ENVIRONMENTAL RIVER ENHANCEMENT PROGRAMME

ANNUAL REPORT 2009








ENVIRONMENTAL RIVER ENHANCEMENT PROGRAMME

ANNUAL REPORT 2009

A report commissioned by the Office of Public Works (Drainage Division – Environment Section) and prepared by the Central Fisheries Board.

Central Fisheries Board
An Príomh Bhord Iascaigh

OPW
The Office of Public Works
Oifig na nOibreacha Poiblí

Table of Contents

1. Introduction

The OPW initiated the Environmental River Enhancement Programme (EREP) in 2008 and commissioned the CFB to undertake the studies identified in the project outline. The programme aimed to ‘enhance’ river corridors along arterially drained channels, managed by OPW, through either a Capital Works programme or through use of Enhanced Maintenance strategies. In both cases, it was envisaged that ‘enhancement’ or increased diversity of the physical and flow regimes would facilitate increases in biodiversity. In 2009, the second year of the programme, progress was made in all elements of the study. Walkover surveys led to the design of a series of Capital Works and Enhanced Maintenance programmes for pilot sites on a range of OPW channels. Monitoring of physical habitat and biological variables was undertaken at a subset of sites and ongoing studies of maintenance impacts on lamprey and crayfish continued. A training programme was developed, scheduled for roll-out in 2010, and circa 25% of OPW machine crews, engaged in routine maintenance, received audit visits from the EREP team.

The EREP programme has two major strands – a Capital Works programme dealing with enhancement or restoration of OPW drained channels and an Enhanced Maintenance element dealing with the robust implementation of OPW’s recently-developed protocol on channel maintenance. The Capital Works programme for 2009 included 7 locations from the 2008 programme and an additional 4 locations identified in 2009. Works were completed at 8 of these locations, including the R. Dee (Glyde – Dee CDS), R. Maine (Maine CDS), R. Enfield Blackwater (Boyne CDS) and R. Morningstar (Maigue CDS). The capital works programmes involve importation of stone and gravels, diggings and placement of materials to create instream physical diversity and bankfull fencing on completion of the instream works. As such, the works represent a new departure for OPW staff. Close liaison at the works sites has led to successful outcomes and there is a sense that the OPW personnel involved are pleased to have completed a series of these tasks and are confident with regard to implementing further such capital works. Walkover surveys to specify tasks for Enhanced Maintenance were undertaken in eleven channels in 2009.

Monitoring of biodiversity – as represented by fish, aquatic invertebrates, riparian and instream vegetation - was undertaken post-works at sites where the agreed works programmes of 2008 – Capital Works or Enhanced Maintenance – had been completed. The biodiversity element of the project was further developed during 2009. A major survey looking at the association between birds and rivers was undertaken by the CFB project team in the spring and summer, examining a number of channels throughout the OPW network. This will provide a baseline on species composition and abundance of birds in drained Irish channels. Compilation of species lists of riparian vegetation has also continued apace during 2009. In addition, plant surveys were undertaken in a number of drainage channels, of no specific fisheries value, to assess impact of regular maintenance on the instream and riparian vegetation. Comparative studies were also undertaken on four channels, where undrained sections were available to permit comparison with drained and maintained sections. Examination of physical habitat factors and how these may also be impacted both by channel enhancement works and by proactive maintenance is a significant component, complementing the biodiversity studies. Pre-maintenance monitoring in this context was undertaken in the R. Dalgan (Corrib Clare CDS) and at a series of berm management locations on the R. Deel (Deel CDS). An additional element in 2009 was the commencement of catchment-wide sampling to determine fish biodiversity. The strategy was extensive rather than intensive, with widespread sampling in the Cappa sub-catchment (Cappa-Kilcrow CDS), the Deel CDS and the Owenavorragh CDS. Fish community composition and abundance was assessed, including presence/absence of juvenile lamprey and of crayfish. The outcomes are considered extremely valuable and are reportable in GIS format. These should provide an additional information layer for OPW staff planning future maintenance operations. Given the success of this new approach, further catchments, where fish information is limited, will be targeted in 2010.

Scientific studies investigating lamprey and crayfish, initiated through previous OPW projects, have been incorporated into the EREP. Monitoring at some sites is ongoing annually since 2006 and an important information base is developing. Results of recovery among crayfish populations are not consistent across survey channels. While all studies indicated a decline in numbers following maintenance, levels of impact and rates of recovery have varied substantially. It is apparent that maintenance has potential to impact adversely on both crayfish and juvenile lamprey, both listed as Annex II Habitats Directive species. OPW has implemented SOPs for both groups during 2009 and monitoring the effect of these operating procedures will be of considerable significance going forward.

A driver training programme was rolled out during the EDM project in 2003. In this, protocols developed for environmentally friendly maintenance were described and discussed with OPW staff involved in maintenance programmes. The new EREP project will deliver the next phase of driver training during spring 2010. This training programme will consist of an updated version of the original training programme, aimed at focusing on those areas of enhanced maintenance which are proving difficult for machine drivers to implement. It will also introduce the whole Capital Works element of the project and provide familiarisation to drivers on the background to selecting particular low level structures, how they work and how they are installed. The new training regime will also address the recently-developed Standard Operating Procedures (SOPs) developed by OPW's Environment Unit in respect of Annex II (Habitats Directive) species such as lamprey, crayfish and otter.

In the EDM study, follow up to the driver training programme has involved site visits to a number of drivers actively implementing drainage maintenance. The aims of these visits were to assess whether environmentally friendly maintenance was being achieved, whether the potential had been identified and acted upon and how successful it was. The visits also provided an opportunity for on-site coaching, where appropriate. This process has been upscaled in importance by OPW in the new EREP and a formal auditing process is being developed. A standard form, identifying the suite of options present in the 10-point training programme, has been developed with OPW Environment unit and field cross-calibration exercises were carried out in 2009. A total of 18 site visits were made by EREP staff, accompanied by OPW foremen, to machine drivers in 2009. Following roll-out of the new training module in spring 2010, it is intended that the EREP team will visit *circa* 33% of the OPW's network of driver teams annually. This external audit will complement an internal audit process, using the same criteria and recording process, to be undertaken by OPW's Environment unit. The audit process will anticipate a robust implementation of all the maintenance elements presented in the new training programme, where appropriate and relevant.

2. Sampling Methodologies

New Sampling Methodologies for 2009

A review of all sampling methodologies was carried out after the 2008 field season. This led to a number of changes in survey methods to be applied from the 2009 field season onwards.

2.1. Fish Population Index (FPI)

In order to assess the impacts of Enhanced Maintenance and Capital Works undertaken within OPW drained rivers, in terms of biological diversity, there is a need to establish the 'status quo', in fish terms, prior to any works being undertaken. Fisheries information for some OPW catchments is limited, especially in some of the more low gradient channels that would not be recognised as important salmonid systems. This lack of fisheries information at a catchment level has lead to a new electrofishing surveying protocol being initiated in 2009.

The 10 minute Fish Population Index (FPI) survey was developed and successfully implemented this field season. It will be the preliminary survey method used to assess other OPW catchments into the future where fisheries information is not available or limited. However, electrofishing methods previously described are still used, and will continue to be used, where experimental and control monitoring sites are set up.

The FPI surveying technique quickly and efficiently increases fisheries knowledge in catchments where little or no recent data is available. The abundance level of certain fish species can also be used to infer water quality and the identification of imbalances in the population structure of certain fish species can be used to recognise habitat deficiencies. These surveys will be used to identify channels of fisheries importance and locations where fisheries enhancement/development may be undertaken. It will also be used to identify crayfish and lamprey locations at a catchment level.

The CFB has traditionally monitored fish populations using the quantitative electrofishing technique. These multiple-pass-based population estimates give detailed quantitative estimates for each fish species at each of their life stages and are essential in monitoring the changes in a fish population in a defined geographic area. However, this technique can be labour intensive and time consuming, especially in large catchments.

