

Monitoring of Aquatic Habitat Cloonkeen Oughter, Co. Galway

EU Life Restoration of Raised Bogs project

Post-felling survey – Year 4



Aquatic Services Unit (ASU)
 University College Cork (UCC)
 ERI Building, Lee Road, Cork
 P: +353 21 490 1935/ F: +353 21 490 1940

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			<i>L.M. O'Connell</i>		

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1. Executive Summary

Five years of annual aquatic surveys were carried out at Cloonkeen Oughter Forest Property, Derrinlough Bog, Co. Galway to study the effect of tree-felling and raised bog restoration works on water quality. This biological water quality monitoring formed part of a project entitled *Demonstrating Best Practice in Raised Bog Restoration in Ireland*. The project was co-financed by the EU (under the LIFE+ Nature programme), the National Parks and Wildlife Service of the Department of Environment, Heritage and Local Government (under the Environment Fund) and Coillte Teoranta.

A pre-felling survey was conducted in August 2011 with four years of annual post-felling monitoring occurring in August of 2012 – 2015. The current report compares 2015 data to previous monitoring results.

There were two monitoring sites, one upstream (CK1) and one downstream (CK2) of the felled coupe. There were no suitable biological sampling sites located within the Derrinlough Bog NHA boundary as the stream was historically drained with sluggish flows and soft substrates. Harvesting operations occurred between July 22nd and October 15th, 2011.

The purpose of the monitoring was to assess whether harvesting, as part of bog restoration on the site, had any impact on downstream water quality. To this end, it can be said that the downstream site was 'slightly polluted' (Q3-4, 'Moderate' status), in pre-felling surveys and generally remained at this quality rating throughout the monitoring. In 2012, there were indications that water quality had slightly improved (Moderate-to-Good status), but this returned in 2013, 2014 and 2015 to the pre-felling classification of 'Moderate' status.

The upstream (control) site showed an apparent deterioration in water quality over the five year monitoring period, declining from 'slightly polluted' in 2011/2012 to 'moderately polluted' (Q3, 'Poor' status) from 2013 to 2015.

In conclusion, the upstream (control) and downstream sites were both at least 'slightly polluted' (Q3-4, 'Moderate' status) since monitoring was initiated in 2011. While the upstream site deteriorated, the downstream site remained 'slightly polluted' throughout the monitoring period. Hence, felling in 2011 as part of bog restoration at Cloonkeen Oughter had no significant effect on apparent water quality using biological metrics as indicators.

2. Introduction

Coillte commissioned the Aquatic Services Unit (ASU) to carry out aquatic monitoring surveys prior to, and for four years following, harvesting at Cloonkeen Oughter Forest Property, Co. Galway. The felling site was within the Derrinlough Bog NHA (Site Code 001254)¹.

Water quality monitoring in relation to clearance of forestry from the NHA formed part of a project entitled *Demonstrating Best Practice in Raised Bog Restoration in Ireland*. The project was co-financed by the EU (under the LIFE+ Nature programme), the National Parks and Wildlife Service (NPWS) of the Department of Environment, Heritage and Local Government (under the Environment Fund); and Coillte Teoranta².

The watercourse running through the coupe is a first order stream in the headwaters of the Grange River, a tributary of the Clare River, which eventually drains to Lough Corrib. The stream flows into the Coillte property from the Richmond Esker Nature Reserve immediately upstream of Derrinlough Bog. It flows past Ballinphuill forest property and onwards in an easterly direction along the northern boundary of Derrinlough Bog NHA. The stream runs through a fen area that occurs on the in-filled Derrin Lough. From there the stream flows south and then southwesterly, adjacent to the Cloonkeen Oughter forest block.

Stream substrates were unsuitable for biological sampling anywhere within the NHA – being drained channels in the peat; in places very deep and overgrown with aquatic macrophytes. Suitable upstream and downstream monitoring locations, with hard substrates and riffles, were selected.

This report presents biological water quality results of the last of five years of annual surveys that occurred between 2011 (pre-felling) and 2012 – 2015 (post-felling). Biological surveys included: (i) macroinvertebrate sampling, (ii) assessment of macrophyte and macroalgae coverage (%), and (iii) assessment of siltation levels. This report summarises the four years of post-felling surveys in comparison to the pre-felling survey of August, 2011. This completes the biological water quality monitoring programme for the project.

¹ <http://www.npws.ie/media/npwsie/content/images/protectedsites/sitesynopsis/SY001254.pdf>

3. Methodology

3.1 Site selection

The sampling plan adopted at Cloonkeen Oughter (Derrinlough) allowed for upstream-downstream comparison over the course of monitoring with the general approach for site selection as follows:

- (i) **CK1** - a site upstream (US) of the proposed forestry management; effectively the control site.
- (ii) **CK2** - a site a short distance downstream (DS) of the area of forestry harvesting operations.

OSI maps of the area show no connection between the upstream and downstream sites, however, ground-truthing showed that the stream does in fact originate upstream of the NHA and flows through the bog and onwards towards Cloonkeen Bridge on the R328. The stream was sluggish with peaty substrates through the Derrinlough Bog and downstream for some distance downstream (see previous reports for images). Stream morphology and substrates were not suitable for macroinvertebrate sampling and monitoring any closer to the SP than the sites selected. **Table 1** shows dates of pre- and post-felling surveys and harvesting period.

Table 1: Survey dates and harvesting period

Activity	Dates
Pre-felling survey (CK2)	09/08/2011
Pre-felling survey (CK1)	21/09/2011
Harvesting period	22/07/2012 to 15/08/2012
Post-felling annual surveys - Year 1	13/08/2012
Post-felling annual surveys - Year 2	21/08/2013
Post-felling annual surveys - Year 3	14/08/2014
Post-felling annual surveys - Year 4	04/08/2015

Figure 1, below, illustrates the two sampling locations on the stream in relation to Derrinlough raised bog, and marks nearby EPA monitoring stations.

3.2 Site Investigations

Biological sampling for water quality interpretation included: (i) macroinvertebrate collection, (ii) assessment of macrophyte and macroalgae cover (%); (iii) assessment of siltation levels. The sampling programme was designed to characterise the stream benthic community for each chosen location and to identify potential responses, if any, to harvesting activity on the raised bog site during the study period.

Each monitoring site was assessed during each visit using a standard checklist of variables that characterise the aquatic physical habitat, including records of the following:

- Stream width and depth
- Substrate type, listing substrate in order of dominance, i.e. large rocks, cobble, gravel, sand, mud etc.
- Flow type, listing percentage of riffle, glide and pool in the sampling area
- Dominant bankside vegetation, listing the main species overhanging the stream
- Estimated summer cover by bankside vegetation, by percentage shade of the sampling site.
- Grid references using handheld GPS and digital photographs.

