaeta	3.5	*Oligochaeta spp.*	2
2012	R1	Realignment	Polycentropodidae	8.6	*Plectrocnemia conspersa*	1
2012	R1	Realignment	Heptageniidae	9.8	*Rhithrogena semicolorata*	46
2012	R1	Realignment	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	1
2012	R1	Realignment	Simulidae	5.8	*Simulidae spp.*	1
2012	R1	Realignment	Tipulidae	5.5	*Tipulidae spp.*	2
2014	R1	Realignment	Planorbidae	2.9	*Ancylus fluviatilis*	1
2014	R1	Realignment	Athericidae		*Athericidae spp.*	2
2014	R1	Realignment	Baetidae	5.3	*Baetis muticus*	1
2014	R1	Realignment	Baetidae	5.3	*Baetis rhodani*	19
2014	R1	Realignment	Chironomidae	3.7	*Chironomidae spp.*	5
2014	R1	Realignment	Heptageniidae	9.8	*Ecdyonurus torrentis*	10
2014	R1	Realignment	Elmidae	6.4	*Elmis aenea*	24
2014	R1	Realignment	Empididae		*Empididae spp.*	10
2014	R1	Realignment	Gammaridae	4.5	*Gammarus pulex*	11
2014	R1	Realignment	Glossiphoniidae	3.1	*Glossiphonia complanata*	1
2014	R1	Realignment	Glossosomatidae	7	*Glossosoma conformis.boltoni*	8
2014	R1	Realignment	Gyrinidae	7.8	*Gyrinus spp.*	4
2014	R1	Realignment	Hydraenidae		*Hydraena spp.*	1
2014	R1	Realignment	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	21
2014	R1	Realignment	Hydropsychidae	6.6	*Hydropsyche siltalai*	3
2014	R1	Realignment	Hydroptilidae	6.7	*Hydroptilidae spp.*	3
2014	R1	Realignment	Perlodidae	10.7	*Isoperla grammatica*	1
2014	R1	Realignment	Elmidae	6.4	*Limnius volckmari*	26
2014	R1	Realignment	Limoniidae		*Limoniidae spp.*	4
2014	R1	Realignment	Lymnaeidae	3	*Lymnaea truncata*	19
2014	R1	Realignment	Oligochaeta	3.5	*Oligochaeta spp.*	15
2014	R1	Realignment	Elmidae	6.4	*Oulimnius spp.*	35
2014	R1	Realignment	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	4
2014	R1	Realignment	Pediciidae		*Pediciidae spp.*	1
2014	R1	Realignment	Perlidae	12.5	*Perla bipunctata*	13
2014	R1	Realignment	Polycentropodidae	8.6	*Plectrocnemia conspersa*	1
2014	R1	Realignment	Nemouridae	9.1	*Protonemura meyeri*	1
2014	R1	Realignment	Lymnaeidae	3	*Radix balthica*	1
2014	R1	Realignment	Heptageniidae	9.8	*Rhithrogena semicolorata*	7

2014	R1	Realignment	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	2
2014	R1	Realignment	Sericostomatidae	9.2	*Sericostoma personatum*	5
2014	R1	Realignment	Tabanidae		*Tabanidae spp.*	1
2014	R1	Realignment	Tipulidae	5.5	*Tipulidae spp.*	2
2012	R2	Realignment	Planorbidae	2.9	*Ancylus fluviatilis*	1
2012	R2	Realignment	Baetidae	5.3	*Baetis muticus*	5
2012	R2	Realignment	Baetidae	5.3	*Baetis rhodani*	56
2012	R2	Realignment	Corixidae	3.7	*Callicorixa praeusta*	1
2012	R2	Realignment	Ceratopogonidae		*Ceratopogonidae spp.*	3
2012	R2	Realignment	Chironomidae	3.7	*Chironomidae spp.*	37
2012	R2	Realignment	Heptageniidae	9.8	*Ecdyonurus torrentis*	19
2012	R2	Realignment	Elmidae	6.4	*Elmis aenea*	1
2012	R2	Realignment	Gammaridae	4.5	*Gammarus pulex*	14
2012	R2	Realignment	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	21
2012	R2	Realignment	Dytiscidae	4.8	*Ilybius spp.*	1
2012	R2	Realignment	Limnephilidae	6.9	*Limnephilidae spp.*	3
2012	R2	Realignment	Limnephilidae	6.9	*Limnephilus rhomicus*	2
2012	R2	Realignment	Lymnaeidae	3	*Lymnaea truncata*	1
2012	R2	Realignment	Oligochaeta	3.5	*Oligochaeta spp.*	3
2012	R2	Realignment	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	12
2012	R2	Realignment	Pediciidae		*Pediciidae spp.*	2
2012	R2	Realignment	Perlidae	12.5	*Perla bipunctata*	3
2012	R2	Realignment	Dytiscidae	4.8	*Platambus maculatus*	2
2012	R2	Realignment	Limnephilidae	6.9	*Potamophylax latipennis*	2
2012	R2	Realignment	Nemouridae	9.1	*Protonemura meyeri*	4
2012	R2	Realignment	Heptageniidae	9.8	*Rhithrogena semicolorata*	107
2012	R2	Realignment	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	4
2012	R2	Realignment	Simulidae	5.8	*Simulidae spp.*	2
2012	R2	Realignment	Sphaeriidae	3.6	*Sphaeriidae spp.*	1
2012	R2	Realignment	Tipulidae	5.5	*Tipulidae spp.*	2
2014	R2	Realignment	Baetidae	5.3	*Baetis muticus*	1
2014	R2	Realignment	Baetidae	5.3	*Baetis rhodani*	5
2014	R2	Realignment	Chironomidae	3.7	*Chironomidae spp.*	10
2014	R2	Realignment	Heptageniidae	9.8	*Ecdyonurus torrentis*	56
2014	R2	Realignment	Elmidae	6.4	*Elmis aenea*	13
2014	R2	Realignment	Empididae		*Empididae spp.*	3
2014	R2	Realignment	Gammaridae	4.5	*Gammarus pulex*	17
2014	R2	Realignment	Glossosomatidae	7	*Glossosoma conformis.boltoni*	1
2014	R2	Realignment	Gyrinidae	7.8	*Gyrinus spp.*	2
2014	R2	Realignment	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	19
2014	R2	Realignment	Hydropsychidae	6.6	*Hydropsyche siltalai*	3
2014	R2	Realignment	Hydroptilidae	6.7	*Hydroptilidae spp.*	2
2014	R2	Realignment	Lepidostomatidae	10.4	*Lepidostoma hirtum*	5
2014	R2	Realignment	Leptoceridae	7.8	*Leptoceridae spp.*	1

2014	R2	Realignment	Elmidae	6.4	*Limnius volckmari*	26
2014	R2	Realignment	Limoniidae		*Limoniidae spp.*	2
2014	R2	Realignment	Lymnaeidae	3	*Lymnaea truncata*	29
2014	R2	Realignment	Oligochaeta	3.5	*Oligochaeta spp.*	2
2014	R2	Realignment	Elmidae	6.4	*Oulimnius spp.*	15
2014	R2	Realignment	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	15
2014	R2	Realignment	Pediciidae		*Pediciidae spp.*	2
2014	R2	Realignment	Perlidae	12.5	*Perla bipunctata*	8
2014	R2	Realignment	Polycentropodidae	8.6	*Plectrocnemia conspersa*	3
2014	R2	Realignment	Lymnaeidae	3	*Radix balthica*	1
2014	R2	Realignment	Heptageniidae	9.8	*Rhithrogena semicolorata*	1
2014	R2	Realignment	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	3
2014	R2	Realignment	Sericostomatidae	9.2	*Sericostoma personatum*	1
2014	R2	Realignment	Taeniopterygidae	10.8	*Taeniopteryx nebulosa*	1
2012	R3	Realignment	Baetidae	5.3	*Baetis muticus*	1
2012	R3	Realignment	Baetidae	5.3	*Baetis rhodani*	33
2012	R3	Realignment	Brachycentridae	9.4	*Brachycentrus subnubilus*	1
2012	R3	Realignment	Ceratopogonidae		*Ceratopogonidae spp.*	1
2012	R3	Realignment	Chironomidae	3.7	*Chironomidae spp.*	25
2012	R3	Realignment	Heptageniidae	9.8	*Ecdyonurus torrentis*	17
2012	R3	Realignment	Elmidae	6.4	*Elmis aenea*	3
2012	R3	Realignment	Empididae		*Empididae spp.*	1
2012	R3	Realignment	Gammaridae	4.5	*Gammarus pulex*	35
2012	R3	Realignment	Limnephilidae	6.9	*Halesus radiatus.digitatus*	1
2012	R3	Realignment	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	25
2012	R3	Realignment	Limnephilidae	6.9	*Limnephilidae spp.*	3
2012	R3	Realignment	Limnephilidae	6.9	*Limnephilidae spp.*	7
2012	R3	Realignment	Elmidae	6.4	*Limnius volckmari*	1
2012	R3	Realignment	Limoniidae		*Limoniidae spp.*	1
2012	R3	Realignment	Lymnaeidae	3	*Lymnaea truncata*	3
2012	R3	Realignment	Nemouridae	9.1	*Nemoura cambrica.erratica*	2
2012	R3	Realignment	Oligochaeta	3.5	*Oligochaeta spp.*	16
2012	R3	Realignment	Elmidae	6.4	*Oulimnius spp.*	1
2012	R3	Realignment	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	7
2012	R3	Realignment	Pediciidae		*Pediciidae spp.*	1
2012	R3	Realignment	Perlodidae	10.7	*Perlodes mortoni*	2
2012	R3	Realignment	Limnephilidae	6.9	*Potamophylax latipennis*	4
2012	R3	Realignment	Limnephilidae	6.9	*Potamophylax latipennis*	4
2012	R3	Realignment	Nemouridae	9.1	*Protonemura meyeri*	1
2012	R3	Realignment	Heptageniidae	9.8	*Rhithrogena semicolorata*	30
2012	R3	Realignment	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	1
2012	R3	Realignment	Sericostomatidae	9.2	*Sericostoma personatum*	3
2012	R3	Realignment	Sialidae	4.5	*Sialis lutaria*	2
2012	R3	Realignment	Simulidae	5.8	*Simulidae spp.*	1

2012	R3	Realignment	Tipulidae	5.5	*Tipulidae spp.*	4
2014	R3	Realignment	Planorbidae	2.9	*Ancylus fluviatilis*	1
2014	R3	Realignment	Baetidae	5.3	*Baetis rhodani*	13
2014	R3	Realignment	Chironomidae	3.7	*Chironomidae spp.*	6
2014	R3	Realignment	Heptageniidae	9.8	*Ecdyonurus torrentis*	17
2014	R3	Realignment	Elmidae	6.4	*Elmis aenea*	29
2014	R3	Realignment	Empididae		*Empididae spp.*	4
2014	R3	Realignment	Gammaridae	4.5	*Gammarus pulex*	11
2014	R3	Realignment	Glossosomatidae	7	*Glossosoma conformis.boltoni*	40
2014	R3	Realignment	Gyrinidae	7.8	*Gyrinus spp.*	4
2014	R3	Realignment	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	37
2014	R3	Realignment	Hydropsychidae	6.6	*Hydropsyche siltalai*	6
2014	R3	Realignment	Hydroptilidae	6.7	*Hydroptilidae spp.*	3
2014	R3	Realignment	Elmidae	6.4	*Limnius volckmari*	46
2014	R3	Realignment	Limoniidae		*Limoniidae spp.*	25
2014	R3	Realignment	Lymnaeidae	3	*Lymnaea truncata*	200
2014	R3	Realignment	Oligochaeta	3.5	*Oligochaeta spp.*	3
2014	R3	Realignment	Elmidae	6.4	*Oulimnius spp.*	29
2014	R3	Realignment	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	4
2014	R3	Realignment	Pediciidae		*Pediciidae spp.*	1
2014	R3	Realignment	Perlidae	12.5	*Perla bipunctata*	8
2014	R3	Realignment	Perlodidae	10.7	*Perlodes mortoni*	3
2014	R3	Realignment	Polycentropodidae	8.6	*Plectrocnemia conspersa*	3
2014	R3	Realignment	Nemouridae	9.1	*Protonemura meyeri*	2
2014	R3	Realignment	Lymnaeidae	3	*Radix balthica*	3
2014	R3	Realignment	Heptageniidae	9.8	*Rhithrogena semicolorata*	15
2014	R3	Realignment	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	4
2014	R3	Realignment	Scirtidae	6.5	*Scirtidae spp.*	1
2014	R3	Realignment	Sericostomatidae	9.2	*Sericostoma personatum*	12
2014	R3	Realignment	Sphaeriidae	3.6	*Sphaeriidae spp.*	2
2014	R3	Realignment	Tabanidae		*Tabanidae spp.*	2
2014	R3	Realignment	Taeniopterygidae	10.8	*Taeniopteryx nebulosa*	1
2014	XC1	Control	Nemouridae	9.1	*Amphinemura sulcicollis*	1
2014	XC1	Control	Baetidae	5.3	*Baetis muticus*	4
2014	XC1	Control	Baetidae	5.3	*Baetis rhodani*	4
2014	XC1	Control	Chloroperlidae	12.4	*Chloroperla torrentium*	1
2014	XC1	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	18
2014	XC1	Control	Elmidae	6.4	*Elmis aenea*	33
2014	XC1	Control	Gammaridae	4.5	*Gammarus pulex*	20
2014	XC1	Control	Gyrinidae	7.8	*Gyrinus spp.*	1
2014	XC1	Control	Hydraenidae		*Hydraena spp.*	3
2014	XC1	Control	Hydropsychidae	6.6	*Hydropsyche siltalai*	1
2014	XC1	Control	Perlodidae	10.7	*Isoperla grammatica*	1
2014	XC1	Control	Leuctridae	9.9	*Leuctra inermis*	1

2014	XC1	Control	Elmidae	6.4	*Limnius volckmari*	47
2014	XC1	Control	Limoniidae		*Limoniidae spp.*	24
2014	XC1	Control	Lymnaeidae	3	*Lymnaea truncata*	300
2014	XC1	Control	Oligochaeta	3.5	*Oligochaeta spp.*	1
2014	XC1	Control	Oligochaeta	3.5	*Oligochaeta spp.*	1
2014	XC1	Control	Elmidae	6.4	*Oulimnius spp.*	11
2014	XC1	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	2
2014	XC1	Control	Pediciidae		*Pediciidae spp.*	3
2014	XC1	Control	Perlidae	12.5	*Perla bipunctata*	11
2014	XC1	Control	Perlodidae	10.7	*Perlodes mortoni*	1
2014	XC1	Control	Nemouridae	9.1	*Protonemura meyeri*	39
2014	XC1	Control	Lymnaeidae	3	*Radix balthica*	2
2014	XC1	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	17
2014	XC1	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	1
2014	XC1	Control	Sericostomatidae	9.2	*Sericostoma personatum*	2
2014	XC1	Control	Simulidae	5.8	*Simulidae spp.*	1
2014	XC1	Control	Tipulidae	5.5	*Tipulidae spp.*	1
2014	XC2	Control	Planorbidae	2.9	*Ancylus fluviatilis*	1
2014	XC2	Control	Athericidae		*Athericidae spp.*	5
2014	XC2	Control	Baetidae	5.3	*Baetis rhodani*	13
2014	XC2	Control	Chironomidae	3.7	*Chironomidae spp.*	3
2014	XC2	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	14
2014	XC2	Control	Elmidae	6.4	*Elmis aenea*	6
2014	XC2	Control	Empididae		*Empididae spp.*	1
2014	XC2	Control	Gammaridae	4.5	*Gammarus pulex*	4
2014	XC2	Control	Glossosomatidae	7	*Glossosoma conformis.boltoni*	2
2014	XC2	Control	Hydraenidae		*Hydraena spp.*	3
2014	XC2	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	1
2014	XC2	Control	Hydropsychidae	6.6	*Hydropsyche siltalai*	3
2014	XC2	Control	Hydroptilidae	6.7	*Hydroptilidae spp.*	1
2014	XC2	Control	Leptoceridae	7.8	*Leptoceridae spp.*	2
2014	XC2	Control	Elmidae	6.4	*Limnius volckmari*	31
2014	XC2	Control	Limoniidae		*Limoniidae spp.*	3
2014	XC2	Control	Lymnaeidae	3	*Lymnaea truncata*	15
2014	XC2	Control	Oligochaeta	3.5	*Oligochaeta spp.*	1
2014	XC2	Control	Elmidae	6.4	*Oulimnius spp.*	12
2014	XC2	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	3
2014	XC2	Control	Pediciidae		*Pediciidae spp.*	2
2014	XC2	Control	Perlidae	12.5	*Perla bipunctata*	2
2014	XC2	Control	Nemouridae	9.1	*Protonemura meyeri*	12
2014	XC2	Control	Lymnaeidae	3	*Radix balthica*	6
2014	XC2	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	15
2014	XC2	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	1
2014	XC2	Control	Sericostomatidae	9.2	*Sericostoma personatum*	3

2014	XC2	Control	Tabanidae		*Tabanidae spp.*	1
2014	XC3	Control	Athericidae		*Athericidae spp.*	4
2014	XC3	Control	Baetidae	5.3	*Baetis rhodani*	3
2014	XC3	Control	Caenidae	7.1	*Caenis rivulorum*	1
2014	XC3	Control	Ceratopogonidae		*Ceratopogonidae spp.*	2
2014	XC3	Control	Chironomidae	3.7	*Chironomidae spp.*	11
2014	XC3	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	10
2014	XC3	Control	Elmidae	6.4	*Elmis aenea*	52
2014	XC3	Control	Gammaridae	4.5	*Gammarus pulex*	2
2014	XC3	Control	Glossiphoniidae	3.1	*Glossiphonia complanata*	1
2014	XC3	Control	Hydraenidae		*Hydraena spp.*	1
2014	XC3	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	7
2014	XC3	Control	Hydropsychidae	6.6	*Hydropsyche siltalai*	3
2014	XC3	Control	Hydroptilidae	6.7	*Hydroptilidae spp.*	1
2014	XC3	Control	Lepidostomatidae	10.4	*Lepidostoma hirtum*	8
2014	XC3	Control	Leuctridae	9.9	*Leuctra hippopus.moselyi*	1
2014	XC3	Control	Limnephilidae	6.9	*Limnephilidae spp.*	4
2014	XC3	Control	Elmidae	6.4	*Limnius volckmari*	18
2014	XC3	Control	Limoniidae		*Limoniidae spp.*	4
2014	XC3	Control	Lymnaeidae	3	*Lymnaea truncata*	48
2014	XC3	Control	Oligochaeta	3.5	*Oligochaeta spp.*	11
2014	XC3	Control	Elmidae	6.4	*Oulimnius spp.*	23
2014	XC3	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	23
2014	XC3	Control	Pediciidae		*Pediciidae spp.*	1
2014	XC3	Control	Dytiscidae	4.8	*Platambus maculatus*	1
2014	XC3	Control	Polycentropodidae	8.6	*Plectrocnemia conspersa*	12
2014	XC3	Control	Nemouridae	9.1	*Protonemura meyeri*	1
2014	XC3	Control	Lymnaeidae	3	*Radix balthica*	1
2014	XC3	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	5
2014	XC3	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	2
2014	XC3	Control	Sericostomatidae	9.2	*Sericostoma personatum*	4
2014	XC3	Control	Simulidae	5.8	*Simulidae spp.*	5
2014	XC3	Control	Taeniopterygidae	10.8	*Taeniopteryx nebulosa*	2
2014	XC4	Control	Nemouridae	9.1	*Amphinemura sulcicollis*	6
2014	XC4	Control	Planorbidae	2.9	*Ancylus fluviatilis*	2
2014	XC4	Control	Athericidae		*Athericidae spp.*	29
2014	XC4	Control	Baetidae	5.3	*Baetis rhodani*	31
2014	XC4	Control	Chironomidae	3.7	*Chironomidae spp.*	18
2014	XC4	Control	Heptageniidae	9.8	*Ecdyonurus torrentis*	8
2014	XC4	Control	Elmidae	6.4	*Elmis aenea*	26
2014	XC4	Control	Empididae		*Empididae spp.*	1
2014	XC4	Control	Gammaridae	4.5	*Gammarus pulex*	38
2014	XC4	Control	Glossosomatidae	7	*Glossosoma conformis.boltoni*	1
2014	XC4	Control	Gyrinidae	7.8	*Gyrinus spp.*	3