The 10 minute FPI survey is designed to create a fish population index which allows for greater spatial coverage across a given catchment in a shorter period of time. In wadeable rivers (water depth <50cm) a suitable site is located, which should cover a riffle-glide-pool sequence, if present, and bank side electrofishing equipment is used. The site is then fished for a period of exactly 10 minutes. This on average corresponds to a channel length of approximately 20-30m depending on channel width. In deeper river channels (water depth >50cm) boat based equipment is used. Here the boat is rowed down the channel and the site is then fished for a period of exactly 10 minutes. This corresponds to approximately 150 – 400 meters in channel length.

All fish are then measured to the nearest centimetre and released. A habitat and invertebrate assessment is also undertaken at each site, noting land use, vegetation, tree species and cover as well as establishing the basic macro-invertebrate assemblage.

2.2. Sampling Programme for Macroinvertebrates

The macro-invertebrate sampling methodology used in 2008 was amended in 2009. The method now used involves taking a multi-habitat sample i.e. pool, riffle and glide habitats are sampled at the same time. Previously, each habitat type was sampled separately. This resulted in an excessive amount of sample replicates which were both time and labour intensive to process. In addition, replicates are now sub sampled when being processed. This provides a good reflection of the invertebrate community present and is a good compromise in terms of sampling effort and the diminishing returns experienced as processing progresses.

2.3. Bird Survey Methodologies

Birds can be a very significant element in the biodiversity of a river corridor and those present are likely to be impacted by OPW drainage maintenance or indeed to any disturbance within the river ecosystem. Surveying for birds is a new departure for the

CFB and a comprehensive training programme in bird surveying methodologies was provided to the EREP survey team to ensure their competency in this area.

In general, standard bird survey methods used by Bird Watch Ireland and other relevant agencies were applied. Some minor adjustments were made to the standard recording forms, to fit the project requirements. No bird information regarding distribution, abundance or diversity was available within the CFB and thus the first objective, for the EREP project, was to build up a database of such information through general baseline surveys. OPW's EcIA No.6 on Riparian Birds has developed some baseline data for typical arterial drainage channels.

Baseline surveys for the specific channels to be enhanced allowed data to be collected that provided information on the relative abundance, species richness and distribution of all bird species present along the specific river corridor and within the channel itself. This data will also contribute to our understanding on the possible impacts drainage and drainage maintenance may have on these species.

In order to accurately reflect both the migratory and resident populations in Ireland, a two stage sampling programme is undertaken. The first of the two visits conducted at each waterway, is undertaken from mid April to mid May. This reflects the abundance of residents and early migrants observed in Irish waterways. The second survey from mid May to mid June, reflects the later migrants in waterways. A minimum period of four weeks is left between the two surveys. It is important that both sampling periods, and all subsequent surveys to a site, are undertaken by the same observers, to minimise the likelihood of error. Each survey begins shortly after dawn and finishes at approximately 10am, to coincide with the period of greatest bird activity. Additionally, in order to facilitate accurate gathering of data, surveys are conducted only on days with relatively dry and calm weather conditions.

For the purpose of this survey a line transect method is utilized. It involves two observers standing on opposite banks, beginning at predefined starting points and walking 500m in a fixed line along the river bank in a slow steady pace, whilst recording all the adult birds seen or heard within relevant distant bands. The distance bands utilized left and right of the transect line are <5m, 5-10m, 10-25m and >25m.

Each distance band reflects the perpendicular distance from the transect line to the individual bird recorded. The position of the river within the relevant distant bands is also recorded.

To facilitate accurate recordings of observed birds, each transect is further sub-divided into five 100m sections. Hand-held GPS instruments and maps are used to mark the start and end of each 100m section. Every effort is made to ensure that each bird is recorded in the 100m section they are first observed and that each bird is recorded only once. Birds not conclusively identified are omitted.

Data collected at each site is pooled into one survey sheet. Additionally behaviours such as nesting, aggression, feeding and bathing are also recorded by each observer. Birds in flight are recorded separately, although birds that are usually seen in flight, such as House Martins, Sand Martins and Swallows, which use the river habitat or the surrounding area, are recorded within the appropriate distant band. Additionally, birds which are seen outside the sampling transect, for instance behind the observer, are only recorded in the additional species section of the data sheet. Site variables are also recorded at each site - these include drainage history, width of channel, vegetation stratification profile and bank slope features.

2.4. Botanical Sampling Methodology 2009

Following a review of the plant sampling methodology used in 2008, a new approach was adopted. This involves a semi quantitative sampling approach to most sites and a detailed quantitative study of selected experimental sites.

1. **Semi quantitative**: The surveyor walks the river bank and compiles a species list. Initially the bulk of species are encountered in the early stages of the walk. There is then a ‘diminishing return’ in respect of new species. At the point where new species are not being encountered with regularity (within reason), the recording process is halted and the length of bank sampled is established. Start and end points are GPS referenced. Individual species are then assigned a ‘DAFOR’ abundance score.

This same methodology is used for the riparian, marginal and instream vegetation.

The above methodology has the advantage of being more time efficient and less labour intensive, thus allowing for more sites to be surveyed. The strategy is also considered to permit a greater length of bank to be observed and a more robust species list to be recorded.

2. **Tree survey:** The procedure is the same as 2008 i.e. within the bank length of a sample site, a list of tree abundance, species composition and height structure is compiled

3. Impact studies: a number of experimental sites are selected for a detailed investigation of the impacts of maintenance works on the plant flora. In 2009, experimental sites were surveyed by compiling a species list, a tree survey where necessary and a series of quadrats. The quadrats provide a quantitative record of the species list and degree of cover provided by each species and a series of quadrats is compiled in each trial plot. This facilitates a before- and after- statistical testing for changes in the flora following works. Two such impact studies were established in 2009:

- A series of berms on the River Deel, Limerick were subject to different management strategies following quantitative sampling of the existent flora. A total of 36 1 x 1m quadrats were compiled across 4 berms. These will be monitored over the coming years to assess the impact of the different management approaches on plant recolonisation.

- A heavily wooded section (260m approx) of the Gageborough River had tree growth on both bank slopes. A set of 10 quadrats was compiled on each bank. The riparian understorey and trees were subject to a detailed quantitative survey. Clumps of trees at given intervals will be removed and the impact of this on the riparian, marginal and aquatic vegetation will monitored in the coming years.

2.5. Changes to CFB Monitoring Programme for Environmental River Enhancement Programme (EREP) in 2009.

EREP involves two approaches to channel enhancement, Capital Enhancement and Enhanced Maintenance. The effectiveness of both of these programmes is being assessed through monitoring the impacts of the necessary physical works on the river corridor biodiversity and hydromorphology.

The biodiversity element of the project had the potential to monitor fish, macro-invertebrates, riparian and instream vegetation and birds using the river corridor in an exclusive manner as part of their ecology. Examination of physical habitat factors and how these may also be impacted both by channel enhancement works and by proactive maintenance will be a significant component, complementing the biodiversity studies.

Monitoring allows for the collection of scientific data. This data when processed and analysed should indicate how the monitored variable is reacting/changing over time. E.R.E.P. is interested in assessing the effectiveness of capital works and enhanced maintenance works on the whole river corridor and channel hydromorphology. To achieve this, monitoring of the various elements is carried out prior to works being implemented and then following works over a series of years. Experimental (where works are undertaken) and control (no works carried out) sites are selected and monitored for a number of E.R.R.P. elements.

E.R.E.P. includes seven elements that it would like to collect data on through monitoring (fish, flora, birds, macro-invertebrate, hydromorphology, crayfish and lamprey). The field season required to achieve this spreads across April to October each year. Over the 5 year period of E.R.E.P. a different set of channels will be involved in work programmes in each year. Therefore the channels selected for survey work out of each year’s programme, along with the post monitoring of sites from previous years work programmes would soon add up to quite a significant number of channels / sites that need to have survey works undertaken. This level of monitoring and survey work would not be sustainable.