3.3 Macroinvertebrate Surveys

Benthic macroinvertebrate communities were sampled using standard 2-minute kick-samples at selected monitoring locations. Faster flowing (riffle) areas of the stream were targeted using a long-handled pond net (250 mm width, mesh size 1 mm; adhering to ISO Standard for kick sampling and utilising the EPA/WRBD protocols). Stonewashing was also employed to detach clinging species. One sample was taken at each of two monitoring locations. Samples were preserved with 70% IMS alcohol and were analysed in the laboratory. All collected specimens were identified to the lowest taxonomic level possible. The biological indices calculated include Q value, BMWP and ASPT and EQR's.

Table 2: EPA water quality status summary

Biotic Index	EQR³	EPA Quality Status	Water Quality	WFD⁴ Status
Q5	1.0	Unpolluted	Good	High
Q4-5	0.9	Unpolluted	Fair-to-Good	High
Q4	0.8	Unpolluted	Fair	Good
Q3-4	0.7	Slightly Polluted	Doubtful-to- Fair	Moderate
Q3	0.6	Moderately Polluted	Doubtful	Poor
Q2-3	0.5	Moderately Polluted	Poor-to-Doubtful	Poor
Q2	0.4	Seriously Polluted	Poor	Bad
Q1-2	0.3	Seriously Polluted	Bad-to-Poor	Bad
Q1	0.2	Seriously Polluted	Bad	Bad

³ EQR = Environmental Quality Ratio (Observed/Reference)

⁴ WFD = Water Framework Directive (EPA, 2006)

Samples were assessed using the Quality Rating System (Q-value) scheme, developed by Ireland's Environmental Protection Agency (EPA, 2006). In 2006 this scheme, was intercalibrated in order to ascribe Ecological Quality Ratios (EQRs) for the benthic invertebrate fauna element in the rivers Operational Monitoring programme (McGarrigle and Lucey, 2009) under the Water Framework Directive (WFD). When the EQR is derived from the Q-value the site is assigned to one of five ecological status classes ranging from High to Bad (EPA, 2009). The WFD requires "good water status" and/or "good ecological status" for rivers by 2015, to be achieved through integrated catchment management (EPA, 2006). Sites have been labelled with "potential" WFD Status classification for the purpose of the monitoring, since data from outside the formal WFD monitoring programmes are not formally included in reporting of ecological status at a national level. Formal EU classification of Ecological Status is carried out by public bodies designated by the Regulations (S.I. 272 of 2009), at nominated monitoring sites. All other data would be considered to have "potential" WFD status based on the criteria set out in the Fifth Schedule to the S.I. 272 of 2009. Table 2 shows the relationship between Q-values and WFD status.

The BMWP (Biological Monitoring Working Party) Score and ASPT (Average Score per Taxon) macroinvertebrate biotic indices were also used for comparative purposes. These latter are useful in that they enable a precise score to be calculated based on taxon sensitivity to organic pollution from 1 (most tolerant) to 10 (least tolerant). The EPA Q-value assessment is somewhat more subjective as it involves individual operator interpretation of the water quality at a particular site.

Surveys were conducted at the same time each year to limit seasonal differences in the dataset.

3.4 Macrophyte and Macroalgae Surveys

A stretch of channel equal to 10 x wetted width was surveyed and algae coverage values were assessed in broad groupings for: (i) rooted macrophytes; (ii) bryophytes, and; (iii) macroalgae (visible to the eye). This length of channel will generally encompass all available flow types and microhabitats within a river or stream and represent the conditions at the monitoring site accurately. All assessments were based on "qualified judgment".

3.5 Silt level

Silt plumes were assessed whilst conducting macroinvertebrate kick-sampling. A simple descriptive categorisation of: Significant, Moderate, Slight, None was used. The description is based on qualified judgment.

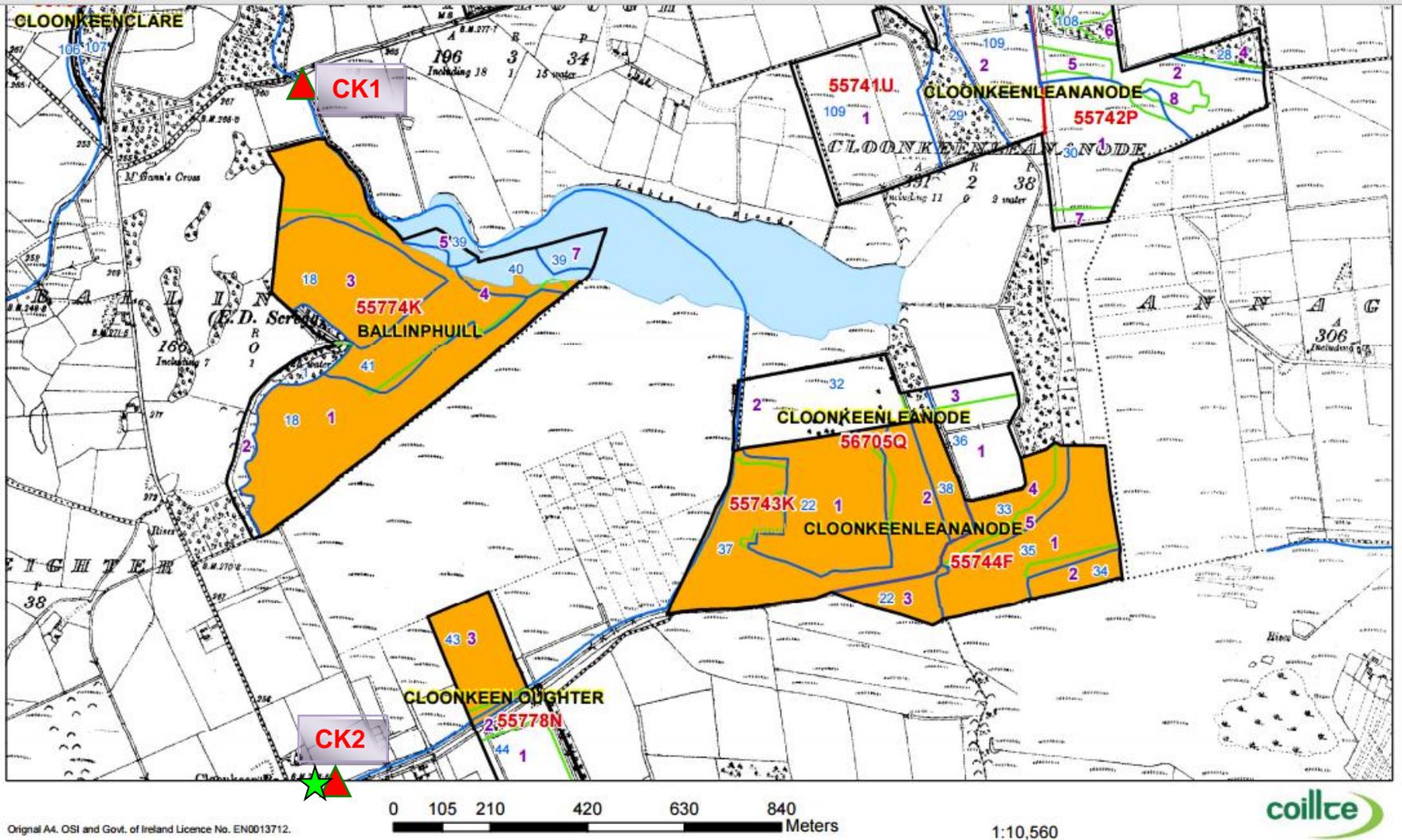


Figure 1 - Sampling locations CK1 (upstream) and CK2 (downstream) in relation to the Derrinlough Raised Bog Restoration Felling Areas (Yellow). Green star marks EPA water quality monitoring station.