2014	XC4	Control	Hydraenidae		*Hydraena spp.*	1
2014	XC4	Control	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	6
2014	XC4	Control	Hydropsychidae	6.6	*Hydropsyche siltalai*	55
2014	XC4	Control	Perlodidae	10.7	*Isoperla grammatica*	3
2014	XC4	Control	Leptoceridae	7.8	*Leptoceridae spp.*	6
2014	XC4	Control	Leuctridae	9.9	*Leuctra hippopus.moselyi*	2
2014	XC4	Control	Leuctridae	9.9	*Leuctra inermis*	2
2014	XC4	Control	Limnephilidae	6.9	*Limnephilidae spp.*	8
2014	XC4	Control	Elmidae	6.4	*Limnius volckmari*	191
2014	XC4	Control	Limoniidae		*Limoniidae spp.*	10
2014	XC4	Control	Lymnaeidae	3	*Lymnaea truncata*	200
2014	XC4	Control	Oligochaeta	3.5	*Oligochaeta spp.*	7
2014	XC4	Control	Elmidae	6.4	*Oulimnius spp.*	36
2014	XC4	Control	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	6
2014	XC4	Control	Perlidae	12.5	*Perla bipunctata*	5
2014	XC4	Control	Polycentropodidae	8.6	*Plectrocnemia conspersa*	2
2014	XC4	Control	Nemouridae	9.1	*Protonemura meyeri*	35
2014	XC4	Control	Lymnaeidae	3	*Radix balthica*	5
2014	XC4	Control	Heptageniidae	9.8	*Rhithrogena semicolorata*	11
2014	XC4	Control	Rhyacophilidae	8.3	*Rhyacophila dorsalis*	9
2014	XC4	Control	Sericostomatidae	9.2	*Sericostoma personatum*	4
2014	XC4	Control	Ephemerellidae	7.7	*Serratella ignita*	1
2014	XC4	Control	Simulidae	5.8	*Simulidae spp.*	1
2014	XC4	Control	Taeniopterygidae	10.8	*Taeniopteryx nebulosa*	4
2014	XC4	Control	Tipulidae	5.5	*Tipulidae spp.*	1
2014	XD1	Realignment	Athericidae		*Athericidae spp.*	5
2014	XD1	Realignment	Baetidae	5.3	*Baetis rhodani*	23
2014	XD1	Realignment	Chironomidae	3.7	*Chironomidae spp.*	7
2014	XD1	Realignment	Chloroperlidae	12.4	*Chloroperla torrentium*	2
2014	XD1	Realignment	Heptageniidae	9.8	*Ecdyonurus torrentis*	23
2014	XD1	Realignment	Elmidae	6.4	*Elmis aenea*	12
2014	XD1	Realignment	Gammaridae	4.5	*Gammarus pulex*	15
2014	XD1	Realignment	Glossiphoniidae	3.1	*Glossiphonia complanata*	1
2014	XD1	Realignment	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	4
2014	XD1	Realignment	Hydropsychidae	6.6	*Hydropsyche siltalai*	1
2014	XD1	Realignment	Limnephilidae	6.9	*Limnephilidae spp.*	1
2014	XD1	Realignment	Elmidae	6.4	*Limnius volckmari*	15
2014	XD1	Realignment	Limoniidae		*Limoniidae spp.*	4
2014	XD1	Realignment	Lymnaeidae	3	*Lymnaea truncata*	41
2014	XD1	Realignment	Oligochaeta	3.5	*Oligochaeta spp.*	10
2014	XD1	Realignment	Elmidae	6.4	*Oulimnius spp.*	14
2014	XD1	Realignment	Leptophlebiidae	8.9	*Paraleptophlebia spp.*	13
2014	XD1	Realignment	Pediciidae		*Pediciidae spp.*	2
2014	XD1	Realignment	Perlodidae	10.7	*Perlodes mortoni*	1

2014	XD1	Realignment	Dytiscidae	4.8	*Platambus maculatus*	1
2014	XD1	Realignment	Nemouridae	9.1	*Protonemura meyeri*	2
2014	XD1	Realignment	Lymnaeidae	3	*Radix balthica*	3
2014	XD1	Realignment	Heptageniidae	9.8	*Rhithrogena semicolorata*	49
2014	XD1	Realignment	Sericostomatidae	9.2	*Sericostoma personatum*	6
2014	XD1	Realignment	Sphaeriidae	3.6	*Sphaeriidae spp.*	3
2014	XD1	Realignment	Tabanidae		*Tabanidae spp.*	4
2014	XD1	Realignment	Tipulidae	5.5	*Tipulidae spp.*	1
2014	XD2	Realignment	Athericidae		*Athericidae spp.*	3
2014	XD2	Realignment	Baetidae	5.3	*Baetis rhodani*	24
2014	XD2	Realignment	Chironomidae	3.7	*Chironomidae spp.*	3
2014	XD2	Realignment	Heptageniidae	9.8	*Ecdyonurus torrentis*	90
2014	XD2	Realignment	Elmidae	6.4	*Elmis aenea*	9
2014	XD2	Realignment	Gammaridae	4.5	*Gammarus pulex*	4
2014	XD2	Realignment	Glossosomatidae	7	*Glossosoma conformis.boltoni*	4
2014	XD2	Realignment	Gyrinidae	7.8	*Gyrinus spp.*	1
2014	XD2	Realignment	Hydraenidae		*Hydraena spp.*	1
2014	XD2	Realignment	Hydropsychidae	6.6	*Hydropsyche pellucida.instabilis*	16
2014	XD2	Realignment	Hydropsychidae	6.6	*Hydropsyche siltalai*	8
2014	XD2	Realignment	Perlodidae	10.7	*Isoperla grammatica*	2
2014	XD2	Realignment	Elmidae	6.4	*Limnius volckmari*	7
2014	XD2	Realignment	Limoniidae		*Limoniidae spp.*	1
2014	XD2	Realignment	Lymnaeidae	3	*Lymnaea truncata*	24
2014	XD2	Realignment	Oligochaeta	3.5	*Oligochaeta spp.*	2
2014	XD2	Realignment	Elmidae	6.4	*Oulimnius spp.*	7
2014	XD2	Realignment	Perlodidae	10.7	*Perlodes mortoni*	2
2014	XD2	Realignment	Polycentropodidae	8.6	*Plectrocnemia conspersa*	5
2014	XD2	Realignment	Nemouridae	9.1	*Protonemura meyeri*	1
2014	XD2	Realignment	Lymnaeidae	3	*Radix balthica*	2
2014	XD2	Realignment	Heptageniidae	9.8	*Rhithrogena semicolorata*	46
2014	XD2	Realignment	Sericostomatidae	9.2	*Sericostoma personatum*	2
2014	XD2	Realignment	Ephemerellidae	7.7	*Serratella ignita*	1
2014	XD2	Realignment	Sialidae	4.5	*Sialis lutaria*	1
2014	XD2	Realignment	Simulidae	5.8	*Simulidae spp.*	4
2014	XD2	Realignment	Sphaeriidae	3.6	*Sphaeriidae spp.*	1
2014	XD2	Realignment	Tipulidae	5.5	*Tipulidae spp.*	2

APPENDIX B: Electrofishing Surveys of the River Nith - NDSFB 2013 and 2014

Electrofishing Survey Of The River Nith To Assess Juvenile Salmonid Populations In The Vicinity Of The Greenburn Surface Coal Mine And The Braehead River Diversion

Volume 1
(2013)

Commissioned by
KIER MINING

Survey undertaken by
J. Henderson
Director

Nith District
Salmon Fishery Board

Contents

Cover photo: Braehead Diversion Channel

1 Introduction

1.1 Background

The River Nith is a river of major importance as a salmon and sea trout fishery, and is the largest river in south west Scotland. It has its source in Ayrshire and flows through Dumfriesshire, spanning approximately one hundred kilometres to its estuary in the Solway Firth, a total catchment area of 1200 square kilometres.

The annual catch of migratory salmonids is of significant economic importance to this rural area. An economic survey has been conducted and revealed that the Nith accounts for £ 2.2 million being spent in the local economy (Leslie, 2000). There are net fishing interests in the estuarial reaches, with Haaf netting a commonly used method. There are a range of fixed nets on the western boundary, still within the Nith District Salmon Fishery Board area of jurisdiction. Angling is widespread over most of the main stem and some larger tributaries of The Nith. Net fishing and angling produced a joint catch of 1405 salmon and grilse and 841 sea trout during 2013 (N.D.S.F.B., 2014).

1.2 Nith District Salmon Fishery Board (NDSFB)

The NDSFB is a statutory body constituted under the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003, tasked with the management of migratory salmonid species within their catchment area. The Board is empowered to conduct works and execute measures to safeguard, improve and enhance stocks of migratory salmonids within its jurisdictional area. The NDSFB has no remit to manage non-migratory species other than with the permission of riparian owners and only where management of these species would be deemed to be in the furtherance of migratory species. Management of non-migratory species of fish within the Nith catchment is conducted by the Nith Catchment Fishery Trust who works closely with the Board. The NDSFB is active and works in areas of fisheries protection, restocking hatchery programmes, habitat restoration and predator control (NDSFB, 2014).

1.3 Greenburn OCCS

Greenburn is located in East Ayrshire near to the town of New Cumnock in Southwest Scotland. The site has been owned by Kier Mining since 2003 and surface mining for coal commenced during 2004. In accordance with planning conditions the site was subject to an extensive environmental audit prior to mining operations commencing. Part of that audit included a series of electrofishing surveys to establish baseline data on fish populations known to exist in the watercourses in the vicinity of the Greenburn site.

Due to the nature of the surface mining industry and associated earth works it is necessary to continually discharge water from the site back into the aquatic environment having been treated in settlement lagoons prior to final discharge. Failure to dewater the mine workings would result in the site becoming inundated with water filling the void and in effect creating a large pond. Continued monitoring of fish populations was considered desirable in order that Kier and fisheries

managers could determine if the operation of the site was creating any impacts on fish populations. Annual electrofishing surveys have been carried out on watercourses in the vicinity of the Greenburn site since 2003. The data gained has been used to assist Kier with their environmental protection of the site.

As the mine has been worked, Kier have continued to prospect for coal in the surrounding adjacent areas to the Greenburn site. Drilling has proven that reserves of coal are present in sufficient quantities and at economically exploitable depths to warrant consideration of expanding the original mine site. By continuing to develop new areas the mine has maintained production of coal since 2004. However the Greenburn site is bordered on the south by the River Nith and this has previously acted as a natural boundary whilst reserves of coal still existed to the north and west of the original mine. The area of land on the southern side of the River Nith, known as Braehead Farm, was test drilled and the results of those tests proved that considerable reserves of coal existed in that area. However, in order to fully exploit those reserves it was going to be necessary to divert the course of the River Nith.

1.4 Braehead River Diversion (summer 2012)

The Braehead river diversion was scheduled to take place during the summer of 2012. Prior to the actual diversion occurring, the new river channel was excavated during 2011 and this gave time to create the desired features within the river bed substrate and to establish riparian vegetation in advance of the switch over. NDSFB were consulted by Kier and their engineers regarding the features which could be incorporated into the channel which would favour a diverse fish population. It was important to create a range of substrate material which could accommodate fry aged salmonids and larger material which would suit parr aged salmonids. In addition, slower moving back waters, where silt was permitted to form were established and these areas favour non salmonid species.

During 2011 the fringes of the new river channel were planted with willow whips. These were specifically planted to establish stability to the side slopes and in addition, once mature, these willows create fish habitat by forming draped foliage at the water's edge.

Planting willow whips along the Braehead diversion channel in 2011.

2 This Study

2.1 Aims

This study set out with the following aims:

(a) To utilise a replicable and efficient capture technique for juvenile salmonids suitable for the diverted River Nith at Greenburn OCCS

(b) To assess juvenile salmonid population densities, upstream, downstream and within the site boundaries of Greenburn OCCS, post diversionary works.

(c) To produce data to assist in the environmental policy, considerations and safeguards which may be implemented for the general protection of the River Nith catchment and its environs.

(d) To make recommendations to Kier Mining on how best they can continue restoration of the riparian zone surrounding the new river channels causing minimal impacts on salmonid species, from an informed position, based on facts.

(e) To produce data to assess the populations of salmonid species and presence of other species of fish in the diverted channel.

(f) To produce additional data to assess fish populations within the sections of river diverted at Braehead.

2.2 Feasibility

In order to accurately survey numbers of juvenile salmonids present in the vicinity of the Greenburn site this study had to take account of the time of year when electrofishing was conducted, and the height of water and general conditions at time of survey. For these reasons the survey was conducted during the summer to ensure efficiency of capture was optimum.

2.3 Site selection

This study conducted electrofishing surveys inside the boundaries of the Greenburn site. Sites were also surveyed, upstream and downstream from the opencast site. The sites were chosen for their accessibility and their habitat containing “typically” juvenile salmonid riffles. Some sites surveyed are historic sites that have previously been surveyed for a number of years. To ensure that those sites were relocated accurately photographic images and global positioning equipment was used.

3 Methods

3.1 Equipment

3.1.1 Electrofishing apparatus

Conductivity in the main stem of the River Nith, inside the site boundaries, at the locations of the sites chosen for this survey was high. The level of conductivity at Greenburn site and at every opencast coal site can be explained by the chemical composition and the mineral content present in the water. For this reason generator apparatus positioned on the bank was employed at all times.

The generator used was a 5.5 horse power petrol driven model specifically designed for electrofishing. This was linked to an *Electracatch International* controller unit WFC6-HV used to supply a smooth DC current. The control unit was linked to a stationary cathode of braided copper (placed in the stream) and one mobile anode, which consisted of a two metre pole with a stainless steel ring (used to draw fish) and an operator controlled switch.

Figure 1 - Electrofishing Equipment

3.1.2 Ancillary equipment

One manually operated banner net, two dip nets with 1.3 metre handles attached were used to capture stunned fish.

3.2 Personnel

To conduct this electrofishing survey, NDSFB utilised the services of their own staff, which are qualified and experienced in the use of electrofishing equipment and capable of conducting such

research. The Scottish Fisheries Co-ordination Centre (SFCC) protocol for electrofishing was adhered to throughout this survey.

For their personal protection all personnel wore floatation vests and waders. All personnel could swim. One member of the team was qualified in first aid, and first aid equipment was available in Fishery Board vehicle present throughout the survey. All field staff involved in the electrofishing survey and in attendance on site at Greenburn had undergone Kiers site induction process prior to going on site equipped with the appropriate personal protection equipment.

3.3 Techniques

To accurately assess the population of juvenile salmonids throughout this survey, a method of electrofishing was adopted which could efficiently capture the appropriate age classes of these species. The method adopted entailed selecting natural features on the river which provided boundaries to each electrofishing site. Features such as shallow riffles at the top and bottom of a section of river were typically utilised. Once a site had been selected, the electrofishing team systematically worked from downstream to upstream following a carefully agreed pattern removing all fish caught. Working in an upstream direction prevents any sediment caused by wading in the river from obscuring the working area.

The anode operator was able to draw stunned fish downstream, assisted by the current, towards the hand-held dip net which was lifted clear of the water after each sweep, to permit the removal of captured fish for transfer into water-filled buckets.

This method of capture for salmonids also captured all other species present in the sites. All fish were returned, unharmed to their original capture sites on completion of examination and data recording.

3.4 Data recording

All fish captured were removed from the survey sites and placed in water-filled buckets and allowed to recover from the temporary stunning effects of electrofishing. The area electrofished at each site was measured and recorded. A global positioning system was employed to record the exact location of each site.

3.5 Data Analysis

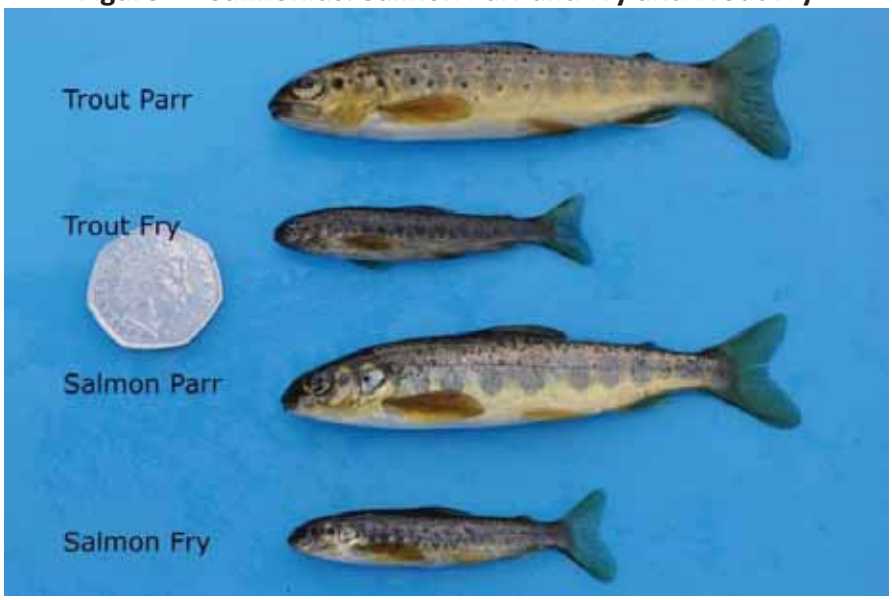
The densities of fry and parr were then classified using the Scottish Fisheries Co-ordination Centre national classification scheme (Godfrey, 2005). This classification scheme categorises the data according to five categories derived using data from over 1600 Scottish sites. This allows the performance of each site surveyed to be demonstrated graphically. See the Section 5.

3.5.1 Salmonid species

Salmonid species were counted and recorded as:
Salmon fry (O^+) which refers to a young fish less than one year old, resulting from spawning at end of 2012.
Salmon parr (1^+) which refers to a young fish which is older than one year old, resulting from spawning at end of 2010/2011.
Trout fry (O^+) which refers to a young fish less than one year old, resulting from spawning at end of 2012.
Trout parr (1^+) which refers to a young fish which is older than one year old, resulting from spawning at end of 2010/2011, or earlier in the case of larger specimens.

Age determination of salmonids has been assessed by the length of individuals captured from each fishing site.

Figure 2 - Salmonids: Salmon Parr and Fry and Trout Fry



3.5.2 Non salmonid species

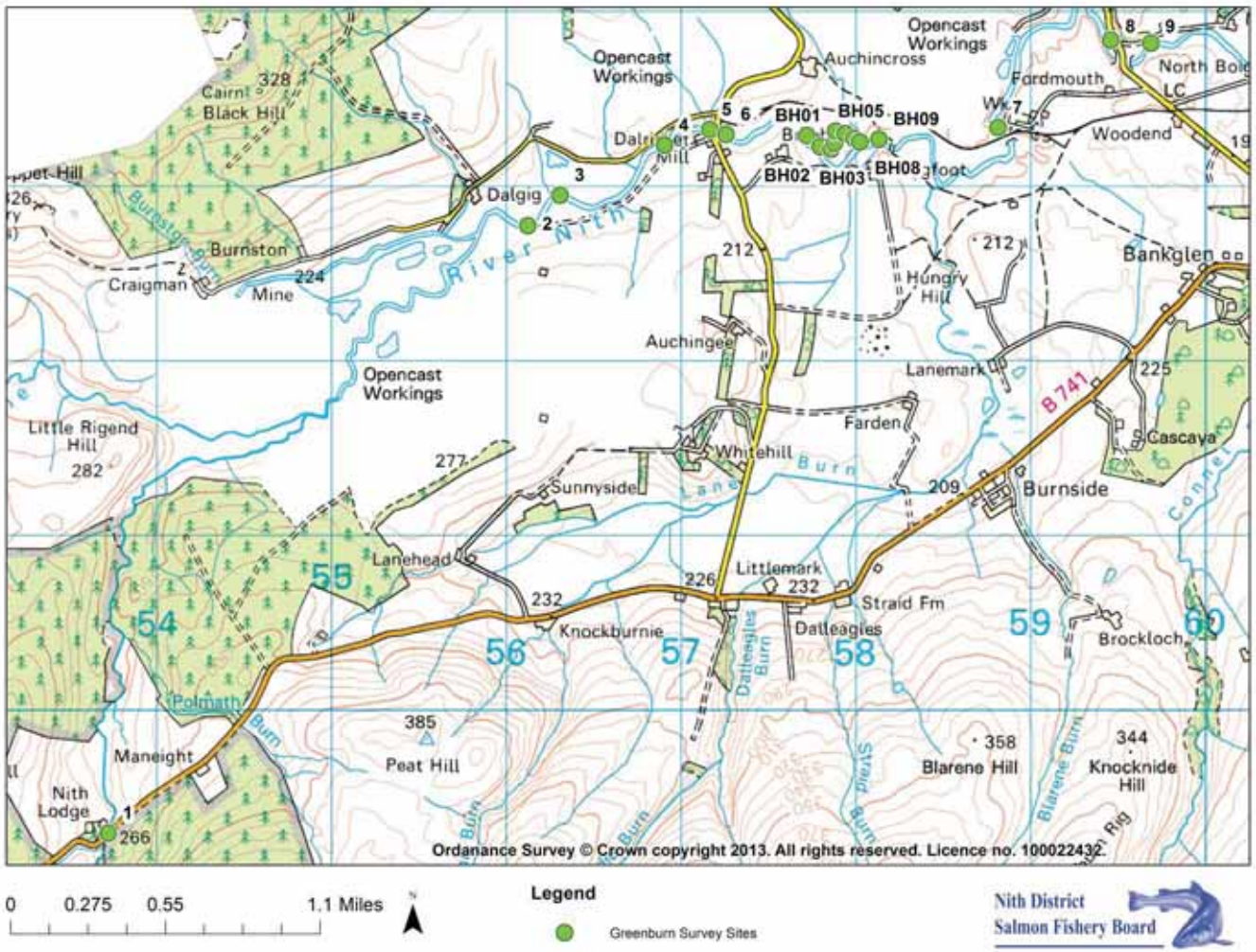
The presence of non salmonid species was recorded at each survey site and population densities were recorded.