Monitoring change in relation to river systems is not new. There have been and still are many other projects / studies which looked at how rivers were affected by enhancement works or similar events (Table 1 and Appendix 1). The work undertaken through many of these studies also monitored/surveyed several of the same elements that EREP are undertaking. The research carried out in relation to fish stocks, macro-invertebrates and hydromorphology is substantial. The data collected from all of these (including those from CFB) clearly describes the outcome of river enhancement works on those elements, and no new information, in respect of this same type of work, can be gained by continuing to monitor the effectiveness of enhancement works in OPW channels.

Hence future monitoring and survey work undertaken through EREP will follow a slightly different approach. The level of pre and post monitoring for fish, macro-invertebrates and hydromorphology will be reduced. Currently the project has 7 channels in which it monitors for these elements. This is sufficient to provide adequate information in line with that of other projects. Any further survey work regarding these elements will be in relation to baseline surveys and in areas where enhancement techniques being applied to the river are relatively new and there is a dearth of backround scientific data. However the importance of survey work and monitoring for birds, riparian and instream vegetation, lamprey and crayfish continues. The possible impacts of capital works and maintenance works on these river elements are still not fully understood. There is therefore a requirement for more scientific work to be undertaken in those areas. This will involve continuing to include channels, each year, for pre and post monitoring along with a number of baseline surveys.

Future survey work and monitoring work will focus on the information gaps. Where there is uncertainty on how a channel and its dependents will react there will be a need to determine what the outcome/changes are. Areas where there is ample data and information confirming the effectiveness and changes that a river system undergoes as a result of river development work will not require intense monitoring.

Table 1. Projects & Reports relating to Enhancement Works and Enhanced Maintenance Works.

Monitoring Element	*Reason for monitoring*	*Source of data collection / monitoring ** *see Appendix for listinf of individual papers, publications & Theses*	*Current monitoring sites*
FISH	Impacts of enhancement works	TAM (Moy, Corrib, and other non drained catchments	
	Statistical analyses on rehabilitation work in drained channels	POMS study report	
	Impacts of drainage	EDM	
	Enhancement works	Scientific publications, Management reports & PhD Theses	
	Impacts of drainage	PhD Thesis	
	Species listing for all major catchments/rivers	**EREP - 10 min e/f, WFD, 5 min salmon fishing**	**Deel, Cappa, Owenavorragh**
		EREP - limited monitoring of pre & post works	**Maine, Gloshagh, Morningstar, Robe, Dee, Enfield Blackwater, Boycetown**
PLANTS & TREES	Tree cover	EDM, Scientific papers & PhD Thesis	
	Instream vegetation	EDM	
	Species listing for all major catchments/rivers	**EREP**	
	Fencing & planting programmes	**EREP**	**Boyne, Dee, Morningstar, Robe**
MACROINVERTEBRATES	Pre & post enhancement works	PhD Theses	
	Changes in tree cover and instream vegetation cover	**EREP**, EDM, PhD Thesis & University projects	**Gloshagh, Boycetown**
	Individual enhancement structures	**EREP**	**Dee, Robe, Morningstar**
	Species listing for individual catchments/rivers	**EREP**, WFD,	
HYDROMORPHOLOGY	Impacts of drainage	PhD Thesis	
	Impacts of drainage	EDM	
	RHATS	EPA, **EREP**	
	General	**EREP**	**Maine, Gloshagh, Morningstar, Robe, Dee, Enfield Blackwater, Boycetown**
BIRDS	General	OPW / Bird Watch Ireland	
	Tree cover	**EREP**	
	Instream cover	**EREP**	
	Gradient	**EREP**	
	Invertebrates	**EREP**	
	Species listing for individual catchments/rivers	**EREP**	
LAMPREY	Impacts of drainage	EDM	
	Impacts of drainage	**EREP**	**Cappa, Stoneyford**
	Distribution and biology	Habitats Directive monitoring	
	Distribution and biology	WFD monitoring	
CRAYFISH	Impacts of drainage	EDM	
	Impacts of drainage	**EREP**	**Robe, Loobagh, Tullamore Silver, Brosna, Glore, Rath**
	Distribution and biology	WFD monitoring	

3. Enhanced Maintenance Programme 2009

Approximately 55 km of channels were identified for enhanced maintenance from the 2009 maintenance programmes of the three OPW Regions (Figure 3.1). These channels were walked with relevant OPW and Regional Fisheries Board (RFB) staff and maintenance options discussed. Agreed enhanced maintenance plans were subsequently drawn up and forwarded to OPW for implementation. A number of channels identified for similar works in 2008 were rolled over into 2009. This gave a total of 82 km of channels where enhanced maintenance was due to be completed in 2009. Summary details for each channel are shown in Table 3.1. All three OPW regions were included with 13 individual CDSs identified for work programmes. A small number of extra channels which were identified by RFB staff for enhanced maintenance were also included in the 2009 work programme. While plans were reviewed and works included under EREP these channels were managed directly by the relevant Regional Fishery Board in most cases.

Throughout the course of works, on a number of rivers, both the CFB and/or the RFBs provided support to foremen and drivers in terms of on-site training and advice when necessary regarding issues/problems that arose during the implementation of work programmes. This is considered a critical element of the EREP project. Continuous on-site support is and will be necessary and provided to drivers for a number of years.

One of the most common issues with drained channels is the lack of pool areas. The Enhanced Maintenance option in such channel types is to create pool areas. Digging pools can be undertaken in long uniform channel sections which only have riffle – glide sequences. Rivers requiring this type of instream fishery enhancement work are easily identified and the necessary works are straight forward to implement. All OPW drivers would be encouraged to engage in this type of fishery work as part of their normal routine approach to maintenance and this element will be strongly emphasised in the forthcoming training programme for OPW staff.