4. Results

4.1 Site descriptions

Appendix 1 contains detailed site descriptions and grid reference locations. Sections 4.1.1 and 4.1.2, show photographs comparing general habitat at each of the sampling locations in 2014 and 2015. Of note was that flows were higher than average at both sites. Habitat had recovered at CK1 following drainage of the stream in 2014. There were high levels of the pollution tolerant macroalgae, *Cladophora*, at the downstream site (CK2).

4.1.1 Site CK1 – Upstream of the SP



Plate 3: CK1 - view downstream, August, 2014. The site had been drained prior to sampling and flows were extremely low.



Plate 4: CK1 - view downstream, August, 2015. Note high flows and regrowth of vegetation following drainage in 2014.

4.1.2 Site CK2 – downstream of the SP



Plate 3: CK2 - view upstream, August 2014.



Plate 4: CK2 - view upstream, August 2015. Note the high flows compared to 2014.

4.2 Water Quality

4.2.1 EPA water quality data

Table 3 shows recent trends in EPA water quality data downstream of Cloonkeen Oughter. In 2012, a year after the felling, the EPA river monitoring station at Cloonkeen Bridge (Station: 30G020120) was classified Q4, equating to 'Good' ecological status. This is at the same location as site CK2 in the current study. The next EPA station downstream is the Bridge near Cloondahamper (Station: 30G020200), located approximately 5km downstream of Cloonkeen Bridge; also rated Q4 in 2012, equating to 'Good' ecological status. This was an improvement over previous EPA monitoring results at the site, from Moderate status recorded in 2006 and 2009.

Table 3: Recent EPA river monitoring data downstream of Cloonkeen Oughter SP

Station name	Station ID	2006	2009	2012
Cloonkeen Bridge	30G020120	4	4	4
Bridge near Cloondahamper	30G020200	3-4	3-4	4

4.2.2 Post-felling water quality at Cloonkeen Oughter – Year 4

Appendix 2 shows macroinvertebrate species lists for 2015 sampling at each monitoring location. Figures 2, 3 and 4 compare macroinvertebrate community assemblage metrics (Q-value, BMWP and ASPT) between pre-felling (2011) and the four post-felling surveys (2012 - 2015).

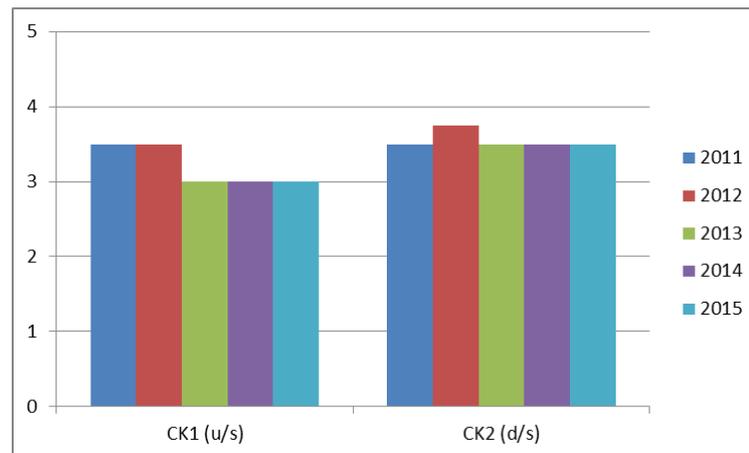


Figure 2- Q-value comparison

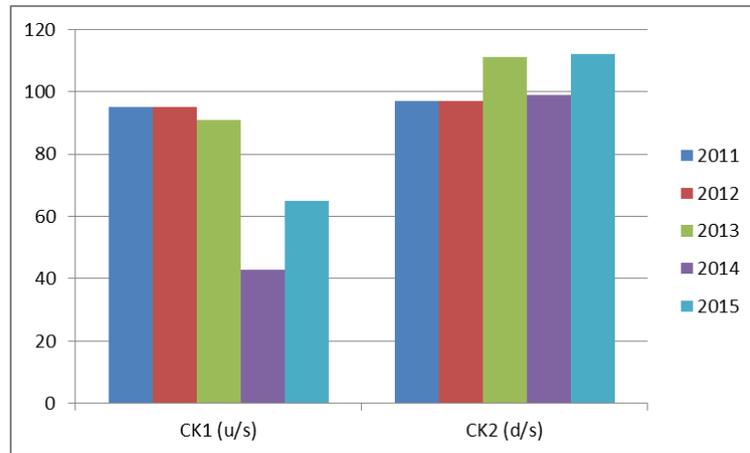


Figure 3 - BMWP comparison

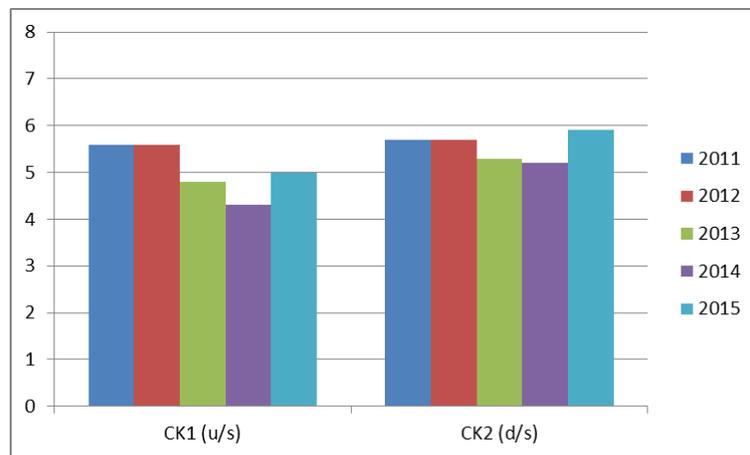


Figure 5 - ASPT comparison

According to Q-values, there was no material change in apparent water quality between pre-felling and post-felling at the site downstream of felling (CK2) over the monitoring period. There was, in fact, a slight increase in Q-value evident during the first year post-felling (2012) but this declined back to the pre-felling level for the final three remaining years of post-felling survey (2013-2015). There was a trend of decline in ASPT at CK2 in 2013/2014 compared to previous surveys (2011/2012), but this trend was matched at the upstream site (CK1), and is not therefore attributed to any activities on the raised bog site (including 2011 felling). White clawed crayfish (*Austropotamobius pallipes*) were present at CK2 in 2015 (2 adults observed).