3.5.3 Photography

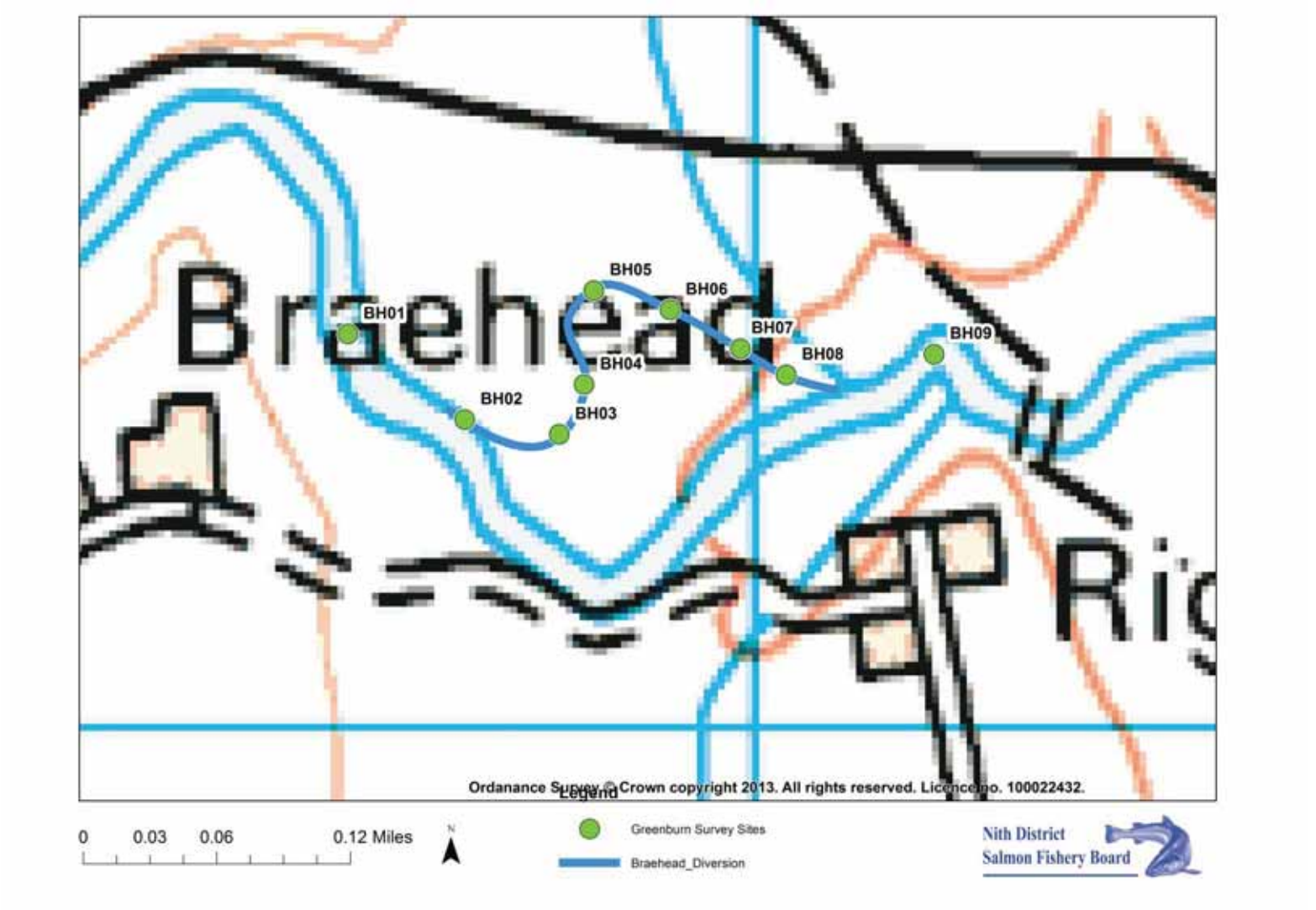
All sites were photographed to provide an accurate record of conditions at time of survey. These photographs are a useful aid in assessing environmental status and recovery of the new river channel. Photographs can also be used to assess the quality of each site with regard to its potential as a salmonid habitat.

In addition to recording the section of river over which electrofishing has been conducted, each photograph provides a record of vegetation present within the riparian zone at each site. Again these will prove valuable in future years when environmental recovery of the site is assessed.

4 Location map of survey sites within Greenburn



4 Location map of survey sites within Braehead diversion



5 Results of Electrofishing Surveys Conducted During 2013 - Greenburn

Watercourse	Site code	Location	Grid reference	Sampling date	Salmon fry (/100m^2)	Salmon parr (/100m^2)	Trout fry (/100m^2)	Trout parr (/100m^2)	Other species present
Nith	1	20m downstream from road bridge at Nith Lodge	253724 609294	15/07/13	10	23	16	8	SL
Nith	2	400m downstream from confluence with Dalgig Burn	256125 612771	17/07/13	86	2	2	2	-
Nith	3	Immediately downstream of Kier discharge/corner field	256309 612947	17/07/13	64	2	16	0	L, SL, M
Nith	4	100m downstream from confluence with Greenburn	256906 613233	17/07/13	57	11	34	0	-
Nith	5	Upstream of Dalricket Mill road bridge	257166 613322	17/07/13	30	48	20	2	-
Nith	6	100m downstream of road bridge at Dalricket Mill	257259 613295	17/07/13	28	23	19	0	M
Nith	7	50m downstream of railway bridge at Brickworks	258815 613333	16/07/13	19	29	16	1	SL, M
Nith	8	100m upstream of Boig road bridge	259460 613834	15/07/13	3	7	0	0	SL, M
Nith	9	250m downstream of Boig road bridge	259689 613818	15/07/13	4	8	2	0	L, SL, M

Key to other species:

E	-	Eel	M	-	Minnow
SL	-	Stone Loach	L	-	Lamprey
SB	-	Stickleback	G	-	Grayling
F	-	Flounder	P	-	Pike

Key to classification of salmonids per 100m^2

absent
very poor
poor
moderate
Good
excellent

5 Results of Electrofishing Surveys Conducted During 2013 – Braehead Diversion

Watercourse	Site code	Location	Grid reference	Sampling date	Salmon fry (/100m^2)	Salmon parr (/100m^2)	Trout fry (/100m^2)	Trout parr (/100m^2)	Other species present
Nith	BH01	100m upstream from top of Braehead diversion	257721 613288	16/07/13	28	8	19	2	L, SL, M
Nith	BH02	25m downstream of lagoon outlet at top of Braehead diversion	257798 613225	16/07/13	36	28	14	0	E, SL, M
Nith	BH03	150m downstream from top of Braehead diversion	257861 613209	16/07/13	59	5	15	0	SL
Nith	BH04	Upstream of corner closest to railway platform	257879 613245	16/07/13	19	2	6	0	E, SL, M
Nith	BH05	Directly on corner closest to railway platform	257886 613313	16/07/13	40	10	18	1	SL, M
Nith	BH06	Downstream of corner closest to train loading bay	257941 613299	18/07/13	25	9	3	0	SL
Nith	BH07	50m downstream from corner closest mine loading platform	257992 613271	18/07/13	7	12	2	0	SL
Nith	BH08	25m upstream from bottom of Braehead diversion	258025 613252	18/07/13	7	6	0	1	E, SL
Nith	BH09	100m downstream of end of Braehead diversion	258132 613267	18/07/13	8	7	12	0	SL

Key to other species:

E	-	Eel	M	-	Minnow
SL	-	Stone Loach	L	-	Lamprey
SB	-	Stickleback	G	-	Grayling
F	-	Flounder	P	-	Pike

Key to classification of salmonids per 100m^2

- absent
- very poor
- poor
- moderate
- Good
- excellent

6 Annual survey sites

6.1 **Site 1**

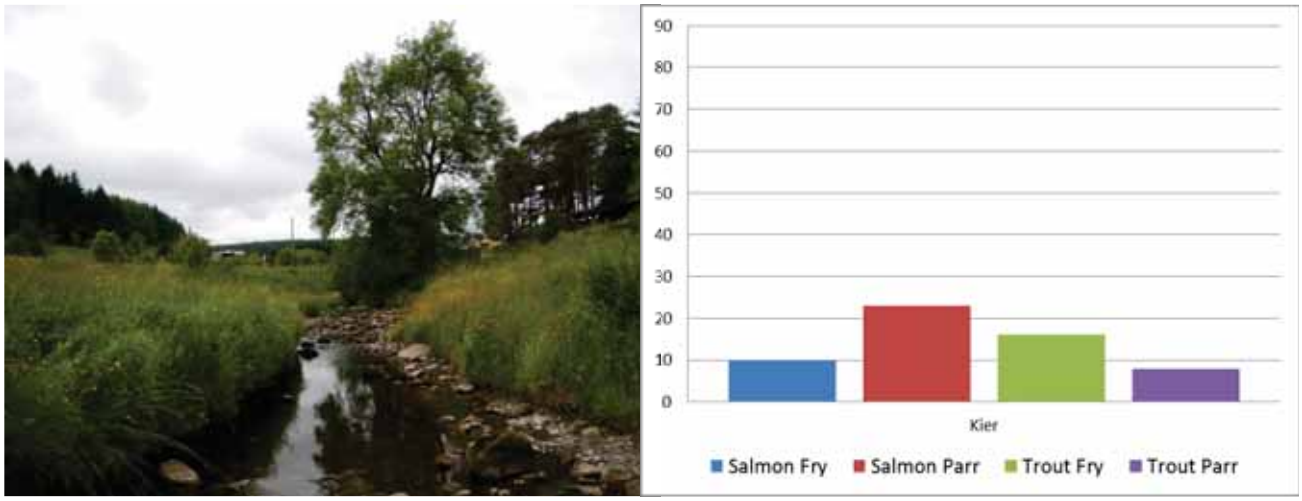


Chart 1 – Abundance of juvenile salmonids at Site 1

Site 1 is located on the River Nith upstream of any influence by mining activity and therefore acts as a control site. Electrofishing surveys revealed poor densities of salmon fry, excellent densities of salmon parr and good densities of trout fry and parr. Stone loach were also present at Site 1.

6.2 **Site 2**

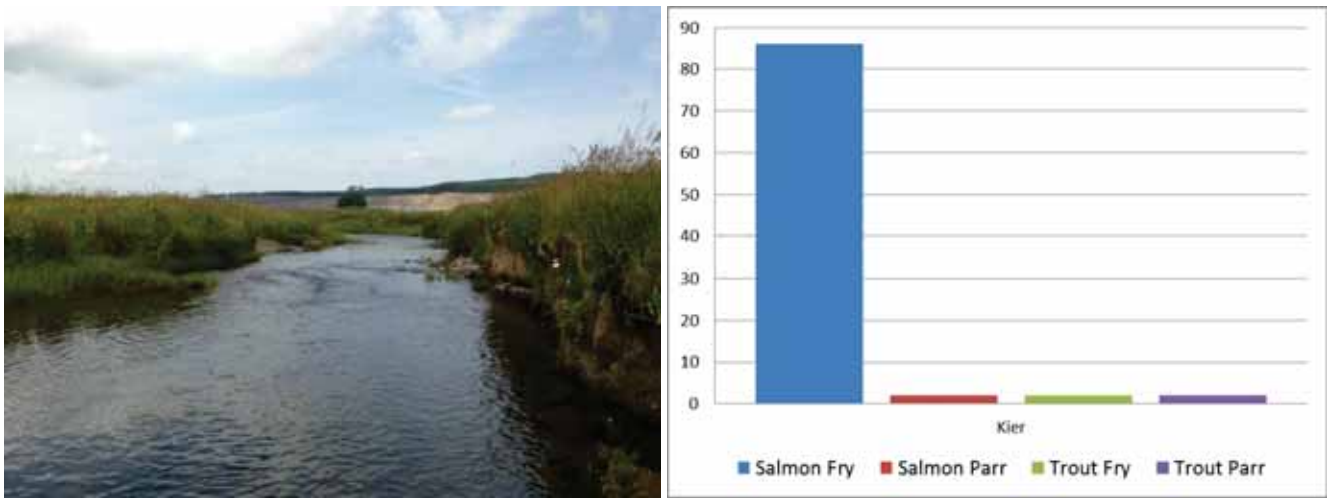


Chart 2 – Abundance of juvenile salmonids at Site 2

Site 2 is located on the River Nith downstream of the confluence with the Dalgig Burn, within the Greenburn site. Excellent densities of salmon fry were found at this site. There were very poor densities of salmon parr and trout fry. Trout parr were present but their densities were poor.

6.3 **Site 3**

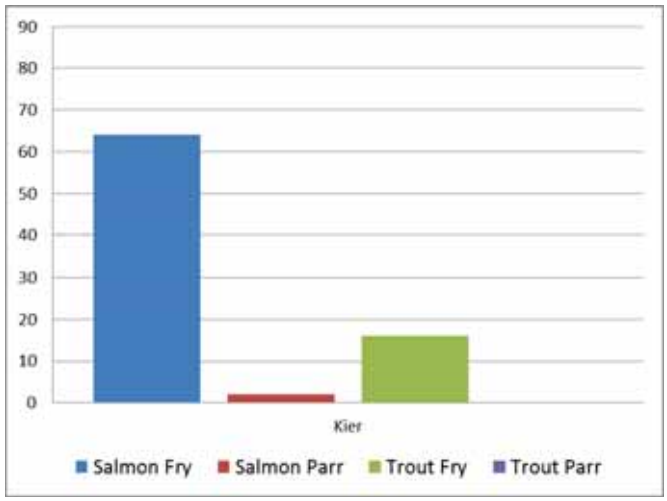


Chart 3 – Abundance of juvenile salmonids at Site 3

Site 3 is located immediately downstream from the outlet of Dalgig lagoons. Surveying showed excellent densities of salmon fry, very poor densities of salmon parr, good densities of trout fry and no trout parr. Lamprey, stone loach and minnow were also found to be present.

6.4 **Site 4**

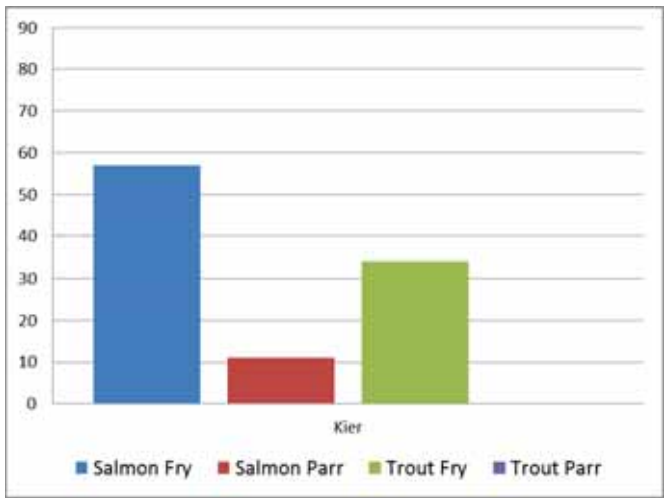


Chart 4 – Abundance of juvenile salmonids at Site 4

Site 4 is located downstream of the confluence with the Greenburn Burn. Excellent densities of salmon fry were present, very poor densities of salmon parr and good densities of trout fry. No trout parr were found to be present.

6.5 **Site 5**

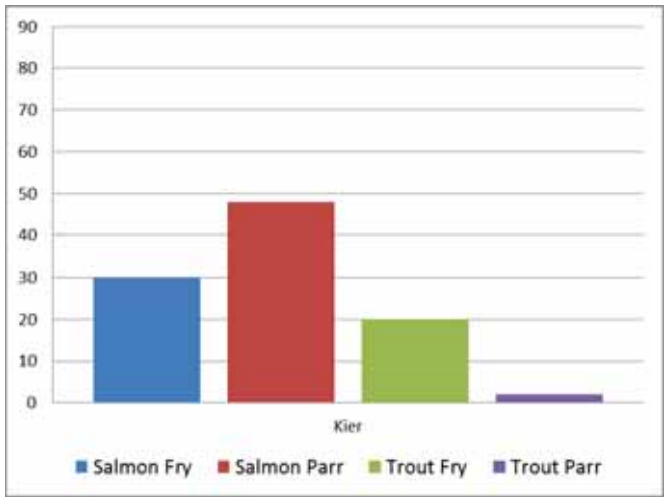


Chart 5 – Abundance of juvenile salmonids at Site 5

Site 5 is located on the River Nith upstream of Dalricket Mill Bridge. Surveys showed good densities of salmon fry, excellent densities of salmon parr, good densities of trout fry and poor densities of trout parr.

6.6 **Site 6**

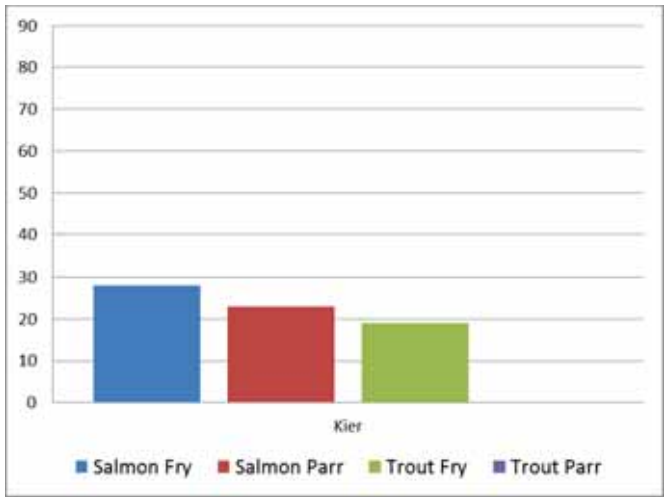


Chart 6 – Abundance of juvenile salmonids at Site 6

Site 6 is located on the River Nith downstream of Dalricket Mill Bridge. Surveys revealed good densities of salmon fry, excellent densities of salmon parr and good densities of trout fry. No trout parr were found to be present. Minnow were also found to be present.

6.7 **Site 7**

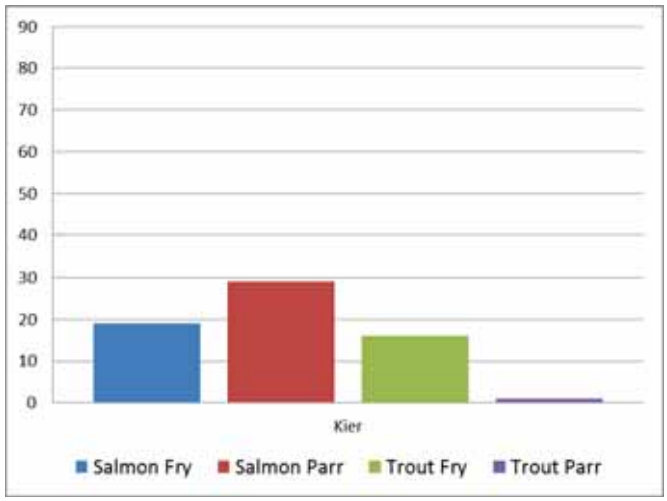


Chart 7 – Abundance of juvenile salmonids at Site 7

Site 7 is located on the River Nith downstream of the Railway Bridge at the disused brickworks. Good densities of salmon fry, excellent densities of salmon parr, good densities of trout fry and very poor densities of trout parr were found to be present. Stone loach and minnow were also found to be present.