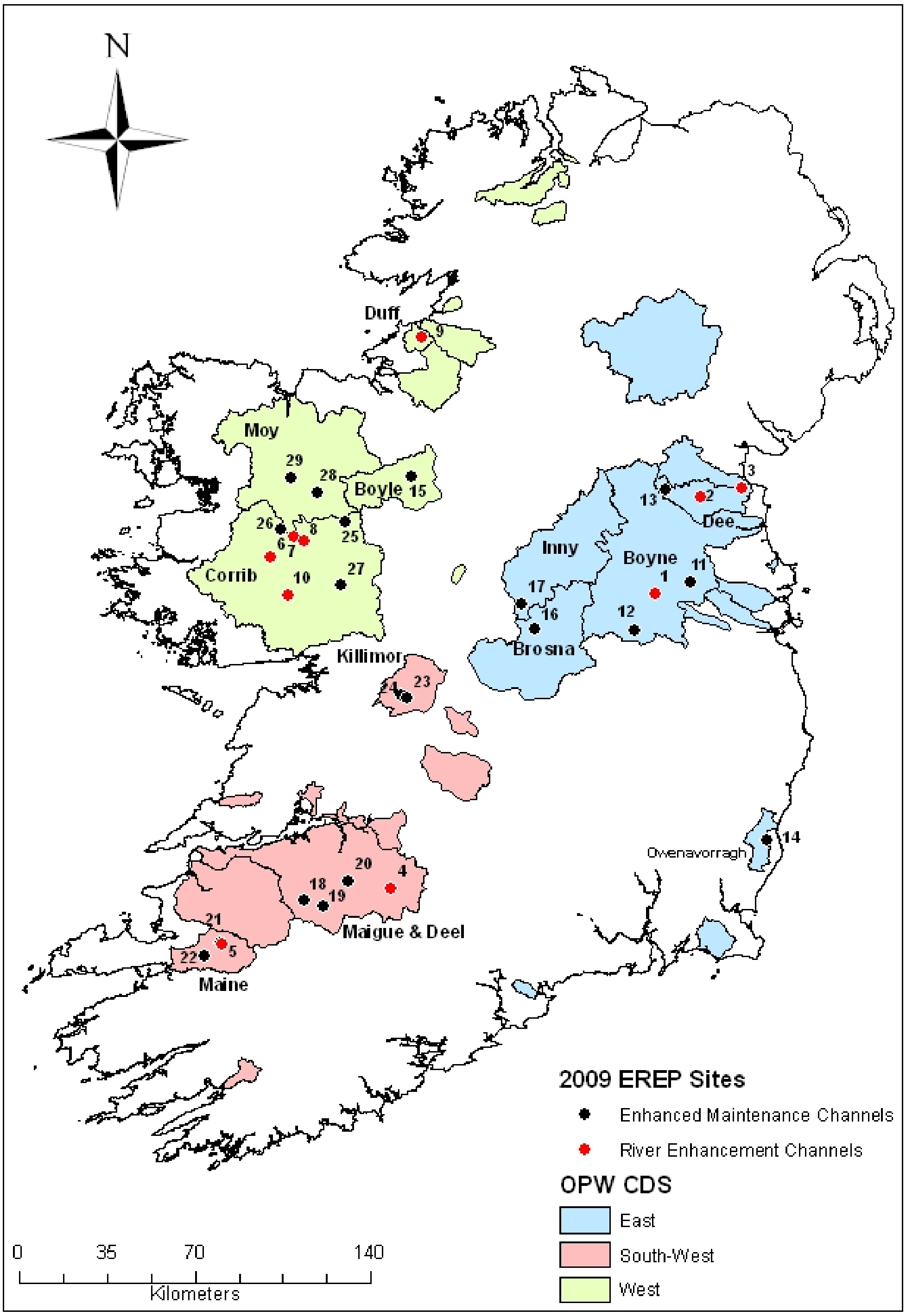


Figure 3.1. Location of channels identified for EREP works, 2009.

Table 3.1. Channels identified for Enhanced Maintenance under EREP 2009 (including those not completed in 2008).

ID Code	OPW Region	OPW CDS	River Name	Summary of Works	Completed	Designated Channel Length (m)
13	East	Glyde & Dee	Kilmainham R. (C2/42)	Tree pruning/removal, excavation of pools, rake cobbles	Partial	7610
12	East	Boyne	Little Boyne (C1)	Removal of excessive instream vegetation and low hanging trees and discrete management of marginal vegetation	Yes	6687
11	East	Boyne	Boycetown (C1/15)	Extensive scrub and tree clearence in tunnelled zones. Some instream vegatation removal and excavate pool riffle sequences	Partial	6125
16	East	Brosna	Gageboro R.C17(1)	Removal of excessive instream vegetation, low hanging trees and trees in the cross section & discrete berm management	No	6564
17	East	Inny	Dungolman R. (Tang) (C8)	Instream vegetation removal, tree management, pool and thalweg excavation	No	7331
14	Southeast	Owenavorragh	Owenavorragh (C1)	Excavate pool riffle sequences, Prune and remove fallen trees, remove flaggers and maintain berms in EDM manner	No	3750
21	Southwest	Maine	Dirtoge Stream (C1/34)	Tree cutting, Berm management, pool and thalweg excavation, bank protection	No	2908
22	Southwest	Maine	Pike Stream (C1/25)	Digging pools & addition of spawning gravels	No	3287
19	Southwest	Deel	Deel (C1)	Extensive berm management, limited tree pruning, some instream Veg. removal		3109
18	Southwest	Deel	Bunoke R. (C17)	Tree pruning, pool excavation, berm management & dig thalweg	Yes	3505
20	Southwest	Maigue	Gloshagh (C1/30)	Extensive scrub and tree clearence in tunnelled zones. Some instream vegatation removal and Excavate pool riffle sequences	Partial	7400
23	Southwest	Cappa/Kilcrow	Cappagh R. (C2)	Removal of instream vegetation, placement of random boulders, tree cutting	Yes	3688
27	West	Corrib Clare	Nanny R. (C3/18/1)	Sensitive instream vegetation removal. Pool excavation. Tree pruning/removal	Yes	10383
27	West	Corrib Clare	Nanny Trib (C3/18/1/1)	Sensitive instream vegetation removal	Yes	1342
27	West	Corrib Clare	Nanny Trib (C3/18/1/2)	Sensitive instream vegetation removal	Yes	3254
25	West	Corrib Clare	Dalgan R. (C3)	Instream Vegetation removal and pool digging	No	6682
26	West	Corrib/Mask	L. Carra Trib (CM5/9)	Fencing	Yes	4218
28	West	Moy	Glore R. (C1/30)	Instream vegetation removal, deflector-rubble mat construction, limited tree cutting & gravel tossing	No	3114
29	West	Moy	Little R. (C1/23/3)	Tree cutting, deflector, rubble mat, pool and thalweg construction	Yes	3145
15	West	Boyle	Bredoge Trib (C6/1)	Alternating deflectors, pools and rock sill for bridge constructed	Yes	561

An example of the type of works that can be achieved, while only using available on-site materials is clearly evident on the Little R. (C1/23/3, Moy CDS) (Plate 3.1). A wide range of enhanced maintenance techniques were successfully applied here. The positive impact on the whole river corridor, post works, should be evident throughout this river over the coming years.

Plate 3.1. Examples of instream works carried out during Enhanced Maintenance on the Little R. Top left photo: series of alternating deflectors and digging out of a thalweg. Bottom right photo: creation of a weir and associated pool area downstream.

A number of technical issues arose in summer 2009 while conducting on-site visits during some of the work programmes. Without resolving them, however, full implementation of enhanced maintenance plans in the future, will be jeopardised. These issues include:

- Difficulties arose in relation to the size of machine buckets being used in small channels (< 3m). In this situation is not unusual for both banks to be scraped and damaged while the bucket attempts to clean out the channel itself (Plate 3.2). The EREP team is of the view that, in many such cases, the buckets are too large for the channels in question and that, in general, a 'one-size-fits-all' approach seems to apply. This is reasonable as a general 'business' model but in the context of implementing environmental strategies it is considered that this issue needs to be addressed. Without being addressed, audits of performance will continue to identify shortcomings in regard to management of bank slope and marginal areas as well as the handling of instream issues in small channels. OPW are of the view that some of the issues arising can be addressed through driver care and experience and suggest that the roll out of the training programme will present an opportunity to highlight these concerns.

Plate 3.2. Machine bucket too big for channel it is working in.

- The need for maintenance works to re-establish the original drainage base-width is also not favourable to environmental maintenance (Plate 3.3.). This emphasis on design base width is commonly presented by OPW staff as a requirement. It may be considered necessary in the light of channel 'naturalisation' occurring over time. A radical implementation of this requirement is likely to lead, in many cases, to an undermining of the aspiration underlying the EREP strategies. The requirement to regain the design base width should be viewed within the overall set of variables within the Manning equation. Increasing the base should lead to increase in cross-sectional area, with knock-on benefits for discharge. However, assessment of Manning's 'n' might facilitate reducing channel roughness elements as a counter-balance to channel widening. Widening of channels in the original drainage schemes has led to many of the ecological and hydromorphological problems currently presenting themselves in OPW channels. Increased channel width facilitates lateral siltation. It also disperses stream power, thereby impeding the channel from focussing its energies to implement natural interactions with the bed and banks. The diminished condition, in terms of hydromorphology, is further reflected in reduced biodiversity. Re-achieving design base width will also lead to steeper bank slopes and reduced capacity for the bank slope area to accommodate spoil removed from the channel. An additional concern of fisheries is that the achievement of increased base width comes at the bottom of the cross section. This part of the cross-section is most critical ecologically. In contrast, it is the least critical for flooding as this area is first to drown out for any increase in stage and will be completely drowned out in bankfull flows.