At the upstream site (CK1), apparent water quality declined in the second year post-felling, from 'Moderate' down to 'Poor' ecological status, remaining at 'Poor' status since.

5. Discussion

The downstream site was classified as Q3-4, 'Moderate' status, in pre-felling surveys and generally remained at this quality rating, apart from indications of slightly better quality in 2012. In that year, the 1st year post-felling, the downstream site was classed as 'Moderate-to-Good' ecological status owing to greater diversity of Group A fauna, however, these were not present in great enough numbers to classify the site as clearly at 'Good' status.

In contrast to Q-value and BMWP, the ASPT, which is a measure of the "average" sensitivity of the macroinvertebrate community showed decline in Year 2 post-felling (2013) at the downstream site. There are two things to note: (1) this trend of decline was matched at the upstream site so cannot be attributed to activities on the Derrinlough Bog site, and (2) ASPT improved in the final monitoring round (2015) to better than the pre-felling level (2011).

Overall the downstream site went through periods of high macroalgae cover (*Cladophora* and/or *Vaucheria*: both pollution tolerant species common in organically enriched waters) and the macroinvertebrate community was generally dominated by moderately pollution tolerant species, with presence of the highly pollution sensitive mayfly *Ecdyonurus*. The site, according to the annual sampling conducted appears to be near the 'Moderate'-'Good' ecological status class boundary throughout the monitoring.

In conclusion, the upstream (control) and downstream sites were both at least 'slightly polluted' by EPA standards (i.e., Q3-4, 'Moderate' status) since monitoring was initiated in 2011. There was no felling upstream of CK1, the upstream (control) site, over the five year monitoring period. The upstream (control) site, however, showed an apparent deterioration in water quality over the monitoring period, declining to 'moderately polluted' (Q3, 'Poor' status). The downstream site remained 'slightly polluted' (Q3-4, 'Moderate' status) throughout the monitoring period. Hence, felling in 2011 as part of bog restoration at Cloonkeen Oughter had no significant effect on apparent water quality using biological metrics as indicators.

6. References

EPA 2006. Water Framework Directive Monitoring Programme. Version 1 2006. Prepared to meet the requirements of the EU Water Framework Directive (2000/60/EC) and National Regulations implementing the Water Framework Directive (S.I. No 722 of 2003) and National Regulations implementing the Nitrates Directive (S.I No. 788 of 2005). Environmental Protection Agency, Ireland.

McGarrigle, M. L., and Lucey, J. 2009. Intercalibration of Ecological Status of Rivers in Ireland for the purpose of the Water Framework Directive. *Biology and Environment: Proceedings of the Royal Irish Academy, Vol 109B, No. 3, 237 – 246.*

Appendix 1: Site descriptions

SITE CODE	CK 1	CK 2
Date	05/08/15	05/08/15
Name	Upstream of SP	Downstream of SP
Irish Grid	M 59182 53537	M 59607 52144
Easting	159182	159607
Northing	253537	252144
Location notes	1st accessible riffle US of SP. Accessed from road near entrance to Richmond Esker Nature Reserve. Site just downstream of road bridge.	Riffle stretching about 10m upstream of Cloonkeen Bridge.
Dominant bankside vegetation	TR - Improved grassland with sparse riparian strip of Phragmites. TL -Riparian strip of woodland/scrub between river and road.	Both banks with about 10m riparian strip of quite mature mixed broadleaf and bramble with conifer plantation beyond.
Estimated summer cover of stream by bankside vegetation (%)	50% dappled light owing to tall marginal vegetation.	50% slightly dappled light
Width (m)	1.3m	2.5m
Depth (cm)	3-5 cm riffle, 10 cm runs/glide	15-20cm riffle; 24cm glide
Velocity	Moderate-Fast	Fast
Water Clarity	Clear	Clear
Colour	Moderate	Moderate-High
Discharge	Above average	Above average
Flow type: Area of Survey		
% riffle	80	80
% glide	20	20
Substrate		
Cobble	2	3
Gravel/pebble	4	2
Coarse Sand	3	1
Mud/Silt	1	
Silt plume visible during sampling	(+++)	(+++)
Other comments	Bank erosion and stream disturbance (stock access) upstream.	Silt and filamentous green algae common
Instream vegetation (% cover)		
Filamentous algae	0	>30% <i>Cladophora</i> spp.
Rooted macrophytes	<5% <i>Apium nodiflorum</i> ; <5% ; <i>Phragmites</i> (+); <i>Mentha</i> sp. 1%.	5% <i>Apium nodiflorum</i> ; <5% <i>Rorripa n-a.</i> ; <1% <i>Sparganium erectum</i>

Appendix 2: Macroinvertebrate Lists

Taxa	EPA Quality Category	2015	
		CK 1 (u/s)	CK 2 (d/s)
MAY FLIES (Ephemeroptera)			
Heptageniidae:	A		*
<i>Ecdyonurus sp.</i>			24
<i>Rithrogenia spp.</i>			
<i>Ephemerella ignita</i>	C		3
<i>Baetis rhodani</i>	C	30	25
<i>Alainites muticus</i>	B		2
<i>Paraleptophlebia spp.</i>	B		1
STONE FLIES (Plecoptera)			
<i>Leuctra spp.</i>	B		1
CADDIS FLIES (Trichoptera)			
<i>Sericostoma personatum</i>	B	1	1
<i>Rhyacophila dorsalis</i>	C	2	
<i>Polycentropus flavomaculatus</i>			5
<i>Plectrocnemia spp.</i>	C	8	1
Glossosomatidae:	~		
<i>Agapetus sp.</i>		14	12
Limnephilidae:	C	*	*
<i>Potamophylax sp.</i>			2
<i>Halesus radiatus</i>		2	
<i>Apatania sp.</i>			2
TRUE FLIES (Diptera)			
Chironomidae	C	19	25
Simuliidae	C	36	100
<i>Dicranota spp.</i>	~	21	19
Tipulidae	C		2
BEETLES (Coleoptera)			
Elmidae	C	27	15
F/W SHRIMPS (Crustacea)			
<i>Austropotamobius pallipes</i>	C		1
<i>Gammarus sp.</i>	C	100	100
<i>Asellus aquaticus</i>	D	8	7
SNAILS (Mollusca)			
<i>Potamopyrgus jenkinsi</i>	C	10	37
Sphaeriidae	D		2
WORMS (Annelida)			
Oligochaetae	E	45	20
LEECHES (Hirudinea)			
<i>Glossophonia complanata</i>	D		1
EPA Q Value		Q3	Q3-4(4)
Total BMWP Score		65	112
ASPT		5	5.9
N taxa		13	19

Monitoring of Aquatic Habitat Sopwell Forest Property, Co.Tipperary

EU Life Restoration of Raised Bogs project

Post-felling survey – Year 4



Aquatic Services Unit (ASU)
University College Cork (UCC)
ERI Building, Lee Road, Cork
P: +353 21 490 1935/ F: +353 21 490 1940

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1. Executive Summary

Five years of annual in-stream aquatic surveys were carried out at Scohaboy Bog, Sopwell Forest Property, Co. Tipperary to study the effect of tree-felling and raised bog restoration works on water quality. The monitoring formed part of a project entitled *Demonstrating Best Practice in Raised Bog Restoration in Ireland*. The project was co-financed by the EU (under the LIFE+ Nature programme), the National Parks and Wildlife Service of the Department of Environment, Heritage and Local Government (under the Environment Fund) and Coillte Teoranta.