6.8 **Site 8**

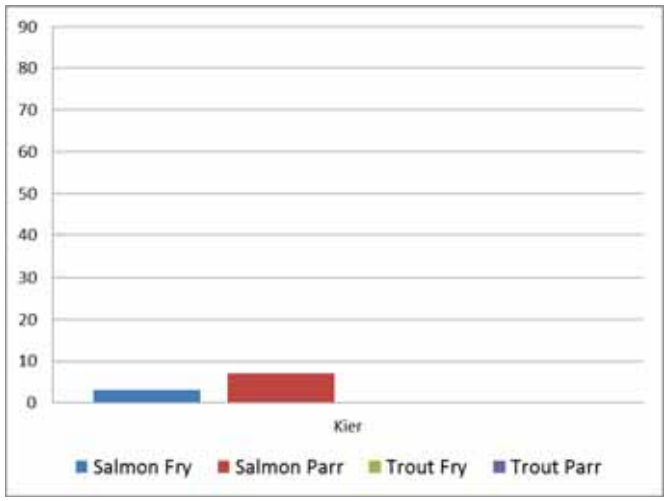


Chart 8 – Abundance of juvenile salmonids at Site 8

Site 8 is located on the River Nith upstream of Boig Road Bridge. A deep layer of sediment was observed at this location whilst surveying. As a result of this sediment, very poor densities of salmon fry and moderate densities of salmon parr were found to be present. No trout fry or parr were found. Stone loach and minnow were also found to be present.

6.9 **Site 9**

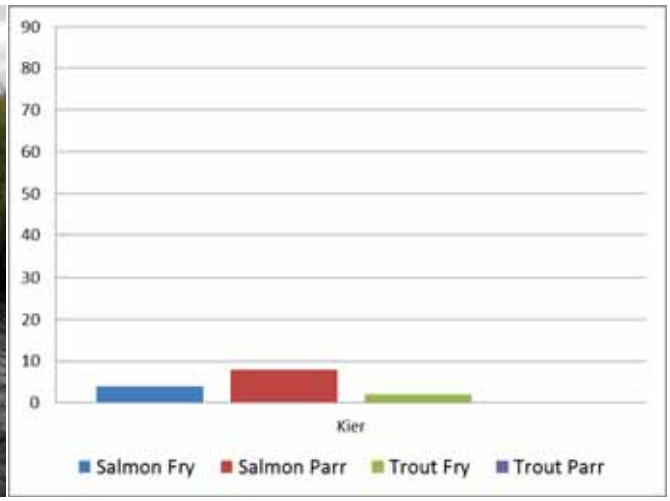


Chart 9 – Abundance of juvenile salmonids at Site 9

Site 9 is located on the River Nith downstream of Boig Road Bridge. Sediment was still present at this site but at lower levels. The survey found very poor densities of salmon fry, moderate densities of salmon parr and very poor densities of trout fry to be present. No trout parr were found. Lamprey, stone loach and minnow were found to be present.

6.10 **Site BH01**

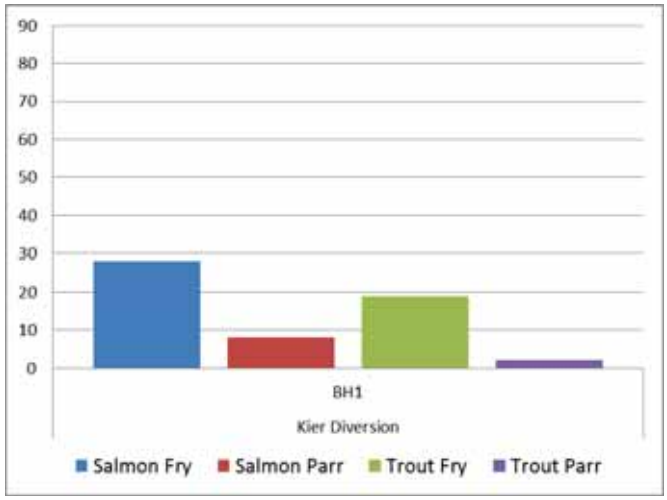


Chart 10 – Abundance of juvenile salmonids at Site BH01

Site BH01 is located on the River Nith upstream of Braehead Diversion channel. This site is used as a control. Electrofishing surveys revealed that good densities of salmon fry, moderate densities of salmon parr, good densities of trout fry and poor densities of trout parr were present. Lamprey, stone loach and minnow were also found.

6.11 **Site BH02**

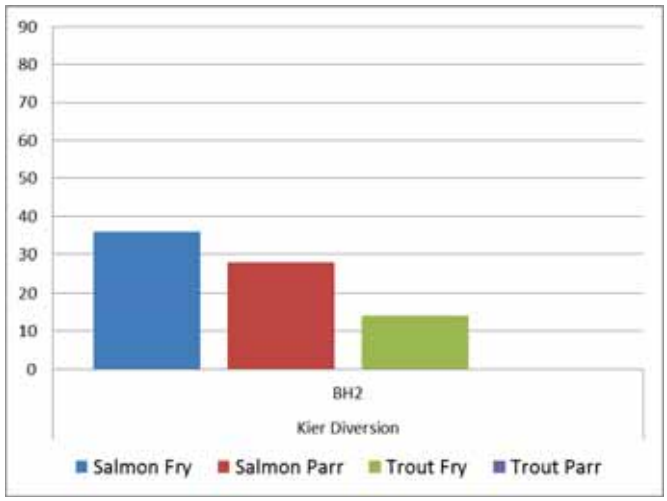


Chart 11 – Abundance of juvenile salmonids at Site BH02

Site BH02 is located on the River Nith, 25m downstream of the lagoon outlet at the top of the Braehead diversion channel. Surveys found good densities of salmon fry, excellent densities of salmon parr and good densities of trout fry to be present. No trout parr were found to be present. Eel, stone loach and minnow were also found to be present.

6.12 **Site BH03**

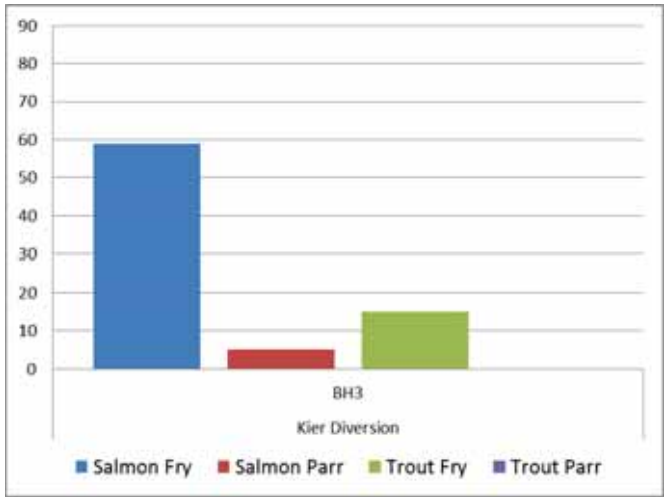


Chart 12 – Abundance of juvenile salmonids at Site BH03

Site BH03 is located on the River Nith, 150m downstream from the top of Braehead diversion channel. At this site excellent densities of salmon fry, poor densities of salmon parr and good densities of trout fry were found. No trout parr were present. Stone loach were also found.

6.13 **Site BH04**

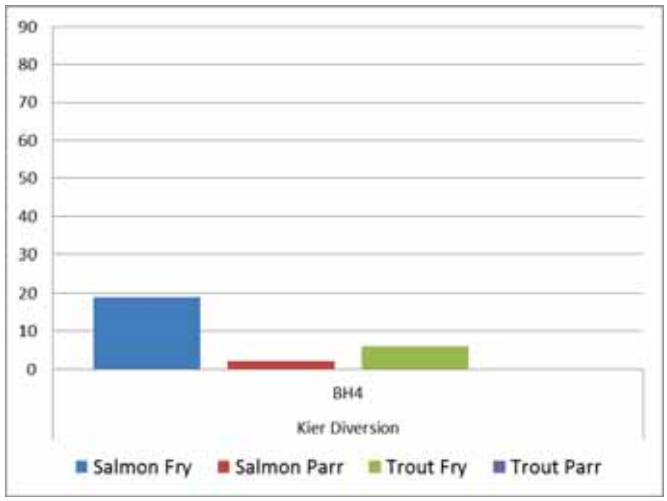


Chart 13 – Abundance of juvenile salmonids at Site BH04

Site BH04 is located within the Braehead diversion channel on the River Nith, upstream of the corner closest to the railway loading platform. Moderate densities of salmon fry, very poor densities of salmon parr and moderate densities of trout fry were found to be present at this site. No trout parr were found. Eel, stone loach and minnow were also found to be present.

6.14 **Site BH05**

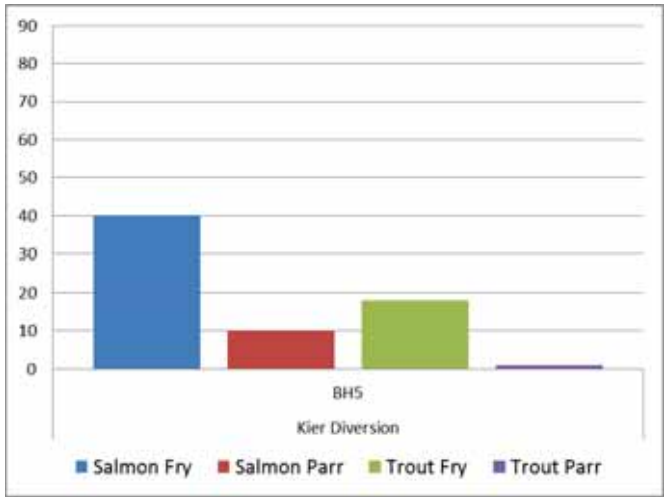


Chart 14 – Abundance of juvenile salmonids at Site BH05

Site BH05 is located within the Braehead diversion channel on the River Nith, directly on the corner closest to the railway loading platform. At this site excellent densities of salmon fry, good densities of salmon parr, good densities of trout fry and very poor densities of trout parr were found to be present. Stone loach and minnow were also found.

6.15 **Site BH06**

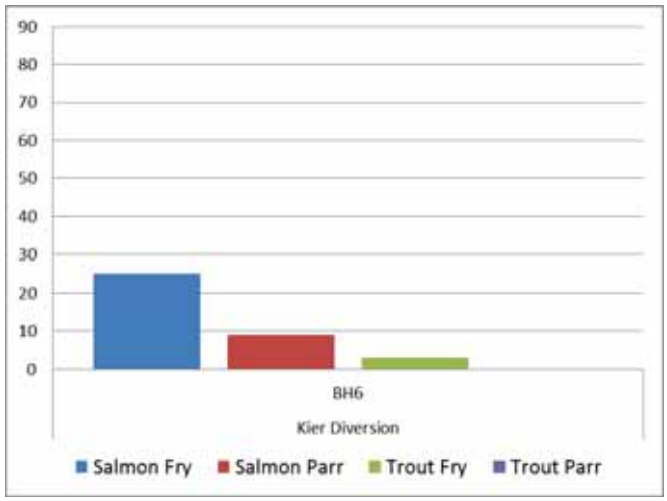


Chart 15 – Abundance of juvenile salmonids at Site BH06

Site BH06 is located within the Braehead diversion channel on the River Nith, downstream of the corner closest to the railway loading platform. Good densities of salmon fry, poor densities of salmon parr and poor densities of trout fry were found to be present. No trout parr were found to be present. Stone loach were present.

6.16 **Site BH07**

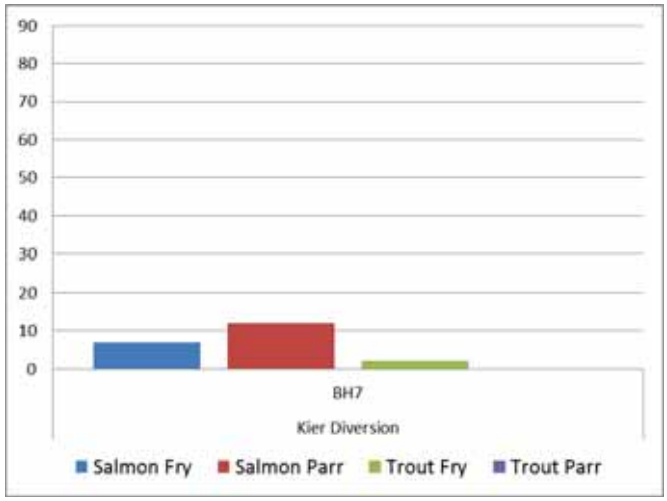


Chart 16 – Abundance of juvenile salmonids at Site BH07

Site BH07 is located within the Braehead diversion channel on the River Nith, 50m downstream of the corner closest to the railway loading platform. At this site poor densities of salmon fry, good densities of salmon parr and very poor densities of trout fry were found to be present. No trout parr were present. Stone loach were found.

6.17 **Site BH08**

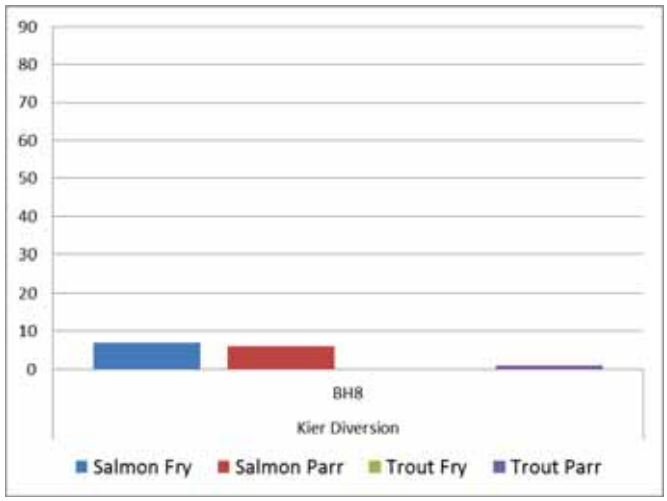


Chart 17 – Abundance of juvenile salmonids at Site BH08

Site BH08 is located within the Braehead diversion channel on the River Nith, 25m upstream from the bottom of the diversion channel. At this site, poor densities of salmon fry and moderate densities of salmon parr and very poor densities of trout parr were found to be present. No trout fry were present. Stone loach and eel were also present.

6.18 **Site BH09**

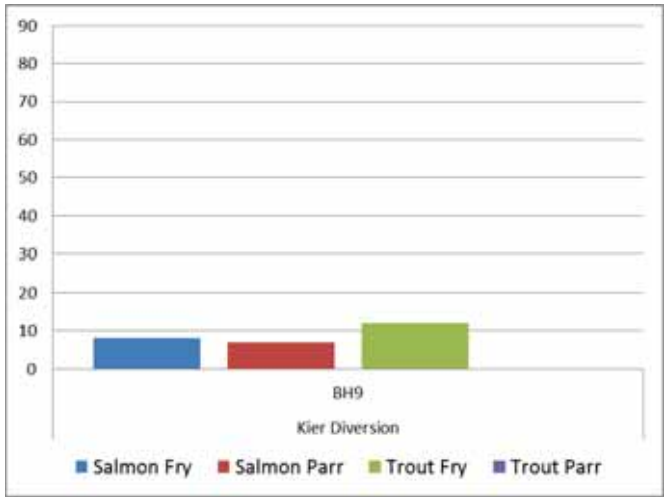


Chart 18 – Abundance of juvenile salmonids at Site BH09

Site BH09 is located out with the Braehead diversion channel on the River Nith, 100m downstream of the end of the diversion channel. Poor densities of salmon fry, moderate densities of salmon parr and moderate densities of trout fry were found to be present at this site. No trout parr were found. Stone loach were also present.

7 Discussion

Sites 2, 3 and 4 contained high densities of fry no doubt due to the presence of spawning habitat/substrate within the site. However, these sites lack parr habitat and this is reflected in the results. This section of river is original and has not been engineered by mining activity.

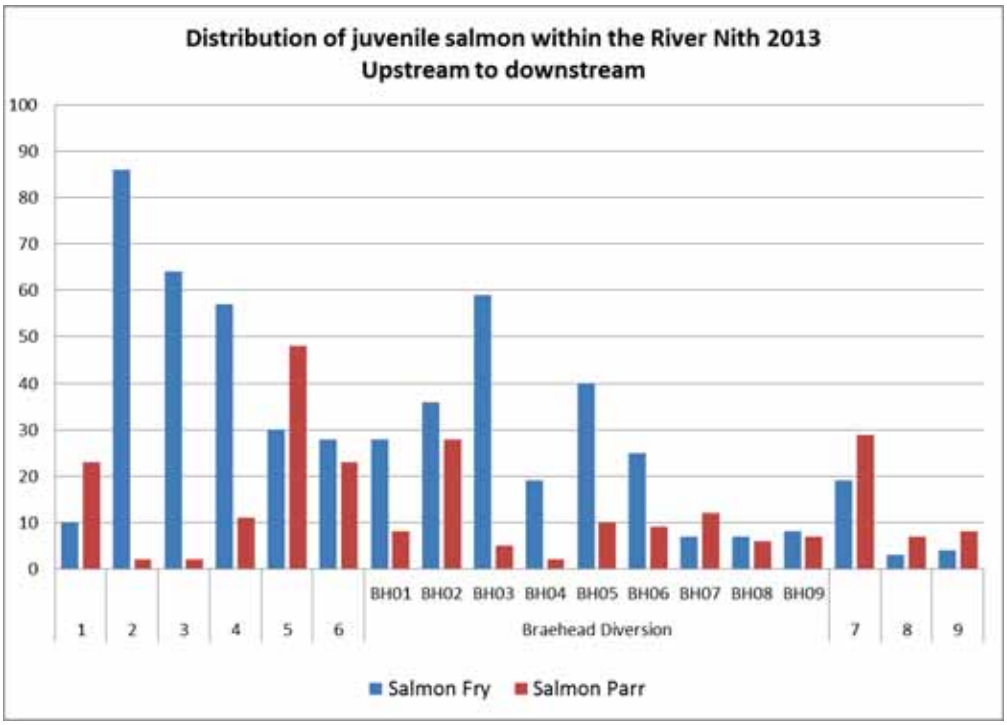
Sites 5, 6 and 7 contained good mixed habitats for all age classes of salmonids. This is reflected in the results.

Sites 8 and 9 have been previously very good for all age classes of salmonids. During 2013, at time of survey, we noted that the substrate of these sites was covered with a thick layer of sediment. Although the source of the sediment input was not identified it was thought to have been the result of a landslip between the disused brickworks and Boig Road Bridge. The silt would have appeared to have impacted on salmon fry.

It can be seen that higher densities of salmon fry are found at sites surveyed further upstream of the diversion compared to those sites surveyed downstream of the diversion (see Chart 19). It is not believed to be an issue with the diversion as reasonable numbers of fry were found within the diversion channel itself.