It is the view of the OPW that there is room for experimental work in this area, and as such this will be followed up in 2010. In particular, the development of a '2 stage channel' which is in some instances already being implemented by OPW. This instream technique will become a key focus of the 2010 Enhanced Maintenance programme of works.

Plate 3.3. Design base width compared to desired base width.

- It is also important to note that enhanced maintenance work may proceed at a slower rate than routine maintenance, especially if instream development or digging work is required. Such digging work will be clearly identified in the agreed walkover survey report and plan. Implementation of Enhanced Maintenance plans is identified by OPW as an integral deliverable within the EREP study. The vision advanced by OPW, within the EREP, study requires the delivery of up to 100 km annually of 'demonstration sites' where Capital Works and Enhanced Maintenance works have been completed in a planned and agreed manner over extended channel lengths. The Enhanced Maintenance strategies are seen as becoming core to the day-to-day maintenance work of OPW, both in- and outside of 'demonstration sites'. Undertaking works to enhance the hydromorphology of a channel may not be 'necessary' in terms of maintenance of the channel's conveyance capacity. However, it is integral to EREP. OPW drivers are required to report on 'progress' and this is measured in respect of 'yardage' or length of channel tracked and maintained. Any 'delays' caused by Enhanced Maintenance may impact adversely on weekly 'yardage'. This issue is regularly flagged to the EREP team. Indeed, it has been evident as an issue for many years within the previous EDM study. There is an apparent inherent conflict between routine or standard maintenance, with no environmentally-sensitive inputs, and the type of maintenance approach required within the EREP approach. The latter is considered to be time-consuming, with a negative effect on output or 'yardage'. It should be noted that the EDM study developed a 10-point environmental training programme that has been implemented and is now considered to be standard practice. No allowances for time were made in implementing the EDM environmental elements. It was the view of several OPW staff that the loss of time in implementing some environmental strategies was balanced by time gained through such strategies as skipping sections that did not require maintenance. It is the view of the EREP team that a coherence of approach must be present within OPW in terms of 'delivery' of Enhanced Maintenance by driver crews, as reflected in 'yardage' reports that are passed to administrators. OPW might usefully investigate the notion of 'environmental yardage' to reflect additional time that may be required to expedite some works. It is the understanding of the EREP team that OPW envisages that the forthcoming environmental training will lead to a regime of robust implementation of the training points developed initially in the EDM study. Such robust implementation will lead to significant programmes of agreed environmental maintenance with instream digging strategies and placement of available stone material in many channels. This work WILL take longer to expedite than a traditional maintenance regime would. There is a fundamental conflict between implementing Enhanced Maintenance and the demand for fixed results in terms of 'yardage'. This is something that only

OPW can address. However, if it is not addressed this issue will continue to cloud the view of many OPW staff towards the EREP and will impede widespread implementation of Enhanced Maintenance strategies as the ‘norm’ for maintenance.

It is acknowledged by CFB that a number of variables, beyond the control of OPW, have also hindered the progress of several Enhanced Maintenance Programmes - in particular the two extremely wet summers of 2008 and 2009. This also coincided with the first 2 years of EREP. A second point would be the training of all OPW staff in relation to implementing Enhanced Maintenance strategies. This training programme will be a follow up from that given during the EDM programme, and is to be rolled out to all OPW staff in early 2010.

Plate 3.4. Example of berm management.

Plate 3.5. Type of channel which does not require drainage maintenance.

4. Capital Works Programme 2009

The Capital Enhancement programme for 2009 selected rivers from across all three OPW regions (Figure 4.1). A number of the channels included in the programme had been identified for works in 2008, however due to high water levels that year, not all works could be undertaken. In addition to the existing capital plans (for 9.5 km) a further 4.1 km of channel were identified for capital works in 2009 (Table 4.1). Walk-over surveys and detailed design plans were completed for each of the additional rivers.

Table 4.1. Channels identified for Capital Works under EREP 2009 (including those not completed in 2008).

ID Code	OPW Region	Catchment	River	Summary of Works
2	East	Glyde & Dee	Dee (C2/1)	Extensive Christmas tree work, random boulders, pool development. Fence LHB, toss gravels in small sections. Low grade vortex weir and rip rap.
3	East	Glyde & Dee	Dee (C2/1)	Extensive random boulders, gravel tossing and debris removal. Improve thalweg and excavate a number of pools. Paired deflectors/point bars.
1	East	Boyne	Enfield Blackwater (C1/36)	Vortex weirs, deflectors, rubble mats, rip rap and fencing on site. Spawning beds also constructed.
4	Southwest	Maigue	Morningstar (C1/31)	Gravel shoals, vortex weirs and rubble mats are predominant features. Some rip rap and thalweg excavation.
5	Southwest	Maine	Maine (C1)	Paired/alternating deflectors, random boulders and thalweg excavation prominent features. Pool excavation and placement of spawning gravel shoals.
10	West	Corrib Mask	Black (C4)	Paired and alternating deflectors, gravel beds, rip rap, thalweg excavation & fencing.
7	West	Corrib Mask	Robe (CM4)	Pools, rubble mats and spawning beds constructed. Random boulders also placed in channel.
8	West	Corrib/Mask	Robe (CM4)	Rubble mat, pool and thalweg excavation are predominant features. Cattle drinker, random boulders and selected fencing also in plans.
6	West	Corrib Mask	Bulkaun (CM4/5)	Works to allow fish migration from Robe into Bulkaun R.
	West	Moy	Owengarve (C1/48)	Tree pruning, channel/thalweg excavation and rock weir construction needed in this zone.
9	West	Duff	Duff (C1)	Thalweg and rip rap construction with random boulders. Gravel tossing.