A pre-felling survey was conducted in August 2011 with four years of annual post-felling surveys occurring in August of 2012 – 2015. The current report compares 2015 data to previous monitoring results. There were four monitoring sites, one upstream (SW1) and two downstream of the felling coupe (SW3, SW4), and one located halfway through the coupe (SW2). Harvesting operations occurred in the period September 2011 to February 2012.

The purpose of the monitoring was to assess whether harvesting, as part of bog restoration on the site, had any impact on downstream water quality. To this end, it is evident that in pre-felling (2011) and all post-felling surveys (2012-2015), apparent water quality based on biological metrics was similar at all sites throughout the monitoring period, classified as mainly 'slightly polluted' and of 'Moderate' ecological status.

Overall, the upstream (SW1-control) and most downstream site (SW4) were slightly poorer on average compared to SW2 and SW3, within and immediately downstream of the felling coupe, respectively. Ecological status was considered to be near the Moderate/Poor boundary at all sites throughout the monitoring, and felling had no substantial effect on this.

The only notable post-felling biological response was at SW3, the site immediately downstream of the felled coupe, where macroalgae was recorded in greater abundance in years 1 and 2 post-felling, and black-fly larvae (*Simulium* spp.) were abundant in years 1 and 3 post-felling. Both are commonly reported post-felling responses, neither of which materially altered the biological quality ratings at the site, which was at least 'slightly polluted' prior to felling and throughout the monitoring period.

The stream was already apparently 'slightly-to-moderately polluted' at the upstream (control) site on all sampling occasions and sewage fungus was recorded pre- and post-felling at the site. This indicted the primary source of impairment in the catchment probably originated upstream of the felled coupe and there was no apparent recovery of water quality with distance downstream.

2. Introduction

Coillte commissioned the Aquatic Services Unit (ASU) to carry out aquatic monitoring surveys prior to, and for four years following, harvesting at Sopwell Forest Property, Co. Tipperary, adjacent to the Scohaboy Bog NHA (Site Code 000937)⁵. Water quality monitoring in relation to clearance of forestry from the NHA forms part of as part of a project entitled *Demonstrating Best Practice in Raised Bog Restoration in Ireland*. This project is co-financed by the EU (under the LIFE+ Nature programme), the National Parks and Wildlife Service of the Department of Environment, Heritage and Local Government (under the Environment Fund); and Coillte Teoranta⁶.

Monitoring is being carried out at sites on a small, first order, stream that runs through the Sopwell forest property. Samples were taken upstream, within, and at two locations downstream of the felled coupe. The stream runs just inside the eastern and northeastern boundary of the Scohaboy Bog NHA (Site Code 000937) and is a headwater tributary of the Ballyfinboy River which drains into Lough Derg.

White clawed crayfish (*Austropotamobius pallipes*), a species protected at national and European levels, were recorded during all four annual monitoring rounds to date (2011-2014) at the three sites closest to the Sopwell property.

This report presents biological water quality results of the last of five years of annual surveys that occurred between 2011 (pre-felling) and 2012 – 2015 (post-felling). Biological surveys included: (i) macroinvertebrate sampling, (ii) assessment of macrophyte and macroalgae coverage (%), and (iii) assessment of siltation levels. This report summarises the four years of post-felling surveys in comparison to the pre-felling survey of August, 2011. This completes the biological water quality monitoring programme for the project.

⁵ <http://webgis.npws.ie/npwsviewer/>

3. Methodology

3.1 Site selection

The sampling plan adopted at Sopwell allows for upstream-downstream comparison over the course of monitoring with the general approach for site selection being as follows:

- (iii) **SW1** - a site upstream (US) of the proposed forestry management, which is effectively the control site.
- (iv) **SW2** - a site located within the felling block.
- (v) **SW3** - a site a short distance downstream (DS) of the area of forestry harvesting operations
- (vi) **SW4** – a site further downstream of SW3, on a higher order stream to help place the catchment in context in terms of water quality.

White-clawed crayfish were detected upstream and downstream of the forest property during pre-felling surveys. A site within the property was, therefore, included in the sampling plan to ascertain presence of crayfish there so that any negative impacts on the population could be avoided or mitigated. Sites were selected so that they had broadly similar physical characteristics in order to facilitate interpretation of upstream-downstream data. Figure 1 illustrates the four sampling locations on the stream in relation to the SP.

3.2 Site Investigations

Biological sampling for water quality interpretation included: (i) macroinvertebrate collection, (ii) assessment of macrophyte and macroalgae cover (%), and (iii) assessment of siltation levels. The sampling programme is designed to characterise the stream benthic community for each chosen location and to identify potential responses, if any, to harvesting activity within the catchment during the study period.

Table 1 shows dates of pre- and post-felling surveys and harvesting period.

Table 1 Survey dates and harvesting period

Activity	Dates
Pre-felling survey (SW1,2 and 3)	09/08/2011
Pre-felling survey (SW4)	16/08/2011
Harvesting period	September 2011 – February, 2012
Manual felling (SP) and felling of non-native conifers in riparian buffer strip	Feb.- August 2012
Post-felling annual – Year 1	08/08/2012
Post-felling annual – Year 2	13/08/2013
Post-felling annual – Year 3	15/08/2014
Post-felling annual – Year 4	18/08/2015

Each monitoring site was assessed during each visit using a standard checklist of variables that characterise the aquatic physical habitat, including the following:

- Stream width and depth
- Substrate type, listing substrate in order of dominance, i.e. large rocks, cobble, gravel, sand, mud etc.
- Flow type, listing percentage of riffle, glide and pool in the sampling area
- Dominant bankside vegetation, listing the main species overhanging the stream
- Estimated summer cover by bankside vegetation, by percentage shade of the sampling site.
- Grid references using handheld GPS and digital photographs.

3.3 Macroinvertebrate Surveys

Benthic macroinvertebrate communities were sampled using standard 2-minute kick-samples at selected monitoring locations. Faster flowing (riffle) areas of the stream were targeted using a long-handled pond net (250 mm width, mesh size 1 mm; adhering to ISO Standard for kick sampling and utilising the EPA/WRBD protocols). Stonewashing was also employed to detach clinging species. One sample was taken at each of the four monitoring locations. Samples were preserved with 70% IMS alcohol and were analysed in the laboratory. All collected specimens were identified to the lowest taxonomic level possible. The biological indices calculated include Q value, BMWP and ASPT and EQR's.