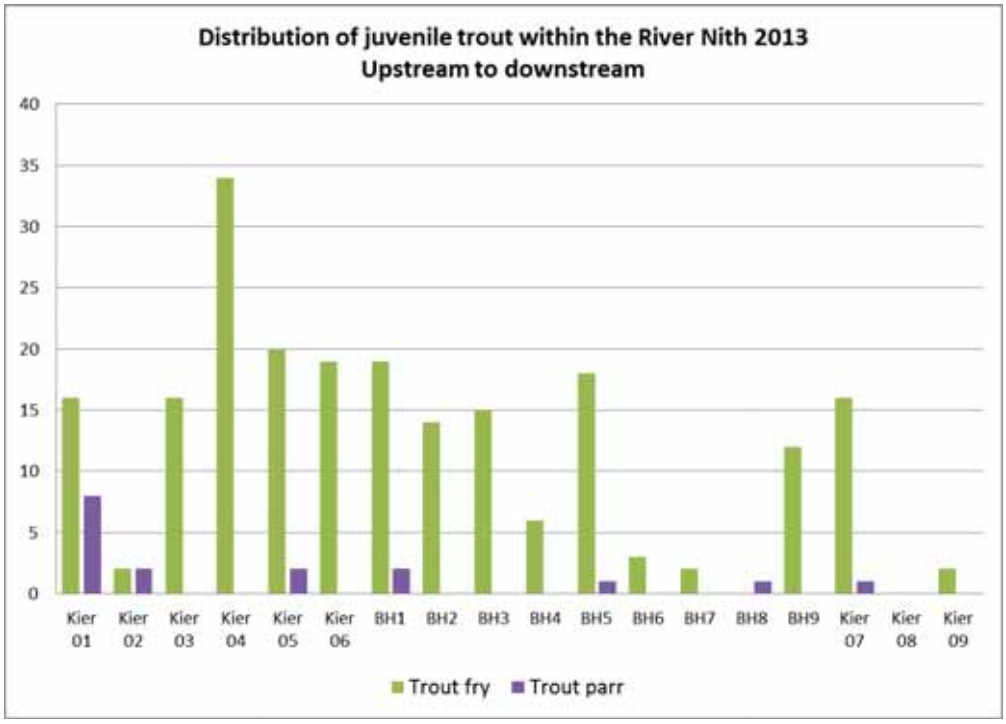
Within the Braehead diversion channel, higher densities of salmon fry were found in the upper half of the channel. Fry densities decreased the further down the channel the surveys progressed. The substrate in the lower section comprises of small pebbles and larger boulders and is more compacted that that in the upper section. This is possibly reducing the amount of habitat available for fry.

Chart 19 – Distribution of salmon fry and parr



The densities of trout fry are lower than that of salmon fry at all sites (see Chart 20). This is expected as salmon generally spawn in larger watercourses than trout. Trout can generally be found in higher densities in tributaries and smaller watercourses feeding into larger watercourses. No trout were found at Site 8. However, this is where the siltation was worst. Within the diversion, higher densities of fry can be found in the upper half of the channel, with the exception of Sites BH05 and BH09.

Chart 20 – Distribution of trout fry and parr



The abundance of juvenile salmon and trout found within the Braehead diversion channel, one year after the diversion occurred, is encouraging and demonstrates that the channel is functioning satisfactorily. Minor adjustment of substrate may be required in future years if there are consistently low densities of fry found in the lower section of the channel.

One aspect of the original channel which we were keen to replicate in the new channel was suitable habitat for lamprey. This is likely to be a slow process as slower sections will naturally develop over time and fine sediment will be laid down. During the course of this survey, no lamprey were found within the diversion channel.

Overall the Braehead diversion has been successful and it is anticipated that, as the channel continues to mature, more riffles/pool sequences will develop providing a diverse range of habitats for all life stages of salmonids and other fish species.

8 Conclusions

This study concludes that:

- Salmonid species of fish migrated through the diversion channel.
- Salmonid species of fish successfully spawned upstream, within and downstream of the diversion channel.
- Parr aged salmonids have taken up residency within the diversion channel.
- Silt remains within the substrate of the diversion channel and this is likely to reduce over time.
- Non salmonid fish have taken up residency within the diversion channel, although it is anticipated that the diversity and numbers of these species will increase as habitats evolve.
- Maturing riparian vegetation is likely to promote higher densities of all fish species.

9 References

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Nith District Salmon Fishery Board, 2014. The River Nith District Salmon Fishery Board, Management Report And Review 2013 Season. Nith District Salmon Fishery Board, Dumfries.

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Electrofishing Survey Of The River Nith To Assess Juvenile Salmonid Populations In The Vicinity Of The Greenburn Surface Coal Mine

Volume 2
(2014)

Commissioned by
KIER MINING

Survey undertaken by
J. Henderson
Director

Nith District
Salmon Fishery Board

Contents

Cover photo: Dalricket Diversion 2014

1 Introduction

1.1 Background

The River Nith is a river of major importance as a salmon and sea trout fishery, and is the largest river in south west Scotland. It has its source in Ayrshire and flows through Dumfriesshire, spanning approximately one hundred kilometres to its estuary in the Solway Firth, a total catchment area of 1200 square kilometres.

The annual catch of migratory salmonids is of significant economic importance to this rural area. An economic survey has been conducted and revealed that the Nith accounts for £ 2.2 million being spent in the local economy (Leslie, 2000). There are net fishing interests in the estuarial reaches, with Haaf netting a commonly used method. There are a range of fixed nets on the western boundary, still within the Nith District Salmon Fishery Board area of jurisdiction. Angling is widespread over most of the main stem and some larger tributaries of The Nith. Net fishing and angling produced a joint catch of 1405 salmon and grilse and 841 sea trout during 2013 (N.D.S.F.B., 2014).

1.2 Nith District Salmon Fishery Board (NDSFB)

The NDSFB is a statutory body constituted under the Salmon and Freshwater Fisheries (Consolidation) (Scotland) Act 2003, tasked with the management of migratory salmonid species within their catchment area. The Board is empowered to conduct works and execute measures to safeguard, improve and enhance stocks of migratory salmonids within its jurisdictional area. The NDSFB has no remit to manage non-migratory species other than with the permission of riparian owners and only where management of these species would be deemed to be in the furtherance of migratory species. Management of non-migratory species of fish within the Nith catchment is conducted by the Nith Catchment Fishery Trust who works closely with the Board. The NDSFB is active and works in areas of fisheries protection, restocking hatchery programmes, habitat restoration and predator control (NDSFB, 2014).

1.3 Greenburn OCCS

Greenburn is located in East Ayrshire near to the town of New Cumnock in Southwest Scotland. The site has been owned by Kier Mining since 2003 and surface mining for coal commenced during 2004. In accordance with planning conditions the site was subject to an extensive environmental audit prior to mining operations commencing. Part of that audit included a series of electrofishing surveys to establish baseline data on fish populations known to exist in the watercourses in the vicinity of the Greenburn site.

Due to the nature of the surface mining industry and associated earth works it is necessary to continually discharge water from the site back into the aquatic environment having been treated in settlement lagoons prior to final discharge. Failure to dewater the mine workings would result in the site becoming inundated with water filling the void and in effect creating a large pond. Continued monitoring of fish populations was considered desirable in order that Kier and fisheries

managers could determine if the operation of the site was creating any impacts on fish populations. Annual electrofishing surveys have been carried out on watercourses in the vicinity of the Greenburn site since 2003. The data gained has been used to assist Kier with their environmental protection of the site.

As the mine has been worked, Kier have continued to prospect for coal in the surrounding adjacent areas to the Greenburn site. Drilling has proven that reserves of coal are present in sufficient quantities and at economically exploitable depths to warrant consideration of expanding the original mine site. By continuing to develop new areas the mine has maintained production of coal since 2004. However the Greenburn site is bordered on the south by the River Nith and this has previously acted as a natural boundary whilst reserves of coal still existed to the north and west of the original mine. The areas of land on the southern side of the River Nith, known as Braehead and Dalricket Farm, were test drilled and the results of those tests proved that considerable reserves of coal existed in those areas. However, in order to fully exploit those reserves it was going to be necessary to divert the course of the River Nith at two locations.

1.4 Braehead River Diversion

The Braehead river diversion took place during the summer of 2012. Prior to the actual diversion occurring, the new river channel was excavated during 2011 and this gave time to create the desired features within the river bed substrate and to establish riparian vegetation in advance of the switch over. NDSFB were consulted by Kier and their engineers regarding the features which could be incorporated into the channel which would favour a diverse fish population. It was important to create a range of substrate material which could accommodate fry aged salmonids and larger material which would suit parr aged salmonids. In addition, slower moving back waters, where silt was permitted to form were established and these areas favour non salmonid species. The fringes of the new river channel were planted with willow whips and native trees. These were specifically planted to establish stability to the side slopes and in addition, once mature, the willows create fish habitat by forming draped foliage at the water's edge.

Electrofishing surveys of the new channel commenced in 2013 and will be continued annually for a period of 20 years.

1.5 Dalricket River Diversion

The new channel was constructed in 2013 in preparation for the river being diverted in 2014. In June 2014, the NDSFB carried out extensive electrofishing to remove fish from the original Nith channel prior to the water being switched over into the new channel. The Nith was successfully diverted on 16th June 2014. In the year prior to the new channel going "live", in-stream and riparian habitat was created in the form of placement of a diverse range of substrate in the bed of the channel and the planting of willow along the banks of the channel, specifically on the outside of bends to assist in stabilising the banks and preventing excessive erosion.

Electrofishing surveys of this new channel will commence in 2015 to determine its performance as a fish friendly habitat and most specifically with regards to juvenile salmonids. These surveys will be carried out annually for a period of 20 years.

2 This Study

2.1 Aims

This study set out with the following aims:

(a) To utilise a replicable and efficient capture technique for juvenile salmonids suitable for the River Nith at Greenburn OCCS and in its vicinity.

(b) To assess juvenile salmonid population densities, upstream, downstream and within the site boundaries of Greenburn OCCS, post diversionary works.

(c) To produce data to assist in the environmental policy, considerations and safeguards which may be implemented for the general protection of the River Nith catchment and its environs.

(d) To make recommendations to Kier Mining on how best they can continue restoration of the riparian zone surrounding the new river channels causing minimal impacts on salmonid species, from an informed position, based on facts.

(e) To produce data to assess the populations of salmonid species and presence of other species of fish in the Braehead diverted channel.

2.2 Feasibility

In order to accurately survey numbers of juvenile salmonids present in the vicinity of the Greenburn site this study had to take account of the time of year when electrofishing was conducted, and the height of water and general conditions at time of survey. For these reasons the survey was conducted during the summer to ensure efficiency of capture was optimum.

2.3 Site selection

This study conducted electrofishing surveys inside the boundaries of the Greenburn site. Sites were also surveyed, upstream and downstream from the opencast site. The sites were chosen for their accessibility and their habitat containing “typically” juvenile salmonid riffles. Some sites surveyed are historic sites that have previously been surveyed for a number of years. To ensure that those sites were relocated accurately photographic images and global positioning equipment was used.

3 Methods

3.1 Equipment

3.1.1 Electrofishing apparatus

Conductivity in the main stem of the River Nith, inside the site boundaries, at the locations of the sites chosen for this survey was high. The level of conductivity at Greenburn site and at every opencast coal site can be explained by the chemical composition and the mineral content present in the water. For this reason generator apparatus positioned on the bank was employed at all times.

The generator used was a 5.5 horse power petrol driven model specifically designed for electrofishing. This was linked to an *Electracatch International* controller unit WFC6-HV used to supply a smooth DC current. The control unit was linked to a stationary cathode of braided copper (placed in the stream) and one mobile anode, which consisted of a two metre pole with a stainless steel ring (used to draw fish) and an operator controlled switch.

Figure 1 - Electrofishing Equipment

3.1.2 Ancillary equipment

One manually operated banner net, two dip nets with 1.3 metre handles attached were used to capture stunned fish.

3.2 Personnel

To conduct this electrofishing survey, NDSFB utilised the services of their own staff, which are qualified and experienced in the use of electrofishing equipment and capable of conducting such

research. The Scottish Fisheries Co-ordination Centre (SFCC) protocol for electrofishing was adhered to throughout this survey.

For their personal protection all personnel wore floatation vests and waders. All personnel could swim. All members of the team were qualified in first aid, and first aid equipment was available in Fishery Board vehicle present throughout the survey. All field staff involved in the electrofishing survey and in attendance on site at Greenburn had undergone Kiers site induction process prior to going on site equipped with the appropriate personal protection equipment.

3.3 Techniques

To accurately assess the population of juvenile salmonids throughout this survey, a method of electrofishing was adopted which could efficiently capture the appropriate age classes of these species. The method adopted entailed selecting natural features on the river which provided boundaries to each electrofishing site. Features such as shallow riffles at the top and bottom of a section of river were typically utilised. Once a site had been selected, the electrofishing team systematically worked from downstream to upstream following a carefully agreed pattern removing all fish caught. Working in an upstream direction prevents any sediment caused by wading in the river from obscuring the working area.

The anode operator was able to draw stunned fish downstream, assisted by the current, towards the hand-held dip net which was lifted clear of the water after each sweep, to permit the removal of captured fish for transfer into water-filled buckets.

This method of capture for salmonids also captured all other species present in the sites. All fish were returned, unharmed to their original capture sites on completion of examination and data recording.

3.4 Data recording

All fish captured were removed from the survey sites and placed in water-filled buckets and allowed to recover from the temporary stunning effects of electrofishing. The area electrofished at each site was measured and recorded. A global positioning system was employed to record the exact location of each site.

3.5 Data Analysis

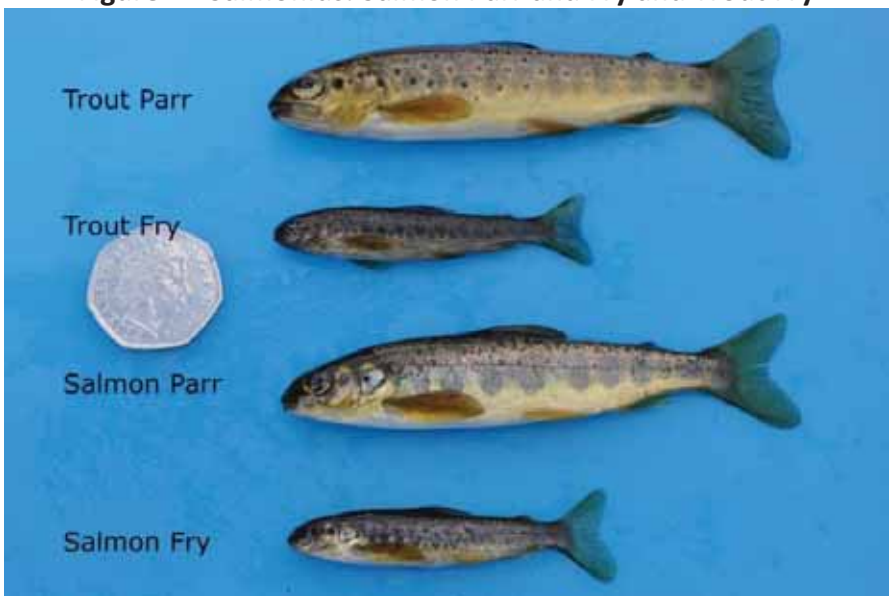
The densities of fry and parr were then classified using the Scottish Fisheries Co-ordination Centre national classification scheme (Godfrey, 2005). This classification scheme categorises the data according to five categories derived using data from over 1600 Scottish sites. This allows the performance of each site surveyed to be demonstrated graphically. See Results.

3.5.1 Salmonid species

Salmonid species were counted and recorded as:
Salmon fry (O^+) which refers to a young fish less than one year old, resulting from spawning at end of 2013.
Salmon parr (1^+) which refers to a young fish which is older than one year old, resulting from spawning at end of 2011/2012.
Trout fry (O^+) which refers to a young fish less than one year old, resulting from spawning at end of 2013.
Trout parr (1^+) which refers to a young fish which is older than one year old, resulting from spawning at end of 2011/2012, or earlier in the case of larger specimens.

Age determination of salmonids has been assessed by the length of individuals captured from each fishing site.

Figure 2 - Salmonids: Salmon Parr and Fry and Trout Fry



3.5.2 Non salmonid species

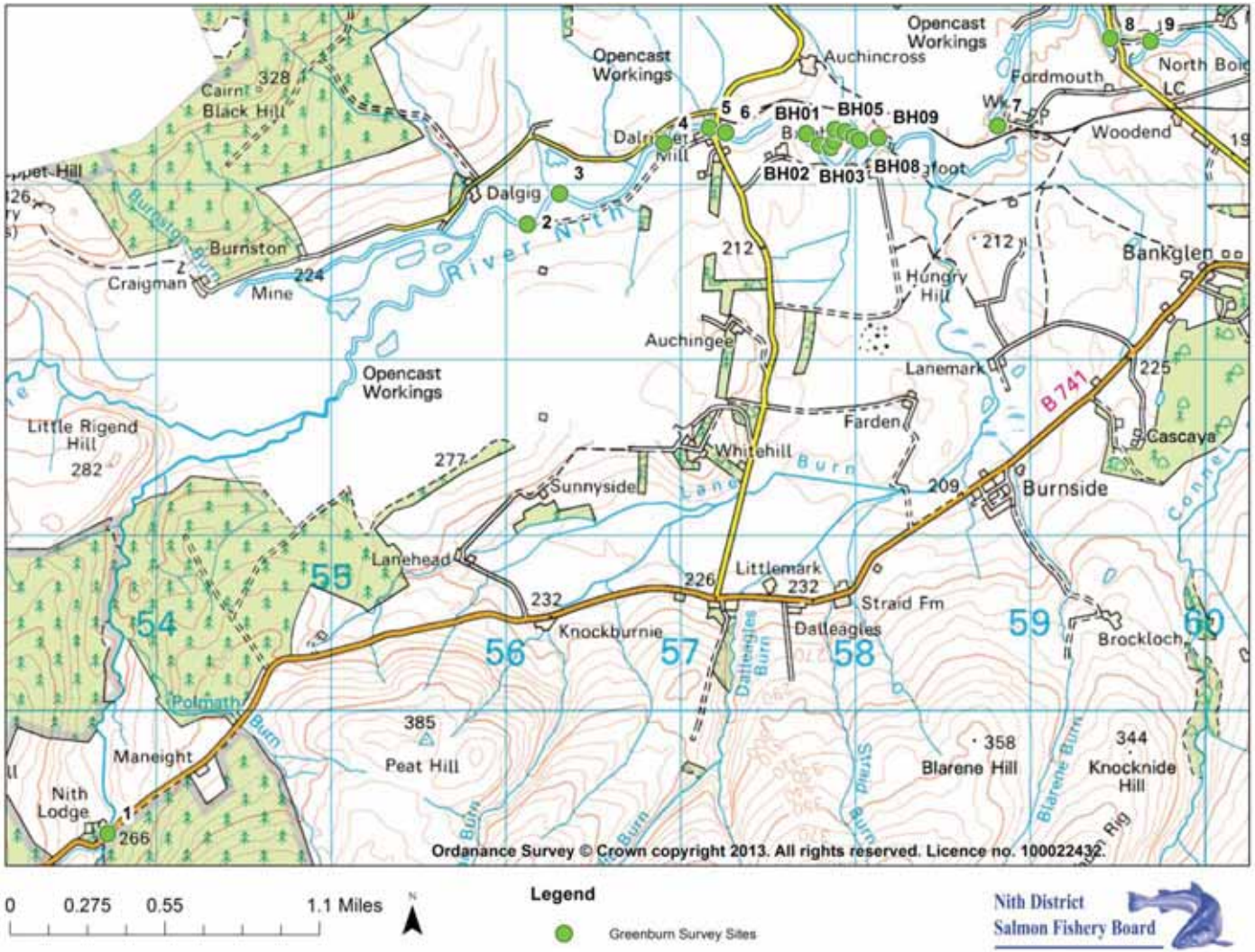
The presence of non salmonid species was recorded at each survey site and population densities were recorded.