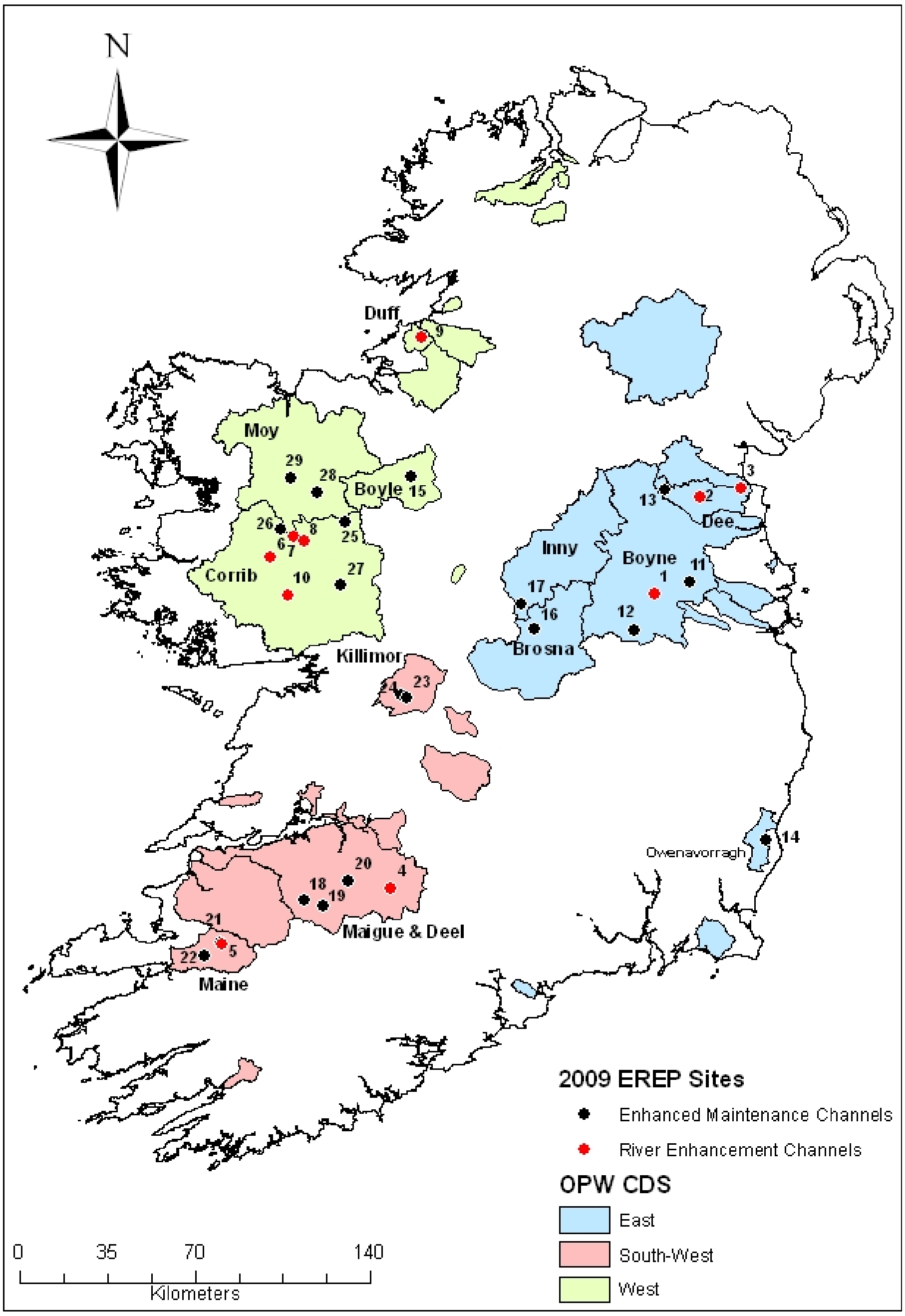


Figure 4.1. Location of channels identified for EREP works, 2009

The selection of channels for inclusion under capital works in 2009 followed those methods outlined in the 2008 annual report. Basic guidelines used to identify channel sections that would benefit from capital works include the following:

- Water quality should be at least moderate/satisfactory with a Q-value rating of at least Q3-4, and

- Ideally work in channels where the gradient is greater than 0.2% (2m/km) but less than 3% (30m/km).

A combination of information and data sources are available that will provide an insight into the selected channel sections and confirm their suitability, such as OPW long-section data, aerial imagery, EPA Q-value data and consultation with the Regional Fishery Boards. The final decision is then made after a site visit.

Capital works are mainly confined to salmonid channels, and as such, enhancement programmes can only operate between June and September. In certain circumstances works may be permitted to operate outside this window (only after consultation with the relevant Regional Fishery Board).

Capital enhancement programmes were carried out in eight catchment drainage schemes (CDS) this year involving 11 separate development plans (Table 4.1). Works commenced in June and continued through to mid-October. Poor weather conditions over the summer months led to some delays with instream works. However by mid October all heavy works were completed leaving only fencing, tree pruning and tree planting still to be carried out. All agreed plans were implemented by the end of 2009, with the exception of tree planting. This type of work should be undertaken in springtime following the implementation of all other works. In some cases tree planting may not be carried out for several years after the initial works. This would leave sufficient time for the natural introduction of certain tree species and thus may not require any specific planting programme.

In the majority of cases draft enhancement plans were fully implemented, although there were a small number of occasions where amendments were necessary. The changes made were generally minor. Some sections were shortened or extended. In the case of the R. Dee the addition of gravels was not necessary after all, as sufficient amounts of existing gravels were exposed within the channel during works. All changes to draft work programmes are subsequently identified and listed on a capital works completion form and the draft enhancement plan is updated.

A - River Dee pre-works, 2008.

B - River Dee during works, 2009.

C - River Dee post works, 2009.

Figure 4.2. Stages of capital works on the River Dee, pre-works (A), during works (B) and post works (C).

4.1. 2009 Programme Status

The Capital Works schedule for 2009 involved a total of 13.7 km of channels. Eight of the enhancement plans, totalling 7.4 km in length, were implemented this year. The remainder of these plans will be included in the 2010 work programme.

Table 4.2. Capital Work programme status 2009.

ID Code	OPW Region	Work Type	River name	OPW code	Channel length Targeted (m)	Status	Length completed (m) in 2009
2	East	Capital works - 2008	Dee (Hem br)	C2(1)	1000	completed	1000
3	East	Capital works - 2008	Dee (Drumcar)	C2(1)	1800	not started	0
1	East	Capital works - 2009	Enfield Blackwater	C1/36	1892	completed	1500
4	Southwest	Capital works - 2008	Morningstar	C1/31	1100	completed	850
5	Southwest	Capital works - 2008	Maine MC	C1/36	1500	completed	650
9	West	Capital works - 2009	Duff	C1	1200	completed	1200
11	West	Capital works - 2008	Owengarve	C1/48	2800	not started	0
7	West	Capital works - 2008	Robe (Sheepwash br)	CM4	550	completed	550
8	West	Capital works - 2009	Robe (Cloonbaniff)	CM4	950	completed	950
6	West	Capital works - 2009	Bulkaun (Robe)	CM4/5	120	not started	0
10	West	Capital works - 2008	Black R (Corrib)	C4	690	completed	690
					13602		7390

Capital work programmes take a significantly longer time to implement than what is required for enhanced maintenance programmes. The nature of the works involved can be quite detailed and technical and will require supervision and support through regular on-site visits, by either the relevant OPW engineer or trained Fishery Board personnel.

Works carried out over the course of 2009 covered many of the channel issues that will be regularly encountered while implementing EREP over the coming years. These range from bank protection, creating a thalweg, building alternating/paired deflectors, random boulders and the construction of weirs and associated pool works. As OPW field staff become more experienced with the implementation of such works, through training and on-site supervision, the delivery of capital works will improve with the added benefit that more channels are likely to be accommodated each year.

5. Biodiversity and Monitoring

5.1. Fish

5.1.1. Capital Works - Morningstar River (C1/31) (Maigue CDS)

A capital works plan for the Morningstar was submitted to the OPW in 2008. However, heavy rainfall in 2008 delayed its start. Works on this site were initiated and completed in 2009 with gravel shoals, vortex weirs, rubble mats, rip rap and thalweg all constructed through the 1.23 km long site. Pre-works a 130m experimental site was selected within this works zone as a location to be monitored (Plate 5.1). Cross sectional, depth- and longitudinal profiles were also measured before and after works.

Plates 5.1. The Morningstar experimental site pre-works (Left) and post works (Right) looking upstream.

Pre-works a quantitative fisheries survey was undertaken at this site. In the 2010 season a repeat survey will be undertaken, to evaluate the effect of the physical works on the resident fish stock. It is hoped that the added depth in the pools and spawning opportunities provided by the gravel shoals, will increase the salmonid population. It is likely that the added depth provided by the pools will allow for a greater stock of adult trout and salmon parr at this site. The availability of increased spawning gravel shoals should also lead to a significant increase in salmonid fry production within the reach and will be of benefit to many other reaches of the Morningstar.

5.1.2. Fish Population Index (FPI)

The FPI surveys were carried out at five OPW catchments in 2009 (Table 5.1 & Figure 5.1). In total 69 sites were fished, of these 47 were bank electrofishing sites and 22 boat sites. Trout were present in every catchment surveyed but not at every site. Salmon were only recorded in four of the catchments surveyed, however it should be noted that salmon are present within the Owenavorragh catchment.

Table 5.1. List of catchments surveyed using FPI in 2009.