Samples were primarily assessed using the Quality Rating System (Q-value) scheme, developed by the EPA (EPA, 2006). In 2006 this scheme, was intercalibrated in order to ascribe Ecological Quality Ratios (EQRs) for the benthic invertebrate fauna element in the rivers Operational Monitoring programme (McGarrigle and Lucey, 2009) under the Water Framework Directive (WFD). It is a well documented fact that community diversity of benthic aquatic invertebrates declines in response to pollution and that sensitive species are progressively replaced by more tolerant forms as pollution increases (EPA, 2007). When the EQR is derived from the Q-value the site is assigned to one of five ecological status classes ranging from High to Bad (EPA, 2009). The WFD requires "good water status" and/or "good ecological status" for rivers by 2015, to be achieved through integrated catchment management (EPA, 2006). Table 2 shows the relationship between Q-values and WFD status.

The BMWP (Biological Monitoring Working Party) Score and ASPT (Average Score per Taxon) macroinvertebrate biotic indices were also used for comparative purposes. These latter are useful in that they enable a precise score to be calculated based on taxon sensitivity to organic pollution from 1 (most tolerant) to 10 (least tolerant). The EPA Q-value assessment is somewhat more subjective as it involves individual operator interpretation of the water quality at a particular site.

Surveys were conducted at the same time each year to limit seasonal differences in the dataset.

Table 3: EPA water quality status summary

Biotic Index	EQR⁷	EPA Quality Status	Water Quality	WFD⁸ Status
Q5	1.0	Unpolluted	Good	High
Q4-5	0.9	Unpolluted	Fair-to-Good	High
Q4	0.8	Unpolluted	Fair	Good
Q3-4	0.7	Slightly Polluted	Doubtful-to- Fair	Moderate
Q3	0.6	Moderately Polluted	Doubtful	Poor
Q2-3	0.5	Moderately Polluted	Poor-to-Doubtful	Poor
Q2	0.4	Seriously Polluted	Poor	Bad
Q1-2	0.3	Seriously Polluted	Bad-to-Poor	Bad
Q1	0.2	Seriously Polluted	Bad	Bad

3.4 Macrophyte and Macroalgae Surveys

A stretch of channel equal to 10 x wetted width was surveyed and algae coverage values were assessed in broad groupings for, (i) rooted macrophytes; (ii) bryophytes, and; (iii) macroalgae (visible to the eye). This length of channel will generally encompass all available flow types and microhabitats within a river or stream and represent the conditions at the monitoring site accurately. All assessments were based on qualified judgment.

3.5 Silt level

Silt plumes were assessed whilst conducting macroinvertebrate kick-sampling. A simple descriptive categorisation of: Significant, Moderate, Slight, None will be used. Assessments were based on qualified judgment.

⁷ EQR = Environmental Quality Ratio (Observed/Reference)

⁸ WFD = Water Framework Directive (EPA, 2006)

4. Results

4.1 Site descriptions

Appendix 1 contains detailed site descriptions and grid reference locations. The following sections (4.1.1 to 4.1.4) show site photographs comparing general habitat between 2014 and 2015 at each sampling location. There was a slight decrease in the level of light penetration to the stream within the felled area owing to bushing out of broadleaved trees and increase in ground cover in the riparian zone following conifer removal. The upstream site, SW1, was again affected by stock access so the sample was taken slightly upstream in the same place as 2014 (Plates 1 and 2).

4.1.1 Site SW1 – Upstream of SP



Plate 1: SW1 - view upstream, August 2014



Plate 2: SW1 - view upstream, August 2015.

4.1.2 Site SW2 – within the SP



Plate 3: SW2 - view looking upstream over the sampling site, August 2014.



Plate 4: SW2 - short gravel riffle, August 2015

4.1.3 Site SW3 – 50m downstream of the SP.



Plate 5: SW3 - view upstream, August 2014.



Plate 6: SW3 - view upstream, August 2015.

4.1.4 Site SW4 – 4500m downstream of the SP

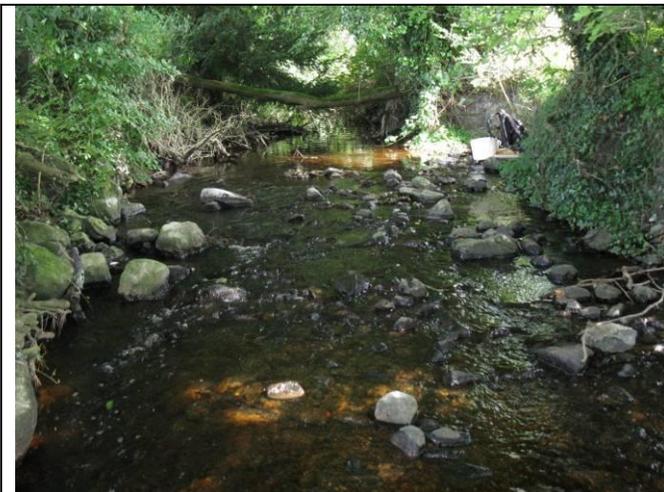


Plate 7: SW4 view upstream, August 2014.



Plate 8: SW4 view upstream, August 2015

4.2 Protected species

White clawed crayfish were captured in 2015 kick samples upstream, within and downstream of the coupe at sites SW1, SW2 and SW3. As in previous years, no crayfish were found at SW4, even though suitable habitat was present.

4.3 Water Quality

4.3.1 EPA water quality data

The closest, downstream, EPA monitoring station is Ballyhooney Bridge (Station 25B020700) on the Ballyfinboy River, approximately 12km west of the Sopwell Forest Property. The EPA classified the site as Q4 in 2005 and 2011 equating to ‘Good’ ecological status under the WFD classification system, and Q3-4, ‘Moderate’ status in 2014.

Table 3: Recent EPA river monitoring data downstream of Sopwell Forest Property

Station name	Station ID	2005	2011	2014
Ballyhooney Bridge	25B020700	4	4	3-4

4.3.2 Post-felling water quality at Sopwell- Year 4

Appendix 2 contains 2015 macroinvertebrate species lists for each sampling location. Figures 2, 3 and 4 compare macroinvertebrate community assemblage metrics (Q-value, BMWP and ASPT) over the five year monitoring period (2011-2015).

In 2015 all sites merited a Q3 rating, which is a slight reduction on previous years, although the result is not attributed to activities on the fell site, because upstream (control) and downstream sites were all affected. ASPT, which is the measure of “average” sensitivity of the community, declined in 2015 at sites SW2, SW3 and SW4 compared to previous post-felling sampling rounds.