3.5.3 Photography

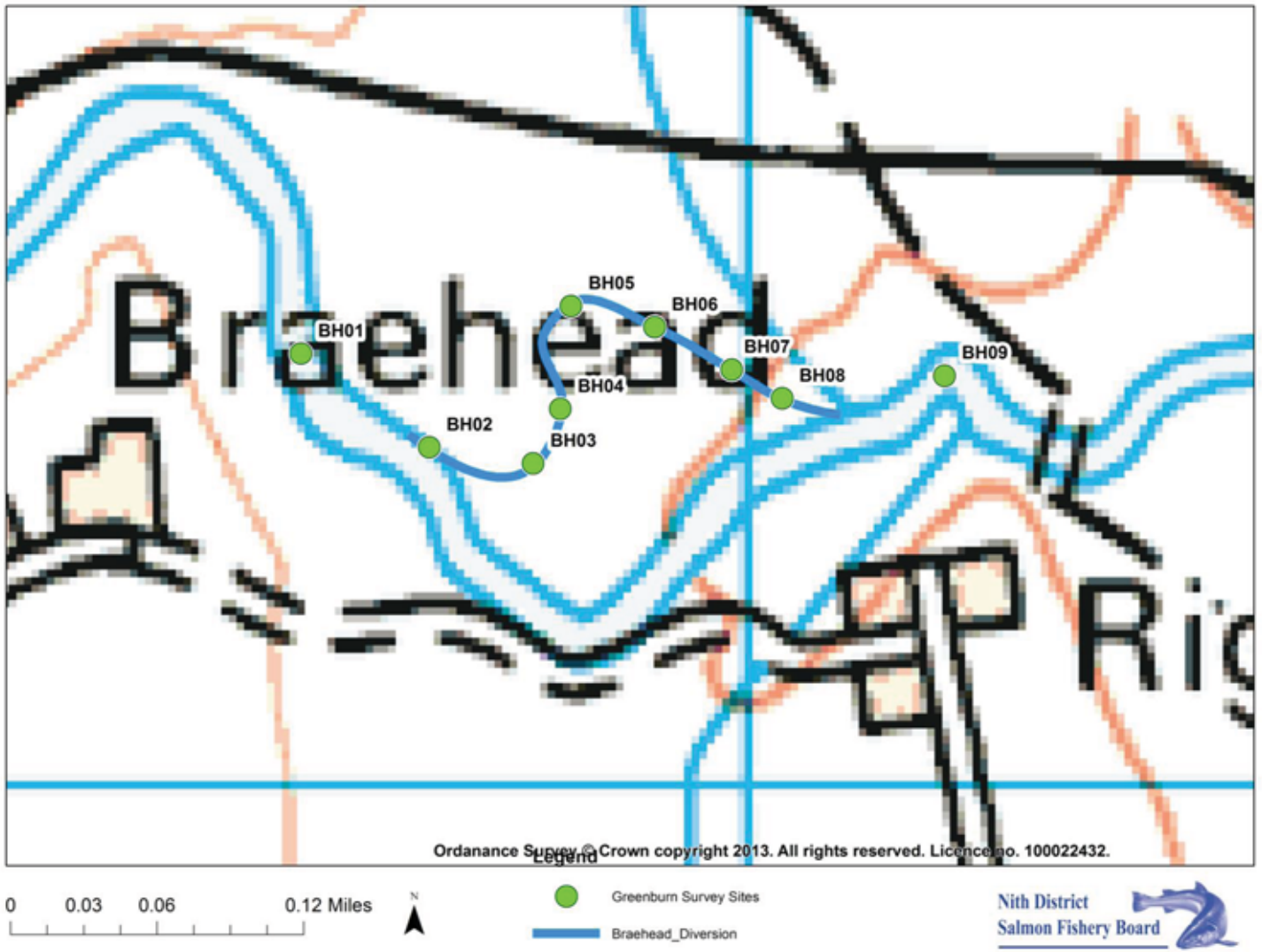
All sites were photographed to provide an accurate record of conditions at time of survey. These photographs are a useful aid in assessing environmental status and recovery of the new river channel. Photographs can also be used to assess the quality of each site with regard to its potential as a salmonid habitat.

In addition to recording the section of river over which electrofishing has been conducted, each photograph provides a record of vegetation present within the riparian zone at each site. Again these will prove valuable in future years when environmental recovery of the site is assessed.

4 Location map of all survey sites for Greenburn Surface Mine



4 Location map of survey sites within Braehead diversion



5 Results of Electrofishing Surveys Conducted During 2014 - Greenburn

Watercourse	Site code	Location	Grid reference	Sampling date	Salmon fry (/100m^2)	Salmon parr (/100m^2)	Trout fry (/100m^2)	Trout parr (/100m^2)	Other species present
Nith	1	20m downstream from road bridge at Nith Lodge	253724 609294	20/08/14	7	9	7	2	SL, M
Nith	2	400m downstream from confluence with Dalgig Burn	256125 612771	05/08/14	56	0	0	0	L, M
Nith	3	Immediately downstream of Kier discharge/corner field	256309 612947	05/08/14	16	2	0	1	E, L, M
Nith	4	100m downstream from confluence with Greenburn	256906 613233	19/08/14	40	12	0	0	P
Nith	5	Upstream of Dalricket Mill road bridge	257166 613322	19/08/14	28	25	0	3	SL
Nith	6	100m downstream of road bridge at Dalricket Mill	257259 613295	19/08/14	25	14	0	3	-
Nith	7	50m downstream of railway bridge at Brickworks	258815 613333	20/08/14	11	27	2	11	SL, M
Nith	8	100m upstream of Boig road bridge	259460 613834	05/08/14	0	28	0	2	SL, M
Nith	9	250m downstream of Boig road bridge	259689 613818	19/08/14	6	21	0	0	SL, M, G

Key to other species:

E	-	Eel	M	-	Minnow
SL	-	Stone Loach	L	-	Lamprey
SB	-	Stickleback	G	-	Grayling
F	-	Flounder	P	-	Pike

Key to classification of salmonids per 100m^2

absent
very poor
poor
moderate
Good
excellent

5 Results of Electrofishing Surveys Conducted During 2014 – Braehead Diversion

Watercourse	Site code	Location	Grid reference	Sampling date	Salmon fry (/100m^2)	Salmon parr (/100m^2)	Trout fry (/100m^2)	Trout parr (/100m^2)	Other species present
Nith	BH01	100m upstream from top of Braehead diversion	257721 613288	20/08/14	21	12	0	6	SL
Nith	BH02	25m downstream of lagoon outlet at top of Braehead	257785 613214	20/08/14	26	10	1	5	-
Nith	BH03	150m downstream from top of Braehead diversion	257861 613209	20/08/14	83	2	0	0	-
Nith	BH04	Upstream of corner closest to railway platform	257879 613245	20/08/14	54	6	4	2	SL
Nith	BH05	Directly on corner closest to railway platform	257886 613313	22/08/14	36	9	0	0	-
Nith	BH06	Downstream of corner closest to train loading bay	257941 613299	22/08/14	25	9	0	0	SL
Nith	BH07	50m downstream from corner closest mine loading platform	257992 613271	22/08/14	15	8	1	5	M
Nith	BH08	25m upstream from bottom of Braehead diversion	258025 613252	22/08/14	72	0	0	0	-
Nith	BH09	100m downstream of end of Braehead diversion	258132 613267	22/08/14	19	8	0	2	SL, M

Key to other species:

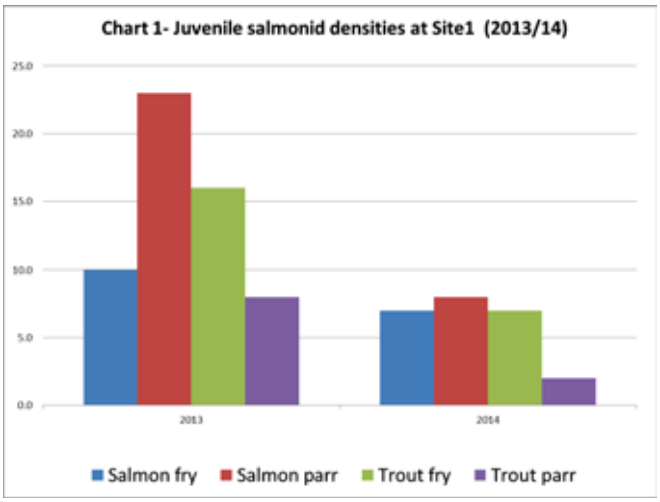
E	-	Eel	M	-	Minnow
SL	-	Stone Loach	L	-	Lamprey
SB	-	Stickleback	G	-	Grayling
F	-	Flounder	P	-	Pike

Key to classification of salmonids per 100m^2

- absent
- very poor
- poor
- moderate
- Good
- excellent

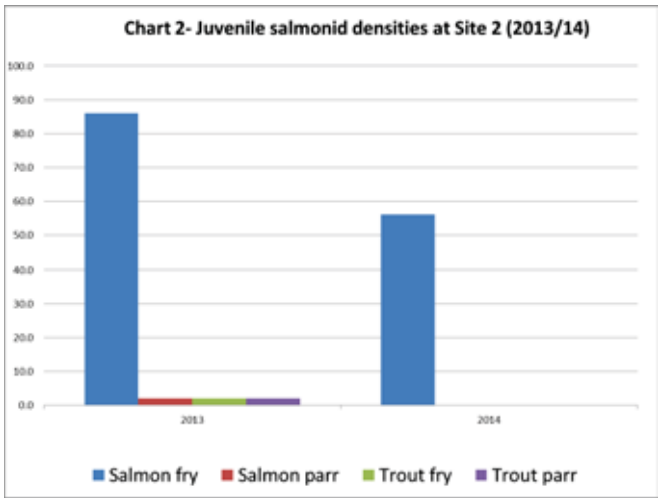
6 Annual survey sites

6.1 Site 1



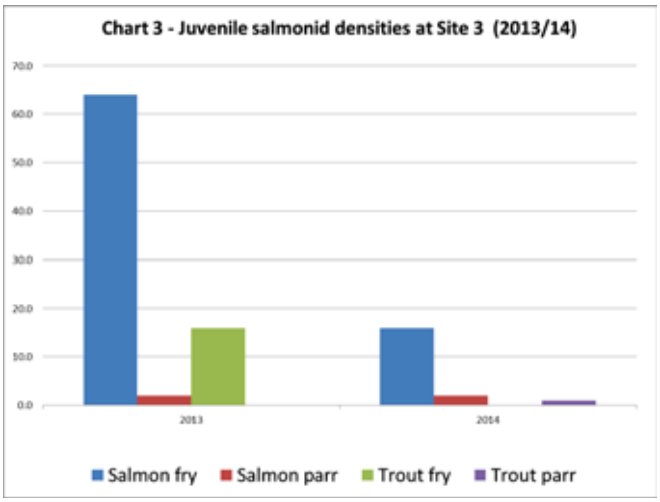
Site 1 is located on the River Nith upstream of any influence by mining activity and therefore acts as a control site. Poor densities of salmon fry and trout parr were found at this site with moderate densities of salmon parr and trout fry. Stone loach and minnow were present.

6.2 Site 2



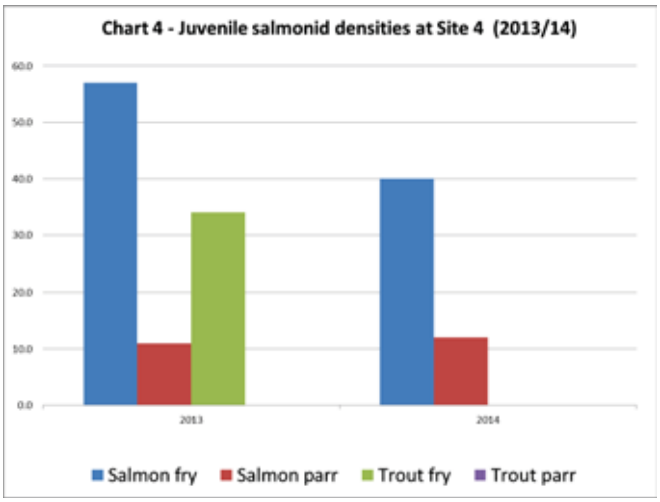
Site 2 is located on the River Nith downstream of the confluence of the former Dalgig Burn, within the Greenburn site. Excellent densities of salmon fry were detected but no salmon parr, trout fry or trout parr were found. This indicated that this site is a spawning area for salmon but it does not contain suitable habitat for parr. Lamprey and minnow were also present in the marginal sections of this site.

6.3 **Site 3**



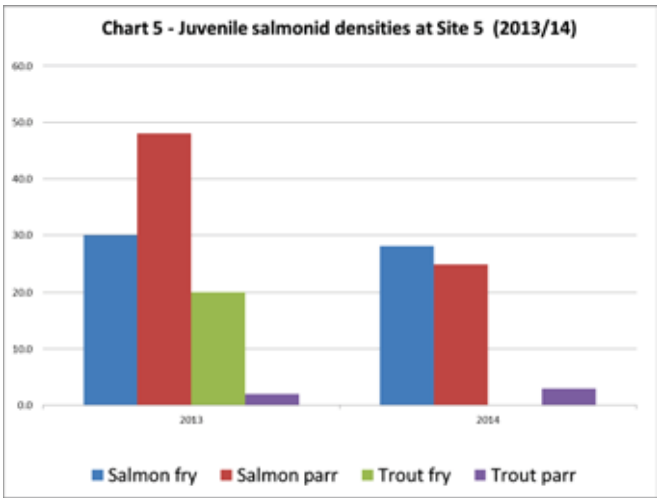
Site 3 is located immediately downstream from the outlet of Dalgig lagoons. Moderate densities of salmon fry were found at this site along with poor densities of salmon parr and trout parr. No trout fry were found. An eel was captured at this site along with lamprey and minnow.

6.4 **Site 4**



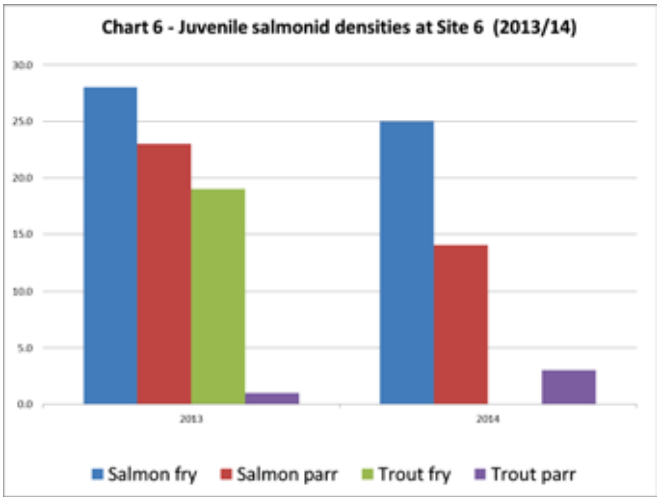
Site 4 is located downstream of the confluence with the Greenburn Burn. This site contained good densities of salmon fry and parr but no trout were present. A small pike was also captured at this site.

6.5 **Site 5**



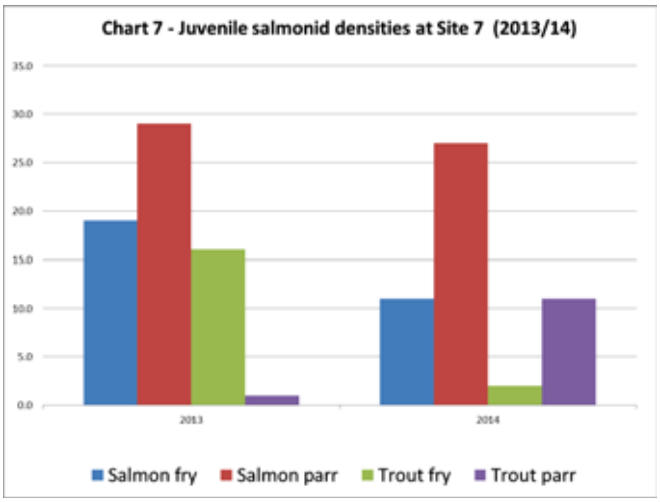
Site 5 is located on the River Nith upstream of Dalricket Mill Bridge. Good densities of salmon fry and excellent densities of salmon parr were present in this site. Poor densities of trout parr were also found along with some stone loach. No trout fry were present.

6.6 **Site 6**



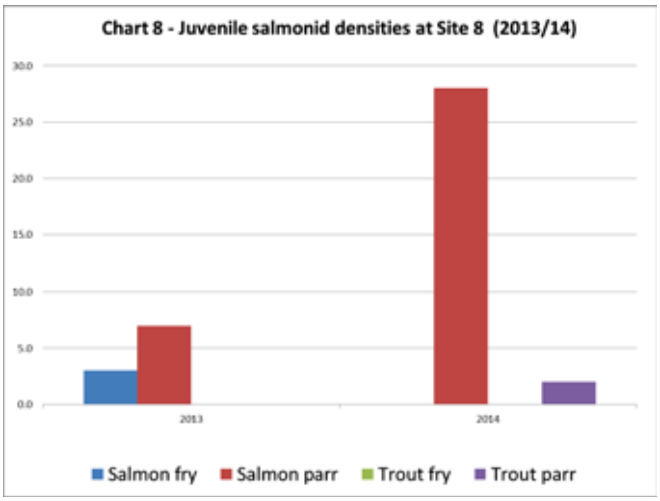
Site 6 is located on the River Nith downstream of Dalricket Mill Bridge. Surveys revealed good densities of salmon fry and parr but no trout fry and poor numbers of trout parr. No other fish species were present.

6.7 **Site 7**



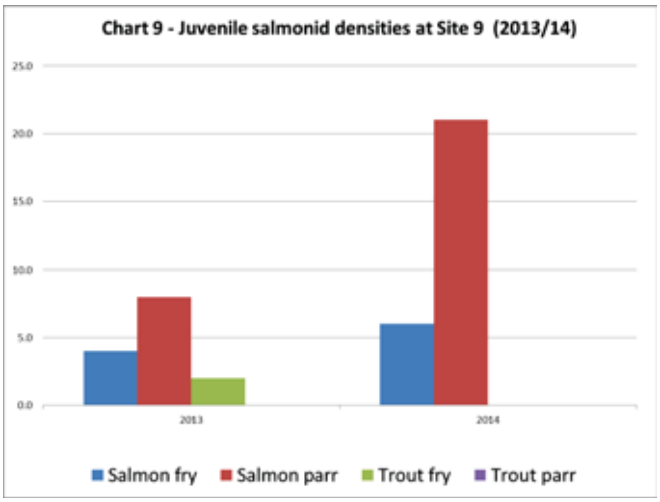
Site 7 is located on the River Nith downstream of the Railway Bridge at the disused brickworks. This site contains very good parr habitat and accordingly excellent densities of both salmon and trout parr were present. Habitat here is not suitable for fry as indicated by the moderate densities of salmon fry and poor densities of trout fry found.

6.8 **Site 8**



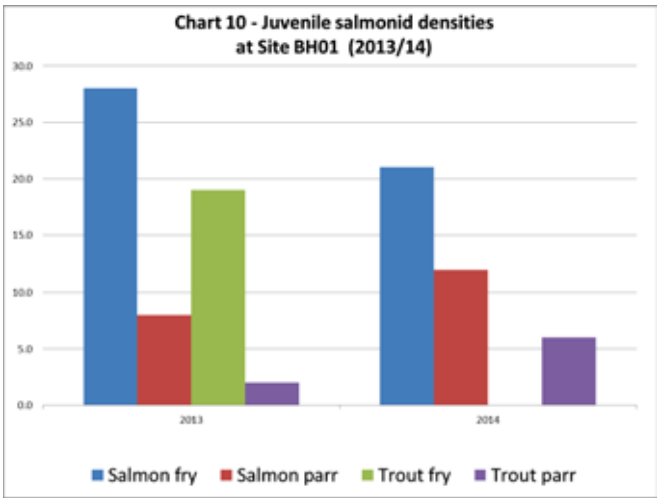
Site 8 is located on the River Nith upstream of Boig Road Bridge. Site 8 contains good parr habitat and contained excellent densities of salmon parr. A couple of trout parr were also present but no fry. Stone loach and minnow were also found.

6.9 **Site 9**



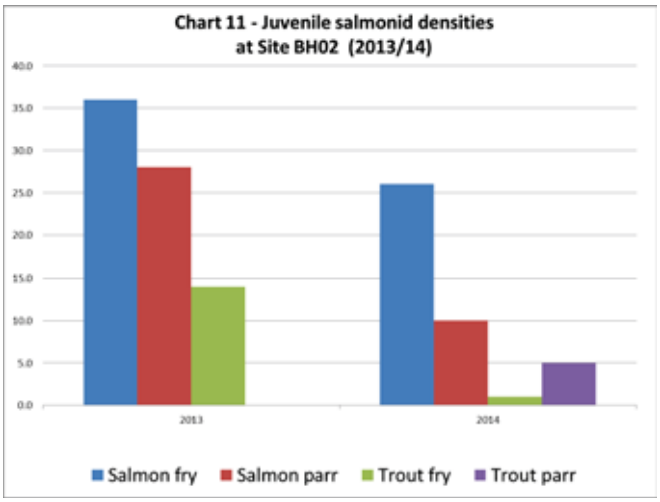
Site 9 is located on the River Nith downstream of Boig Road Bridge. Again this is another good parr site and contained excellent densities of salmon parr and poor numbers of salmon fry. No trout were present but stone loach, minnow and grayling were captured during the course of the survey.