OPW Region	CDS	River System	Number of Sites
East	Boyne	Athboy	3
		Kinnegad	3
		Riverstown	2
		Stonyford	5
	Owenavorragh	Owenavorragh	9
South West	Deel	Deel	17
	Cappagh - Kilcrow	Cappagh	24
West	Moy	Glore	6

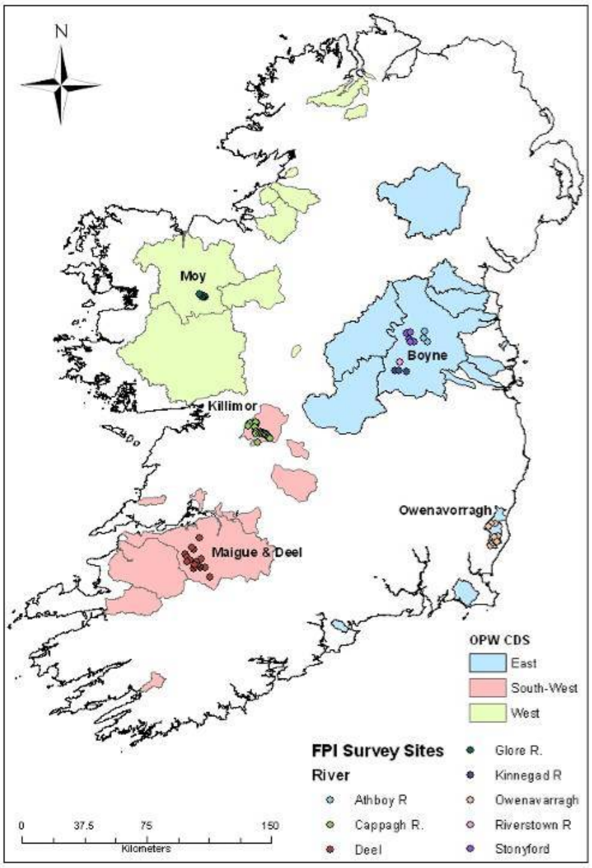


Figure 5.1. OPW catchment drainage systems where FPI surveys were carried out in 2009.

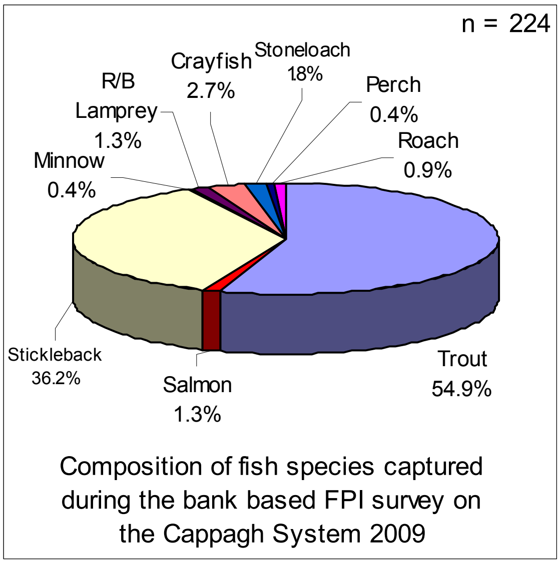
5.1.2.1. The Cappagh System (Killimor – Carrigahorig SR, C2)

The Cappagh River, Co. Galway is a tributary of Lough Derg on the Shannon system, rising near Loughrea and flowing south east to join the Kilcrow River (C1) less than 2 km upstream from Lough Derg. The OPW have 104.4km of drained channel in the Cappagh system. During the FPI survey on the Cappagh system 13 bank based and 11 boat based sampling stations were surveyed across the catchment (Appendix 2a). In total nine fish species were found - trout, salmon, stickleback, minnow, juvenile river/brook (R/B) lamprey, stone-loach, pike, perch and roach. Brown trout was the most abundant species (Figure 5.2). Crayfish were also present.

Initial investigation into the Cappagh system suggests that the Drumkeary Stream (C2/2), Duniry River (C2/10) and a tributary of the Duniry River (C2/10/1) are the most important spawning sites for trout. The main stem below Duniry Bridge downstream to the outfall of the stream C2/6 is the most important nursery/recruitment section for trout. River/brook lamprey juveniles were only present in 3 sites with a total of 3 individual lamprey recorded in the survey.

Only 24 salmon were captured -1 adult, 12 0+ and 11 1+. Two fry were recorded from the Duniry River but the rest were from the main stem of the Cappagh R. predominately immediately downstream of Duniry Bridge.

The absence of crayfish and lamprey from the boat based surveys (Figure 5.2) does not necessarily indicate an absence of these species from the surveyed sites, but is more reflective of their ability to avoid boat based electrofishing gear. Pike were not recorded from the bank based surveys as the sites sampled do not reflect the habitat preferred by pike. Pike preferring the slow flowing deeper main channel waters sampled using the boat.



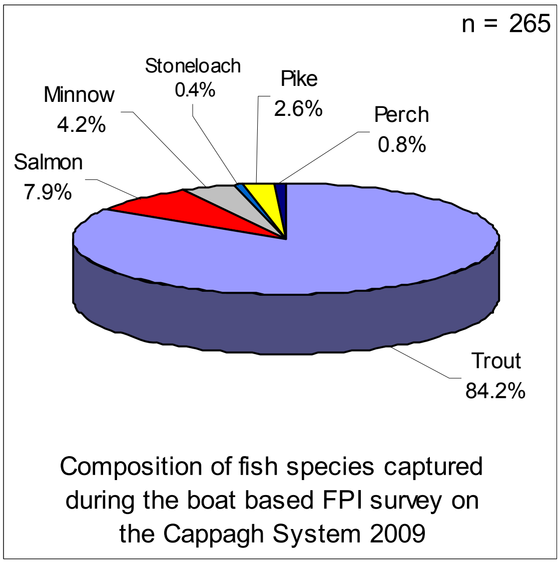


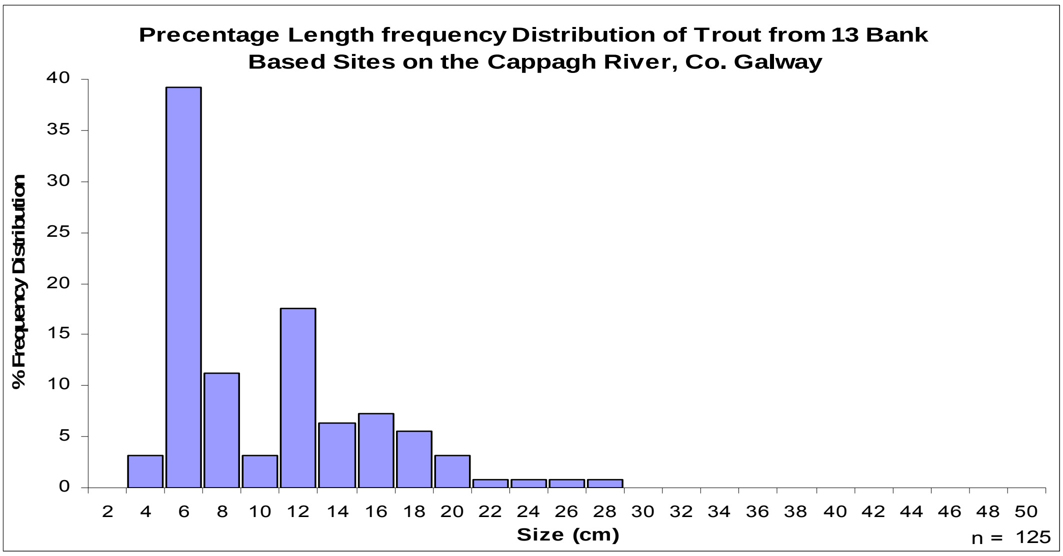
Figure 5.2. Composition of fish species captured during the boat and bank based FPI survey on the Cappagh system 2009.

Trout, the most numerically abundant species were present in 60% of the bank based sites and in all the boat based sites. Trout were absent in very small channels, with a wetted width of <1.5m and an average depth of less than 10 centimetres. Examining the length frequency distributions of trout caught during the boat and bank based surveys (Figure 5.3) it is possible to see how trout at each of their life stages utilise different habitats.