Overall it is considered that Q-values were largely indeterminate between Q3 and Q3-4 at every site throughout the monitoring. Q3-4 was assigned in some cases owing to a diversity of Group B fauna being present, although Group A was absent which pointed to a possible Q3 rating. With all taken into account, it is evident that all sites, upstream and downstream of the fell site apparently had, at least, slightly impaired water quality pre- and post-felling and the felling did not materially alter this.

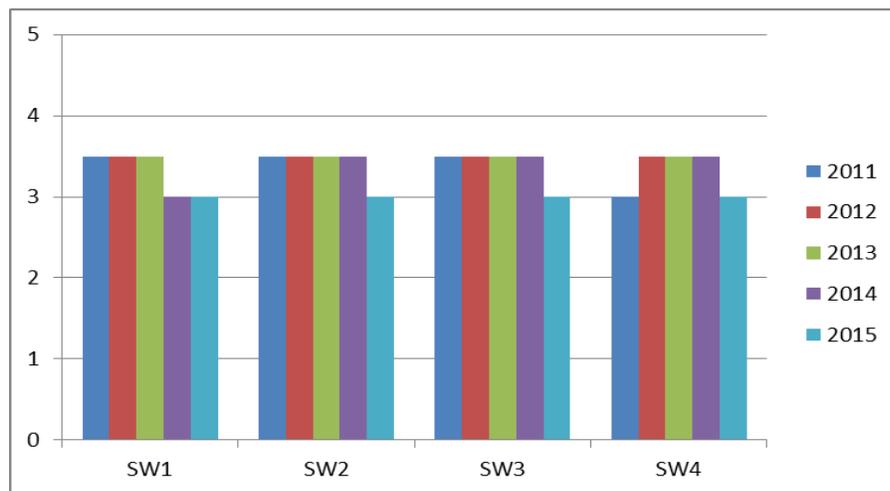


Figure 2 - Q-value comparison

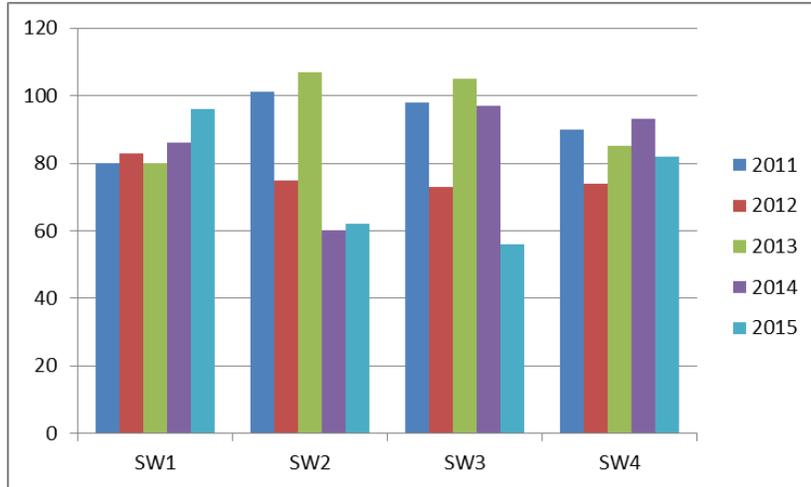


Figure 3 - BMWP comparison

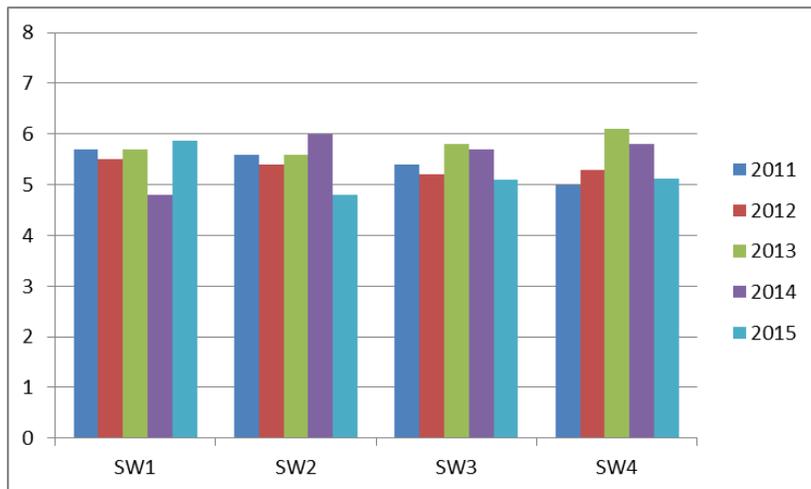


Figure 4 - ASPT comparison

The upstream site (SW1) appears to receive some organic input, possibly an agricultural input upstream. Sewage fungus was recorded in abundance upstream of SW1 in 2011 and in trace amounts at SW1 in 2015. SW1 also suffered physical damage through direct cattle access over the course of the monitoring, although sampling was conducted to avoid the worst of the damaged area.

Over five years of monitoring, filamentous green algae was recorded at the sites immediately upstream (SW1) and downstream (SW3) of the felling coupe. Coverage varied between sampling years, but was recorded in greater abundance at the downstream site, SW3, in 2012 and 2013. Species recorded were, *Vaucheria* and *Cladophora*, both commonly found in waters with slight-to-moderate levels of organic pollution. The filter feeding genera *Simulium* (Black fly larvae) was recorded in abundance during pre-felling surveys at the upstream site (SW1) and at the first site downstream (SW3) in the first and third years post-felling (2012/2013). Simuliidae are commonly associated with elevated levels of

fine particulate organic matter, which can arise from farmyard run-off, waste water and food processing discharges and is also reported as an early post-felling response (O'Halloran et al., 1996).

Silt levels were considerable or significant at each site throughout the monitoring, heaviest at SW2, reflecting the dominance of silty substrates there. Aquatic bryophytes were present on hard substrates at each location and there was no material change in their coverage values since monitoring began.

5. Discussion

The fourth year of post-felling monitoring showed that water quality was slight-to-moderately impaired upstream, within, immediately downstream and further downstream of the forest property. The stream, at all sites, was classified as potentially 'Poor' ecological status, which is a slight reduction compared to previous sampling rounds, when sites were generally Poor-to-Moderate status. The decline is not attributed to activities within the felling coupe/restoration site, as the source of impairment originates upstream of the felled coupe. None of these sites meets the minimum criteria of 'Good' ecological status under the WFD on the basis of the biological (macroinvertebrate) quality metric.

The only notable post-felling biological response was at SW3, the site immediately downstream of the felled coupe where macroalgae was recorded in greater abundance in years 1 and 2 post-felling, and black-fly larvae (*Simulium* spp.) were abundant in years 1 and 3 post-felling. Both are commonly reported post-felling responses.

Physical habitat characteristics at each of the monitored stream sites remained more or less the same at each sampling location throughout the monitoring. The upstream site routinely suffered physical (and water quality) impairment owing to stock access which has resulted in heavy poaching, bank erosion and fouling, locally.