6.10 **Site BH01**



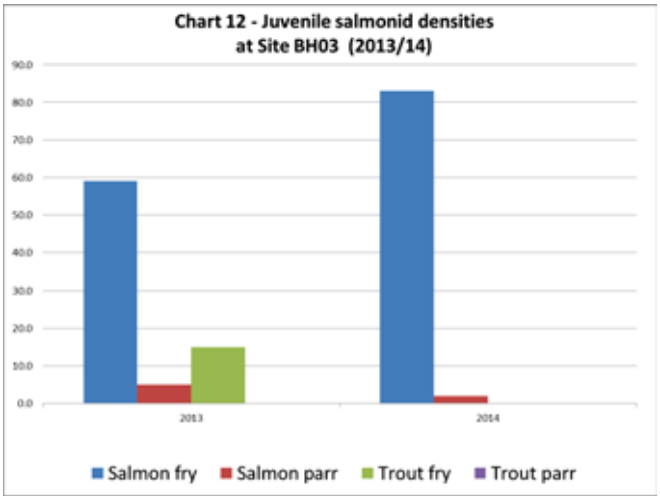
Site BH01 is located on the River Nith upstream of Braehead diversion channel. This site is used as a control. Electrofishing surveys revealed good densities of salmon fry and parr and trout parr. No trout fry were detected but stone loach were.

6.11 **Site BH02**



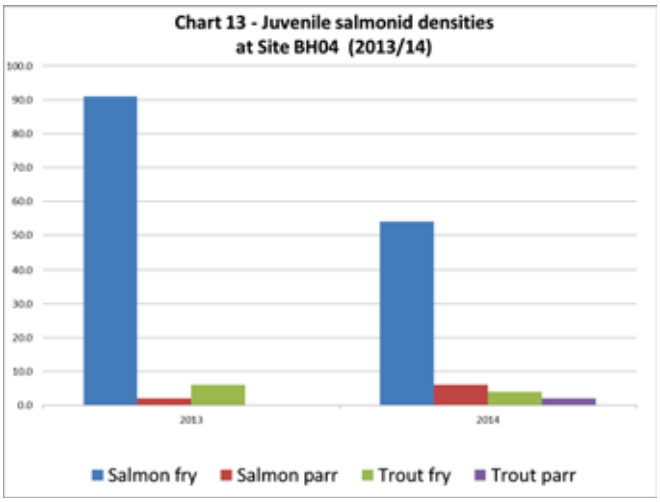
Site BH02 is located on the River Nith, 25m downstream of the lagoon outlet at the top of the Braehead diversion channel. This site contained good densities of salmon fry and parr and trout parr. Only one trout fry was found. Overall, there has been a decrease in the salmon fry, salmon parr and trout fry densities but trout parr were present this year.

6.12 **Site BH03**



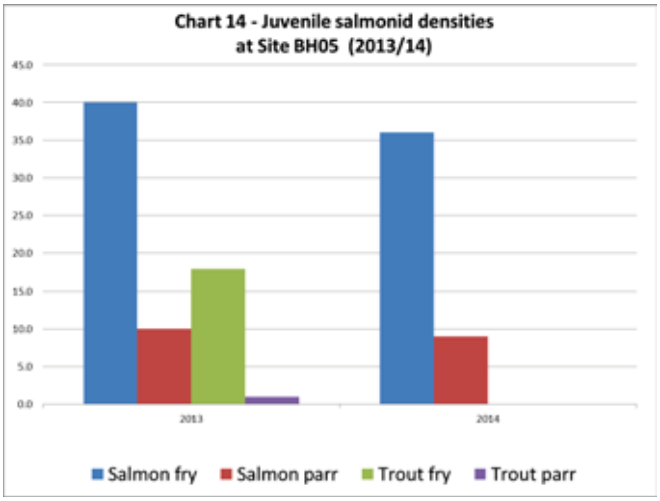
Site BH03 is located on the River Nith, 150m downstream from the top of Braehead diversion channel. Excellent numbers of salmon fry were present at this site but very poor numbers of salmon parr. When compared to 2013, there has been an increase in the number of salmon fry present but a decrease in the number of salmon parr and trout fry.

6.13 **Site BH04**



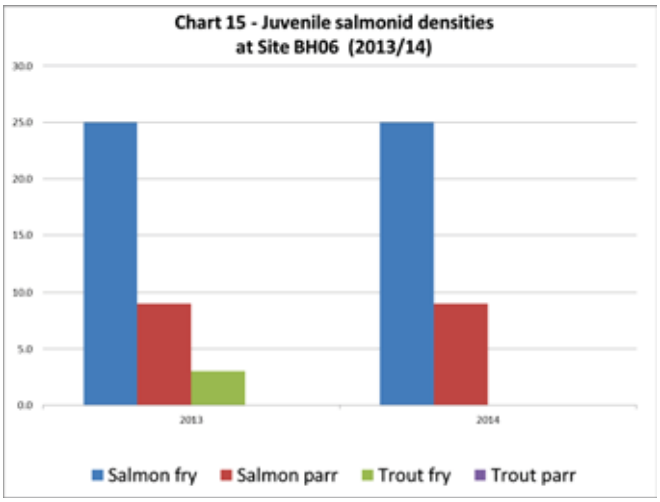
Site BH04 is located within the Braehead diversion channel on the River Nith, upstream of the corner closest to the railway loading platform. Surveys carried out at this site revealed excellent densities of salmon fry, moderate densities of salmon parr and poor densities of trout fry and parr. Stone loach were present here. When compared to 2013, there has been decrease in the number of salmon and trout fry present but an increase in number of salmon parr and trout parr.

6.14 **Site BH05**



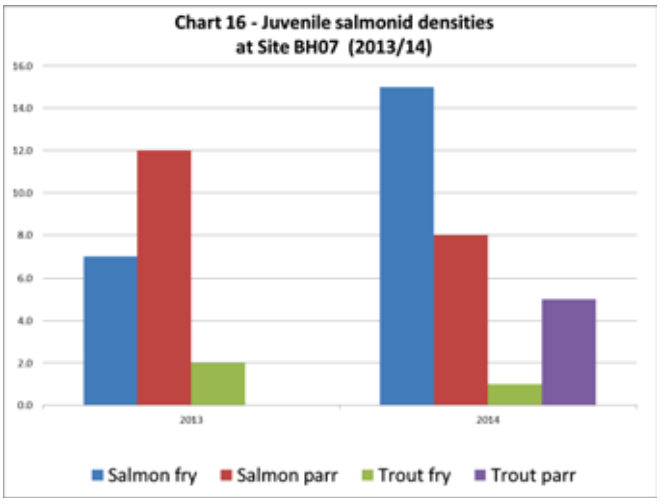
Site BH05 is located within the Braehead diversion channel on the River Nith, directly on the corner closest to the railway loading platform. Good densities of salmon fry and parr were found but no trout were present. Compared to 2013, there has been a slight decrease in the number of juvenile salmon present.

6.15 **Site BH06**



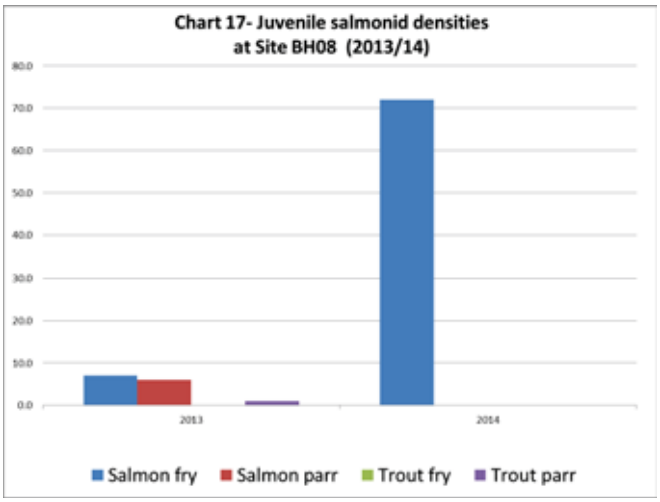
Site BH06 is located within the Braehead diversion channel on the River Nith, downstream of the corner closest to the railway loading platform. Again good densities of salmon fry and parr were found at this site but no trout fry or parr were present. There has been no change in the number of juvenile salmon found.

6.16 **Site BH07**



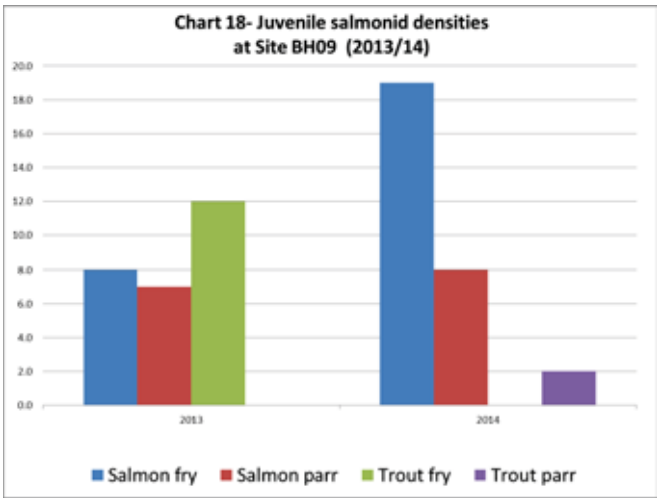
Site BH07 is located within the Braehead diversion channel on the River Nith, 50m downstream of the corner closest to the railway loading platform. Moderate numbers of salmon fry and parr were found to be present along with very poor trout fry densities but good numbers of trout parr. Minnow were also present. This section contains large boulders which make an ideal habitat for parr. In comparison to 2013, more salmon fry and trout parr were present but fewer salmon parr and trout fry.

6.17 **Site BH08**



Site BH08 is located within the Braehead diversion channel on the River Nith, 25m upstream from the bottom of the diversion channel. Surveys revealed excellent densities of salmon fry at this site but no other juvenile salmonids.

6.18 **Site BH09**



Site BH09 is located out with the Braehead diversion channel on the River Nith, 100m downstream of the end of the diversion channel. This site contained moderate densities of salmon fry and parr, no trout fry and poor numbers of trout parr. Stone loach and minnow were present. In comparison with 2013, there has been an increase in the number of juvenile salmon and trout parr.

7 Discussion

Throughout the annual sites, healthy densities of juvenile salmon were found at most sites. When compared to fish data from other main stem Nith sites surveyed during 2014 (41 in total) , it is apparent that densities of juvenile salmonids in this Greenburn survey are similar to those found in the rest of the river. Juvenile trout densities are at concerning levels thoughout the entire system and have been for some time. Again the densities found at Greenburn are replicated throughout the other parts of the main stem River Nith.

Sites	Salmon fry	Salmon parr	Trout fry	Trout parr
Greenburn	30	11	1	2
Nith - main stem	31	9	1	2

Chart 19 – comparison of average densities of salmonids at sites located within the Greenburn surveys with other main stem Nith sites.

Key to classification of salmonids per 100m^2

8 Conclusions

This study concludes that:

- Salmonid species of fish migrated through the diversion channel.
- Salmonid species of fish successfully spawned upstream, within and downstream of the diversion channel.
- Parr aged salmonids have taken up residency within the diversion channel.
- Silt remains within the substrate of the diversion channel but is much reduced form that found in 2013.
- Maturing riparian vegetation is likely to promote higher densities of all fish species.
- The sites surveyed at Greenburn contain comparable densities of fish to other similar sites located throughout the River Nith system.

9 References

Leslie, T. 2000. The Economic Importance of Salmon Angling In Scotland: The River Nith to Dumfries and Galloway and The River Tweed to the Borders. University of Stirling, 2000.

Nith District Salmon Fishery Board, 2014. The River Nith District Salmon Fishery Board, Management Report And Review 2013 Season. Nith District Salmon Fishery Board, Dumfries.

Godfrey, J.D. 2005. Site Condition Monitoring of Atlantic Salmon SACs. Scottish Fisheries Co-ordination Centre 2005.

APPENDIX C: River Habitat Surveys, East Diversion – Environ, 2013 and 2014

RIVER HABITAT SURVEY 2003 Version

A FIELD SURVEY DETAILS

Site Number: (leave blank if new site)

Site Reference: RIVER NITH EAST

Spot-check 1 Grid Ref: NS 58061 13253

Spot-check 6 Grid Ref: NS 57895 13338

End of site Grid Ref: NS 57799 13229

Reach Reference:

River name: NITH

Date 28/08/2013 Time: 10AM

Surveyor name: ADAM FITCHET
NADINE LITTLE

Accredited Surveyor code:

Is the site part of a river or an artificial channel? River ☑ Artificial ☐

Are adverse conditions affecting survey? No ☑ Yes ☐

If yes, state N/A

Is bed of river visible? barely or not ☐ partially ☐ ±entirely ☑

Is health and safety assessment form attached? Yes ☐ No ☑

Number of photographs taken: 11

Photo references:

Site surveyed from: left bank ☑ right bank ☐ channel ☐

☐ **When options shown with 'shadow boxes', tick one box only**

LEFT banks determined by facing downstream RIGHT

B PREDOMINANT VALLEY FORM (within the horizon limit) (tick one box only)

(tick one box only)


☐ shallow vee


☐ deep vee


☐ gorge


☐ concave/bowl


☐ asymmetrical valley


☑ U-shape valley

☐ no obvious valley sides

Distinct flat valley bottom? No ☐ Yes ☑

Natural terraces? No ☑ Yes ☐

C NUMBER OF RIFFLES, POOLS AND POINT BARS (enter total number in boxes)

Riffle(s)	9	Unvegetated point bar(s)	4
Pool(s)	0	Vegetated point bar(s)	1

D ARTIFICIAL FEATURES (indicate total number of occurrences of each category within the 500m site)

If none, tick box ☑

	Major	Intermediate	Minor		Major	Intermediate	Minor
Weirs/sluices				Outfalls/ intakes			
Culverts				Fords			
Bridges				Deflectors/ groynes/croys			
Other - state							

Is channel obviously realigned? No ☐ Yes, <33% of site ☐ ≥33% of site ☑

Is channel obviously over-deepened? No ☑ Yes, <33% of site ☐ ≥33% of site ☐

Is water impounded by weir/dam? No ☑ Yes, <33% of site ☐ ≥33% of site ☐

SITE REF. RIVER NITH EAST | **RIVER HABITAT SURVEY: TEN SPOT-CHECKS** | **Page 2 of 4**

Spot-check 1 is at: upstream end ☐ downstream end ☑ of site (tick one box)

E PHYSICAL ATTRIBUTES (to be assessed across channel within 1m wide transect)

When boxes 'bordered', only one entry allowed	1 GPS	2	3	4	5	6 GPS	7	8	9	10	GPS
LEFT BANK	Ring EC or SC if composed of sandy substrate										
Material NV, BE, BO, CO, GS, EA, PE, CL, CC, SP, WP, GA, BR, RR, TD, FA, BI	BI	EA	EA	EA	EA	EA	EA	EA	EA	BI	
Bank modification(s) NK, NO, RS, RI, PC(B), BM, EM	RS	RS	RS	RS	RS	RS	NO	NO	NO	RS	
Marginal & bank feature(s) NV, NO, EC, SC, PB, VP, SB, VS, NB	VS	VS	NO	RR	RR	RR	NO	NO	NO	RR	
CHANNEL	GP- ring either G or P if predominant										
Channel substrate NV, BE, BO, CO, GP, SA, SI, CL, PE, EA, AR	GP	CO	CO	CO	CO	CO	CO	CO	CO	CO	
Flow-type NV, FF, CH, BW, UW, CF, RP, UP, SM, NP, DR	RP	UW	UW	UW	RP	RP	SM	UW	UW	UW	
Channel modification(s) NK, NO, CV, RS, RI, DA, FO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	
Channel feature(s) NV, NO, EB, RO, VR, MB, VB, MI, TR	VR	RO	RO	RO	RO	NO	NO	PB	NO	RO	
For braided rivers only: number of sub-channels											
RIGHT BANK	Ring EC or SC if composed of sandy substrate										
Material NV, BE, BO, CO, GS, EA, PE, CL, CC, SP, WP, GA, BR, RR, TD, FA, BI	BI	EA	CL	EA	EA	EA	EA	EA	CO	BI	
Bank modification(s) NK, NO, RS, RI, PC(B), BM, EM	RS	RS	RS	RS	RS	RS	RS	RS	NO	RS	
Marginal & bank feature(s) NV, NO, EC, SC, PB, VP, SB, VS, NB	NO	NO	NO	NO	NO	NO	NO	NO	SB	RR	

Enter channel substrate(s) not occurring as predominant in spot-checks but present in >1% of whole site. ↑

F BANKTOP LAND-USE AND VEGETATION STRUCTURE (to be assessed over a 10m wide transect)

Land-use: choose one from BL, BP, CW, CP, SH, OR, WL, MH, AW, OW, RP, IG, TH, RD, SU, TL, IL, PG, NV

LAND-USE WITHIN 5m OF LEFT BANKTOP	IG	IG	IG	IG	IG	IG	IG	IG	IG	IG	
LEFT BANKTOP (structure within 1m) B/U/S/C/NV	U	U	U	U	U	U	U	U	U	U	
LEFT BANK-FACE (structure) B/U/S/C/NV	U	U	U	U	U	U	U	U	U	U	
RIGHT BANK-FACE (structure) B/U/S/C/NV	U	U	U	S	S	U	U	U	B	U	
RIGHT BANKTOP (structure within 1m) B/U/S/C/NV	U	U	U	S	S	U	U	U	S	U	
LAND-USE WITHIN 5m OF RIGHT BANKTOP	IG	IG	IG	TH	TH	IG	IG	IG	TH	IG	

G CHANNEL VEGETATION TYPES (to be assessed over a 10m wide transect: use E (≥ 33% area), ✓ (present) or NV (not visible))

None (✓) or Not Visible (NV)											NV
Liverworts/mosses/lichens									✓	✓	✓
Emergent broad-leaved herbs											NV
Emergent reeds/sedges/rushes/grasses/horsetails				✓						✓	✓
Floating-leaved (rooted)	✓	✓	✓		✓	✓		✓	✓		E
Free-floating											NV
Amphibious											NV
Submerged broad-leaved											NV
Submerged linear-leaved											NV
Submerged fine-leaved											NV
Filamentous algae								✓			✓

Use end column for overall assessment over 500m, including types not occurring in spot-checks (use ✓, E or NV) ↑

SITE REF. RIVER NITH EAST

RIVER HABITAT SURVEY : 500m SWEEP-UP

H LAND-USE WITHIN 50m OF BANKTOP

Use ✓ (present) or E (≥ 33% banklength)

	L	R		L	R
Broadleaf/mixed woodland (semi-natural) (BL)			Natural open water (OW)		
Broadleaf/mixed plantation (BP)	✓	✓	Rough/unimproved grassland/pasture (RP)		
Coniferous woodland (semi-natural) (CW)			Improved/semi-improved grassland (IG)	✓	✓
Coniferous plantation (CP)			Tall herb/rank vegetation (TH)		
Scrub & shrubs (SH)			Rock, scree or sand dunes (RD)		
Orchard (OR)			Suburban/urban development (SU)		
Wetland (e.g. bog, marsh, fen) (WL)			Tilled land (TL)		✓
Moorland/heath (MH)			Irrigated land (IL)		
Artificial open water (AW)			Parkland or gardens (PG)		
			Not visible (NV)		

I BANK PROFILES

Use ✓ (present) or E (≥ 33% banklength)

Natural/unmodified	L	R	**Artificial/modified**	L	R
Vertical/undercut		✓	Resectioned (reprofiled)		
Vertical with toe			Reinforced - whole		
Steep (>45°)		✓	Reinforced - top only		
Gentle	✓		Reinforced - toe only	✓	
Composite			Artificial two-stage		
Natural berm			Poached bank		
			Embanked		
			Set-back embankment		

J EXTENT OF TREES AND ASSOCIATED FEATURES

*record even if <1%

TREES (tick one box per bank)

	Left	Right
None	☐	☐
Isolated/scattered	☑	☑
Regularly spaced, single	☐	☐
Occasional clumps	☐	☐
Semi-continuous	☐	☐
Continuous	☐	☐

ASSOCIATED FEATURES (tick one box per feature)

	None	Present	E (≥33%)
Shading of channel	☑	☐	☐
*Overhanging boughs	☑	☐	☐
*Exposed bankside roots	☑	☐	☐
*Underwater tree roots	☑	☐	☐
Fallen trees	☑	☐	☐
Large woody debris	☑	☐	☐