Instream physical habitat condition in the reach where the stream runs through the felled area was virtually identical to all previous monitoring rounds. Riparian habitat improved over the course of monitoring owing to increased light incidence following the removal of the coniferous crop. Numerous crayfish burrows were observed in the stream and there was no bank or stream damage observed over the course of monitoring as a result of felling. Crayfish were present in 2015 at the three most upstream sites in the catchment (SW1, SW2 and SW3). As in previous years, a relatively high number of juveniles were observed, indicating a breeding population.

6. References

- EPA 2006. Water Framework Directive Monitoring Programme. Version 1 2006. Prepared to meet the requirements of the EU Water Framework Directive (2000/60/EC) and National Regulations implementing the Water Framework Directive (S.I. No 722 of 2003) and National Regulations implementing the Nitrates Directive (S.I No. 788 of 2005). Environmental Protection Agency, Ireland.
- EPA 2007. Water Framework Directive - Proposed Quality Standards for Surface Water Classification A Discussion Document For Public Consultation. Environmental Protection Agency, Ireland.
- McGarrigle, M. L., and Lucey, J. 2009. Intercalibration of Ecological Status of Rivers in Ireland for the purpose of the Water Framework Directive. *Biology and Environment: Proceedings of the Royal Irish Academy, Vol 109B, No. 3, 237 – 246.*
- O'Halloran, J. Giller, P.S., Clenaghan, C., Wallace, J. and Koolen, R. 1996. Plantation Forestry in River Catchments: Disturbance and Recovery, In: Giller, P.S. and Myers, A.A. (eds) Disturbance and recovery in ecological systems, 63-83. Dublin. Royal Irish Academy.

Appendix 1: Site descriptions

SITE CODE	SW 1	SW 2	SW 3	SW 4
Date	18/8/15	18/8/15	18/8/15	18/8/15
Name	US of SP	Within SP	First riffle c.50m DS of SP	Riffle c.4km DS of SP
Irish Grid	R 96989 91876	R 96972 92685	R 96563 92906	R 92835 94648
Easting	196989	196972	196563	192835
Northing	191876	192685	192906	194648
Location notes	1st accessible riffle US of SP. Accessed down rough bog road enter field on the TL of the small stream, cross stream and walk about 40m DS	Small riffle not far upstream of permanent footbridge.	A 10m reach beginning about 50m below the block. Access from forestry road - across farmland at western boundary of SP.	10m riffle US of fenced stock access area - enter field over gate from road about 20m east of bridge on TL of stream and go about 30m US.
Surveyor	LW	LW	LW	LW
Dominant bankside vegetation	TR - Improved grassland with intermittent scrub riparian strip + bare earth. TL -Riparian strip with cutover raised bog beyond.	Both banks with about 10m riparian zone of quite mature mixed broadleaf and scrub/ tall herb /bramble.	Both banks with thin riparian strip of semi mature Alder/Ash/Holly/Birch. Improved grassland on TR.	Both banks - thin riparian strip of Ash/Hawthorn/Alder /Holly with Improved Improved grassland beyond.
Estimated summer cover of stream by bankside vegetation (%)	50% dappled light	40% dappled light	50% dappled light	80% dappled light / dense.
Width (m)	1m	1.5m	1.2m	2.5m
Depth (cm)	3-5 cm riffle, 7cm glides	5-9cm	5-7cm riffle; 10-12cm glides	3-6cm riffles; 7-12cm glides
Velocity	Slow	Slow	Slow	Slow-Mod
Water Clarity	Clear	Clear	Clear	Clear
Colour	None	Slight	Slight	None
Discharge	<Average	<Average	<Average	<Average
Flow type: Area of Survey				
% riffle	80	20	60	60
% glide	20	80	40	40
Substrate				
Cobble	4		3	3
Gravel/pebble	3	3	2	2
Coarse Sand	2	1	1	1
Mud/Silt	1	2		
Peat		3		
Silt plume visible during sampling	(+++)	(+++)	(++)	(++)
Other comments	Crayfish present. Stock access points u/s and d/s.	Crayfish. Short riffle – not ideal for kick-sampling	Crayfish present	No change. Embedded substrates. Freshwater sponge noted.
Instream vegetation (% cover)	Sewage fungus			
Filamentous algae	0	0	>1% <i>Vaucheria</i> sp.	0
Bryophytes - Mosses	5% cover in total (<i>Amblestegium riparium</i> + <i>Rhychostegium ripariodes</i>)	0	10% cover in total: <i>Amblestegium riparium</i> + <5% <i>Rhychostegium ripariodes</i>	<i>Amblestegium riparium</i> <5%.
Bryophytes - Liverworts		0	<i>Pellia epiphylla</i> <1%;	<i>Pellia epiphylla</i> <1%
Rooted macrophytes	50% <i>Apium nodiflorum</i> ; <5% <i>Rorripa n-a</i>		<1% <i>Apium nodiflorum</i> .	

Appendix 2: Benthic macroinvertebrates

Taxa	EPA	2015			
	Quality				
	Category	SW 1	SW 2	SW 3	SW 4
MAY FLIES (Ephemeroptera)					
<i>Seratella ignita</i>	C	1			75
<i>Baetis rhodani</i>	C	28	41	18	2
<i>Alainites muticus</i>	B	7	3	5	1
STONE FLIES (Plecoptera)					
<i>Leuctra spp.</i>	B	3		4	1
CADDIS FLIES (Trichoptera)					
<i>Sericostoma personatum</i>	B	2			
<i>Rhyacophila dorsalis</i>	C	3	1		
<i>Agapetus spp.</i>	C	25			2
Hydropsychidae	C	3	12	100	
<i>Polycentropus flavomaculatus</i>					3
Limnephilidae:	C	*	*	*	*
<i>Halesus indet.</i>		1	1		1
<i>Limnephilus lunata</i>		7			
Limnephilid indet.			2	2	
TRUE FLIES (Diptera)					
Chironomidae	C	4	1	36	100
Simuliidae	C	13			
<i>Dicranota spp.</i>	~	34	17	9	2
BETLES (Coleoptera)					
Elmidae	C	38	4	9	27
DAMSELFLIES (Odonata)					
Coenagrionidae		3			
F/W SHRIMPS (Crustacea)					
<i>Austropotamobius pallipes</i>	C	4	1	10	
<i>Gammarus sp.</i>	C	350	80	100	100
<i>Asellus sp.</i>	D				8
SNAILS (Mollusca)					
<i>Ancylus fluviatilis</i>	C		2		21
<i>Potomapyrgus sp.</i>	C	16	4	3	17
Sphaeriidae	D		72		
WORMS (Annelida)					
Oligochaetae	E		2	5	12
LEECHES (Hirudinea)					
<i>Trocheta sp.</i>	D				1
<i>Glossophonia complanata</i>	D	19			5
EPA Q Value		Q3	Q3	Q3	Q3
Total BMWP Score		96	62	56	82
ASPT		5.87	4.8	5.1	5.13