K EXTENT OF CHANNEL AND BANK FEATURES

(tick one box for each feature) *record even if <1%

	None	Present	E (≥33%)		None	Present	E (≥33%)
*Free fall flow	☑	☐	☐	Exposed bedrock	☑	☐	☐
Chute flow	☑	☐	☐	Exposed boulders	☐	☐	☑
Broken standing waves	☑	☐	☐	Vegetated bedrock/boulders	☑	☐	☐
Unbroken standing waves	☐	☑	☐	Unvegetated mid-channel bar(s)	☑	☐	☐
Rippled flow	☐	☐	☑	Vegetated mid-channel bar(s)	☑	☐	☐
*Upwelling	☑	☐	☐	Mature island(s)	☑	☐	☐
Smooth flow	☐	☑	☐	Unvegetated side bar(s)	☐	☑	☐
No perceptible flow	☑	☐	☐	Vegetated side bar(s)	☐	☑	☐
No flow (dry)	☑	☐	☐	Unvegetated point bar(s)	☐	☑	☐
Marginal deadwater	☑	☐	☐	Vegetated point bar(s)	☐	☑	☐
Eroding cliff(s)	☐	☑	☐	*Unvegetated silt deposit(s)	☑	☐	☐
Stable cliff(s)	☑	☐	☐	*Discrete unvegetated sand deposit(s)	☑	☐	
				*Discrete unvegetated gravel deposit(s)	☑	☐	

SITE REF. RIVER NITH EAST

RIVER HABITAT SURVEY : DIMENSIONS AND INFLUENCES

L CHANNEL DIMENSIONS (to be measured at one location on a straight uniform section, preferably across a riffle)

LEFT BANK		CHANNEL		RIGHT BANK	
Banktop height (m)	2	Bankfull width (m)	4	Banktop height (m)	2
Is banktop height also bankfull height? (Y or N)	N	Water width (m)	3	Is banktop height also bankfull height? (Y or N)	Y
Embanked height (m)	—	Water depth (m)	0·2	Embanked height (m)	—

If trashline lower than banktop, indicate: height above water (m) = — width from bank to bank (m) = —

Bed material at site is: consolidated ☐ unconsolidated (loose) ☑ unknown ☐

Location of measurements is: riffle ☑ other ☐ (state)

M FEATURES OF SPECIAL INTEREST Use ✓ or E (≥ 33% length) *record even if <1%

None	☑	Very large boulders (>1m)	☐	Backwater(s)	☐	Marsh(es)	☐
Braided channels	☐	*Debris dam(s)	☐	Floodplain boulder deposits	☐	Flush(es)	☐
Side channel(s)	☐	*Leafy debris	☐	Water meadow(s)	☐	Natural open water	☐
*Natural waterfall(s) > 5m high	☐	Fringing reed-bank(s)	☐	Fen(s)	☐	Others (state)	☐
*Natural waterfall(s) < 5m high	☐	Quaking bank(s)	☐	Bog(s)	☐		
Natural cascade(s)	☐	*Sink hole(s)	☐	Wet woodland(s)	☐		

N CHOKED CHANNEL (tick one box)

Is 33% or more of the channel choked with vegetation? No ☑ Yes ☐

O NOTABLE NUISANCE PLANT SPECIES Use ✓ or E (> 33% length) *record even if <1%

	bankface	banktop to 50m		bankface	banktop to 50m
None ☑					
*Giant hogweed	☐	☐	*Himalayan balsam	☐	☐
*Japanese knotweed	☐	☐	*Other (state).....	☐	☐

P OVERALL CHARACTERISTICS (Circle appropriate words, add others as necessary)

Major impacts: landfill - tipping - (litter) - sewage - pollution - drought - abstraction - mill - dam - road - rail - industry - housing - (mining) - quarrying - overdeepening - afforestation - fisheries management - silting - waterlogging - hydroelectric power

Evidence of recent management: dredging - bank mowing - weed cutting - enhancement - (river rehabilitation) - gravel extraction - other (please specify)

Animals: (otter) - mink - water vole - kingfisher - dipper - grey wagtail - sand martin - heron - dragonflies - (damselflies)

Other significant observations: if necessary use separate sheet to describe overall characteristics and relevant observations

Q ALDERS (tick one box in each of the two categories) *record even if <1%

*Alders? None ☐ Present ☑ Extensive ☐ | *Diseased Alders? None ☑ Present ☐ Extensive ☐

R FIELD SURVEY QUALITY CONTROL (✓ boxes to confirm checks)

Have you taken at least two photos that illustrate the general character of the site and additional photos of any weirs/ sluices and major/intermediate structures across the channel?	☑
Have you completed all ten spot-checks and made entries in all boxes in E & F on page 2?	☑
Have you completed column 11 of section G (and E if appropriate) on page 2?	☑
Have you recorded in section C the number of riffles, pools and point bars (even if 0) on page 1?	☑
Have you given an accurate (alphanumeric) grid reference for spot-checks 1, 6 and end of site (page 1)?	☑
Have you stated whether spot-check 1 is at the upstream or downstream end of the site (top of page 2)?	☑
Have you cross-checked your spot-check and sweep-up responses with the channel modification indicators given on page 2 of the spot-check key?	☑

A FIELD SURVEY DETAILS

Site Number: (leave blank if new site)

Site Reference: RIVER NITH EAST

Spot-check 1 Grid Ref: NS 58061 13253

Spot-check 6 Grid Ref: NS 57876 13317

End of site Grid Ref: NS 57799 13229

Reach Reference:

River name: NITH

Date 19/08/2014 Time: 1020

Surveyor name: A FITCHET
E HELLAND

Accredited Surveyor code: —

Is the site part of a river or an artificial channel? River ☑ Artificial ☐

Are adverse conditions affecting survey? No ☑ Yes ☐

If yes, state —

Is bed of river visible? barely or not ☐ partially ☐ ±entirely ☑

Is health and safety assessment form attached? Yes ☐ No ☑

Number of photographs taken: 10

Photo references:

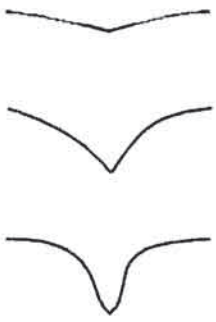
Site surveyed from: left bank ☑ right bank ☐ channel ☐

☐ When options shown with 'shadow boxes', tick one box only

LEFT banks determined by facing downstream RIGHT

B PREDOMINANT VALLEY FORM within the horizon limits (tick one box only)

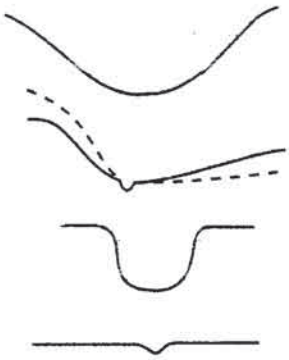
(tick one box only)



☐ shallow vee

☐ deep vee

☐ gorge



☐ concave/bowl

☐ asymmetrical valley

☑ U-shape valley

☐ no obvious valley sides

Distinct flat valley bottom? No ☐ Yes ☑

Natural terraces? No ☑ Yes ☐

C NUMBER OF RIFFLES, POOLS AND POINT BARS (enter number of boxes)

Riffle(s)	9	Unvegetated point bar(s)	0
Pool(s)	0	Vegetated point bar(s)	3

D MAN-MADE FEATURES

If none, tick box ☑

	Major	Intermediate	Minor		Major	Intermediate	Minor
Weirs/sluices				Outfalls/ intakes			
Culverts				Fords			
Bridges				Deflectors/ groynes/croys			
Other - state							

Is channel obviously realigned? No ☐ Yes, <33% of site ☐ ≥33% of site ☑

Is channel obviously over-deepened? No ☑ Yes, <33% of site ☐ ≥33% of site ☐

Is water impounded by weir/dam? No ☑ Yes, <33% of site ☐ ≥33% of site ☐

SITE REF. RIVER NITH EAST | **RIVER HABITAT SURVEY: TEN SPOT-CHECKS** | Page 2 of 4

Spot-check 1 is at: upstream end ☐ downstream end ☑ of site (tick one box)

When boxes 'bordered', only one entry allowed	1 GPS	2	3	4	5	6 GPS	7	8	9	10	GPS
LEFT BANK											
Material NV, BE, BO, CO, GS, EA, PE, CL, CC, SP, WP, GA, BR, RR, TD, FA, BI	NV	NV	NV	EA	NV	NV	NV	NV	NV	NV	
Bank modification(s) NK, NO, RS, RI, PC(B), BM, EM	NO	No	No	RS	RS	No	No	No	No	No	
Marginal & bank feature(s) NV, NO, EC, SC, PB, VP, SB, VS, NB	NO	No	No	No	No	No	No	No	No	No	
CHANNEL											
Channel substrate NV, BE, BO, CO, GP, SA, SI, CL, PE, EA, AR	GP	GP	GP	GP	GP	GP	GP	GP	GP	GP	
Flow-type NV, FF, CH, BW, UW, CF, RP, UP, SM, NP, DR	UW	RP	UW	UW	UW	UW	UW	UW	RP	UW	
Channel modification(s) NK, NO, CV, RS, RI, DA, FO	NO	No	No	No	No	No	No	No	No	No	
Channel feature(s) NV, NO, EB, RO, VR, MB, VB, MI, TR	RO	RO	RO	RO	RO	RO	NO	VR	RO	VR	
For braided rivers only: number of sub-channels	~~NO~~	1		~~VR~~	~~VR~~	~~VS~~		~~VS~~			
RIGHT BANK											
Material NV, BE, BO, CO, GS, EA, PE, CL, CC, SP, WP, GA, BR, RR, TD, FA, BI	BO	EA	EA	NV	NV	NV	NV	EA	EA	EA	
Bank modification(s) NK, NO, RS, RI, PC(B), BM, EM	RS	No	RS	NO	NO	No	No	No	No	RS	
Marginal & bank feature(s) NV, NO, EC, SC, PB, VP, SB, VS, NB	NO	NO	No	VP	VP	VS	No	VS	No	NO	

Enter channel substrate(s) not occurring as predominant in spot-checks but present in >1% of whole site.

F BANKTOP/LAND-USE AND VEGETATION STRUCTURE

Land-use: choose one from BL, BP, CW, CP, SH, OR, WL, MH, AW, OW, RP, IC, TH, RD, SU, TL, IL, PG, NV

	1 GPS	2	3	4	5	6 GPS	7	8	9	10	GPS
LAND-USE WITHIN 5m OF LEFT BANKTOP	IG	IG	IG	IG	IG	IG	IG	IG	IG	IG	
LEFT BANKTOP (structure within 1m) B/U/S/C/NV	S	S	S	S	S	S	S	S	S	S	
LEFT BANK-FACE (structure) B/U/S/C/NV	S	S	S	S	S	S	S	S	S	S	
RIGHT BANK-FACE (structure) B/U/S/C/NV	NV	S	S	S	S	S	S	S	S	S	
RIGHT BANKTOP (structure within 1m) B/U/S/C/NV	S	S	S	S	S	S	S	S	S	S	
LAND-USE WITHIN 5m OF RIGHT BANKTOP	IG	IG	IG	IG	IG	IG	IG	IG	IG	IG	

G CHANNEL VEGETATION TYPES

	1 GPS	2	3	4	5	6 GPS	7	8	9	10	GPS
None (✓) or Not Visible (NV)	✓				✓			✓		✓	
Liverworts/mosses/lichens											
Emergent broad-leaved herbs											
Emergent reeds/sedges/rushes/grasses/horsetails											
Floating-leaved (rooted)											
Free-floating											
Amphibious											
Submerged broad-leaved		✓									
Submerged linear-leaved		✓	✓	✓		✓	✓				
Submerged fine-leaved											
Filamentous algae									✓		

Use end column for overall assessment over 500m, including types not occurring in spot-checks (use ✓, E or NV)

SITE REF. RIVER NITH E | **RIVER HABITAT SURVEY : 500m SWEEP-UP** | **Page 3 of 4**

	L	R		L	R
Broadleaf/mixed woodland (semi-natural) (BL)			Natural open water (OW)		
Broadleaf/mixed plantation (BP)	✓	✓	Rough/unimproved grassland/pasture (RP)		
Coniferous woodland (semi-natural) (CW)			Improved/semi-improved grassland (IG)	✓	✓
Coniferous plantation (CP)			Tall herb/rank vegetation (TH)	✓	✓
Scrub & shrubs (SH)			Rock, scree or sand dunes (RD)		
Orchard (OR)			Suburban/urban development (SU)		
Wetland (e.g. bog, marsh, fen) (WL)			Tilled land (TL)		
Moorland/heath (MH)			Irrigated land (IL)		
Artificial open water (AW)	✓		Parkland or gardens (PG)		
			Not visible (NV)		

Natural/unmodified	L	R	**Artificial/modified**	L	R
Vertical/undercut		✓	Resectioned (reprofiled)	✓	✓
Vertical with toe			Reinforced - whole		
Steep (>45°)	✓	✓	Reinforced - top only		
Gentle	✓		Reinforced - toe only		
Composite			Artificial two-stage		
Natural berm			Poached bank		
			Embanked		
			Set-back embankment		

TREES (tick one box per bank)

	Left	Right
None	☐	☐
Isolated/scattered	☐	☐
Regularly spaced, single	☑	☑
Occasional clumps	☐	☐
Semi-continuous	☐	☐
Continuous	☐	☐

ASSOCIATED FEATURES (tick one box per feature)

	None	Present	E (≥33%)
Shading of channel	☑	☐	☐
*Overhanging boughs	☑	☐	☐
*Exposed bankside roots	☑	☐	☐
*Underwater tree roots	☑	☐	☐
Fallen trees	☑	☐	☐
Large woody debris	☑	☐	☐

	None	Present	E(≥33%)
*Free fall flow	☑	☐	☐
Chute flow	☑	☐	☐
Broken standing waves	☑	☐	☐
Unbroken standing waves	☐	☐	☑
Rippled flow	☐	☑	☐
*Upwelling	☑	☐	☐
Smooth flow	☑	☐	☐
No perceptible flow	☑	☐	☐
No flow (dry)	☑	☐	☐
Marginal deadwater	☑	☐	☐
Eroding cliff(s)	☐	☑	☐
Stable cliff(s)	☑	☐	☐

	None	Present	E (≥33%)
Exposed bedrock	☑	☐	☐
Exposed boulders	☐	☐	☑
Vegetated bedrock/boulders	☐	☑	☐
Unvegetated mid-channel bar(s)	☑	☐	☐
Vegetated mid-channel bar(s)	☑	☐	☐
Mature island(s)	☑	☐	☐
Unvegetated side bar(s)	☑	☐	☐
Vegetated side bar(s)	☐	☑	☐
Unvegetated point bar(s)	☑	☐	☐
Vegetated point bar(s)	☐	☑	☐
*Unvegetated silt deposit(s)	☑	☐	☐
*Discrete unvegetated sand deposit(s)	☑	☐	
*Discrete unvegetated gravel deposit(s)	☑	☐	

SITE REF. RIVER NITH E **RIVER HABITAT SURVEY : DIMENSIONS AND INFLUENCES** **Page 4 of 4**

LEFT BANK		CHANNEL		RIGHT BANK	
Banktop height (m)	2·5	Bankfull width (m)	4	Banktop height (m)	2.0
Is banktop height also bankfull height? (Y or N)	N	Water width (m)	3	Is banktop height also bankfull height? (Y or N)	Y
Embanked height (m)	–	Water depth (m)	0·2	Embanked height (m)	–

If trashline lower than banktop, indicate: height above water (m) = – width from bank to bank (m) = –

Bed material at site is: consolidated ☐ unconsolidated (loose) ☑ unknown ☐

Location of measurements is: riffle ☑ other ☐ (state)

None	☑	Very large boulders (>1m)	☐	Backwater(s)	☐	Marsh(es)	☐
Braided channels	☐	*Debris dam(s)	☐	Floodplain boulder deposits	☐	Flush(es)	☐
Side channel(s)	☐	*Leafy debris	☐	Water meadow(s)	☐	Natural open water	☐
*Natural waterfall(s) > 5m high	☐	Fringing reed-bank(s)	☐	Fen(s)	☐	Others (state)	☐
*Natural waterfall(s) < 5m high	☐	Quaking bank(s)	☐	Bog(s)	☐		
Natural cascade(s)	☐	*Sink hole(s)	☐	Wet woodland(s)	☐		

Is 33% or more of the channel choked with vegetation? No ☑ Yes ☐

		bankface	banktop to 50m		bankface	banktop to 50m
None ☑	*Giant hogweed	☐	☐	*Himalayan balsam	☐	☐
	*Japanese knotweed	☐	☐	*Other (state).....	☐	☐

Major impacts: landfill - tipping - litter - sewage - pollution - drought - abstraction - mill - dam - road - rail - industry - housing mining - quarrying - overdeepening - afforestation - fisheries management - silting - waterlogging - hydroelectric power

Evidence of recent management: dredging - bank mowing - weed cutting - enhancement - river rehabilitation - gravel extraction - other (please specify)

Animals: otter - mink - water vole - kingfisher - dipper - grey wagtail - sand martin - heron - dragonflies/damselflies

Other significant observations: if necessary use separate sheet to describe overall characteristics and relevant observations COMMON FROG.

*Alders? None ☐ Present ☑ Extensive ☐ | *Diseased Alders? None ☑ Present ☐ Extensive ☐

Have you taken at least two photos that illustrate the general character of the site and additional photos of any weirs/ sluices and major/intermediate structures across the channel? ☑
Have you completed all ten spot-checks and made entries in all boxes in E & F on page 2? ☑
Have you completed column 11 of section G (and E if appropriate) on page 2? ☑
Have you recorded in section C the number of riffles, pools and point bars (even if 0) on page 1? ☑
Have you given an accurate (alphanumeric) grid reference for spot-checks 1, 6 and end of site (page 1)? ☑
Have you stated whether spot-check 1 is at the upstream or downstream end of the site (top of page 2)? ☑
Have you cross-checked your spot-check and sweep-up responses with the channel modification indicators given on page 2 of the spot-check key? ☑

Photo 1. East Diversion Spot Check 1

Photo 2. East Diversion Spot Check 2

Title: Photographic Log	**Client:** Kier Mining
Site: Greenburn ECoW 2014	**Date** August 2014

Photo 3. East Diversion Spot Check 3

Photo 4. East Diversion Spot Check 4

Title: Photographic Log	**Client:** Kier Mining
Site: Greenburn ECoW 2014	**Date** August 2014

Photo 5. East Diversion Spot Check 5

Photo 6. East Diversion Spot Check 6

Title: Photographic Log	**Client:** Kier Mining
Site: Greenburn ECoW 2014	**Date** August 2014

Photo 7. East Diversion Spot Check 7

Photo 8. East Diversion Spot Check 8

Title: Photographic Log	**Client:** Kier Mining
Site: Greenburn ECoW 2014	**Date** August 2014

Photo 9. East Diversion Spot Check 9

Photo 10. East Diversion Spot Check 10

Title: Photographic Log	**Client:** Kier Mining
Site: Greenburn ECoW 2014	**Date** August 2014

APPENDIX D: Photographs

September 2011 – Construction Complete

March 2012 – Pre Flow

August 2012 – Day of Tie-In

December 2012

May 2013

September 2013

March 2014

January 2015

September 2011 – Construction Complete

March 2012 – Pre Flow

August 2012 – Day of Tie-In

December 2012

May 2013

September 2013

March 2014

January 2015

September 2011 – Construction Complete

March 2012 – Pre Flow

August 2012 – Day of Tie-In

December 2012

May 2013

September 2013

March 2014

January 2015

September 2011 – Construction Complete

March 2012 – Pre Flow

August 2012 – Day of Tie-In (View looking south from southern bank)

December 2012 (View looking south from northern bank)

May 2013

September 2013 (View looking south from northern bank)

March 2014 (View looking south from northern bank)

January 2015

September 2011 – Construction Complete

March 2012 – Pre Flow

August 2012 – Day of Tie-In (view looking east)

December 2012

May 2013 (view looking east)

September 2013

March 2014

January 2015

September 2011 – Construction Complete

March 2012 – Pre Flow

August 2012 – Day of Tie-In

December 2012

May 2013

September 2013

March 2014 (

January 2015

September 2011 – Construction Complete

March 2012 – Pre Flow (from southern bank)

August 2012 – Day of Tie-In

December 2012

May 2013

September 2013

March 2014

January 2015

September 2011 – Construction Complete

March 2012 – Pre Flow

August 2012 – Day of Tie-In

December 2012

May 2013

September 2013

March 2014

January 2015