Throughout the bank based surveys 88% of the trout sampled were one 1+ fish or younger, with over half the trout captured being 0+ fish (Table 5.2). Trout sampled during the boat survey were larger with more than half being older than 1+ and some considerably more (Figure 5.3). Trout aged from this system indicated that 0+ trout were between 4 – 9 cm, 1 + fish between 10 and 17cm and adult trout were those greater than 19 cm (Figure 5.3). Differences in age structure and size range of fish caught may also be reflective of the survey methods. Bank based electrofishing allows for smaller fish to be more readily captured than when using boats, which sample more deeper waters while moving at a relatively fast pace, making it sometimes difficult to capture smaller fish.

Table 5.2. Trout age class percentages recorded from the Cappagh boat and bank sites.

Trout Age Class	Bank Survey %	Boat Survey %
0+	55.2	9.3
1+	32.8	40.0
>1+	12.0	50.7



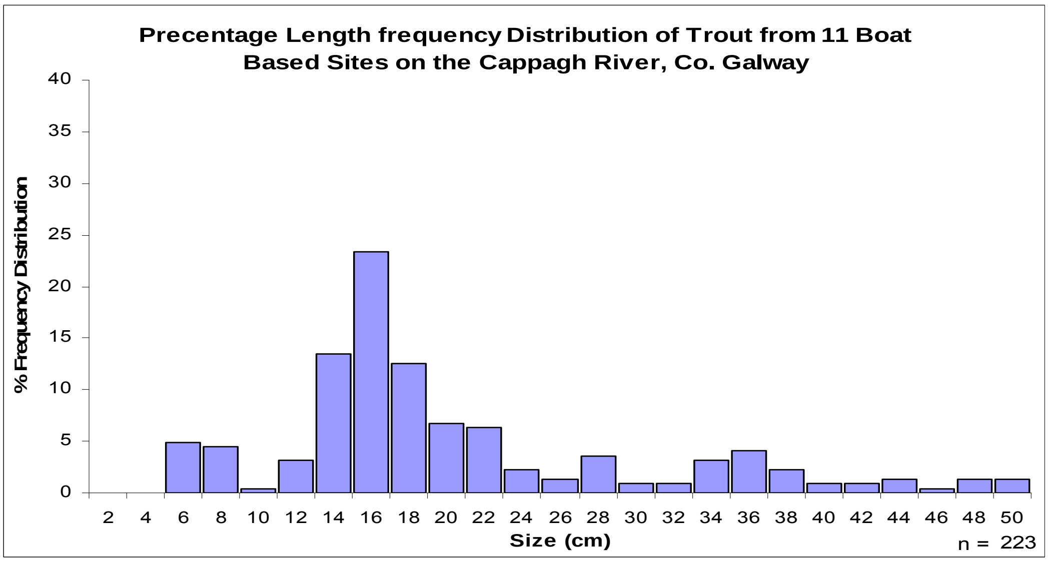


Figure 5.3. Showing the percentage length frequency distribution of trout sampled from the boat and bank based surveys of the Cappagh River, 2009.

This separation of trout age classes into different habitat types shows how the fish utilise different parts of the river as they grow. Trout spawn in shallow riffle areas with gravel beds, the 0+ juveniles spend their first year of life in this type of habitat. During their second year they move to the shallow glides and pools of the river. As >1+ the trout require deeper sections of the river and may even run to lakes on the catchments to continue growing only returning to the shallow sections of their native river to spawn.

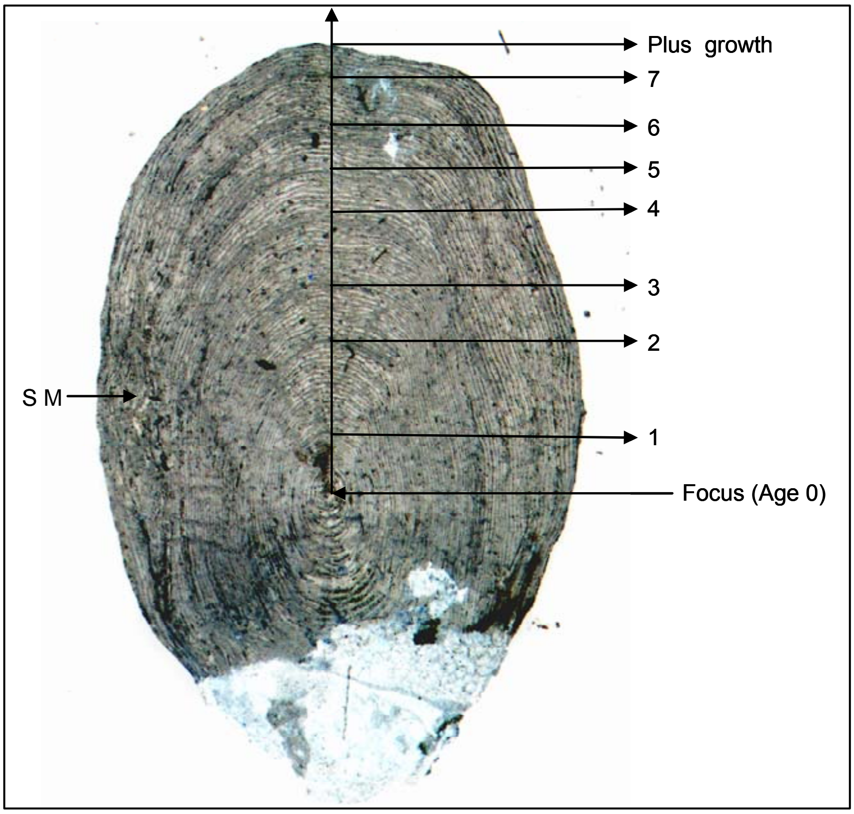
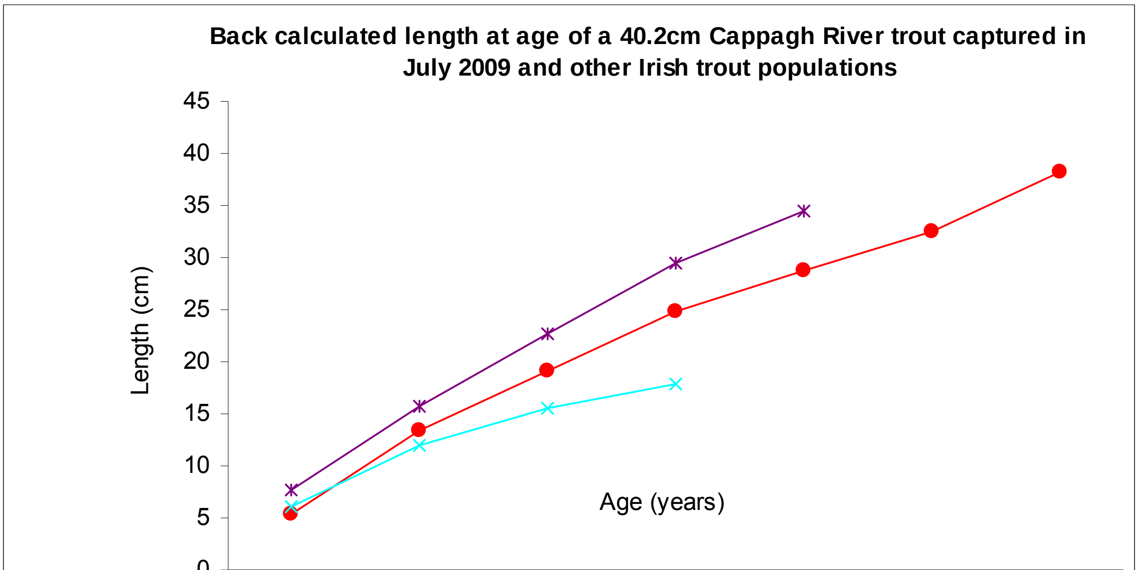


Plate 5.2. A 40x magnification of an adult brown trout scale (40.2cm) captured in the Cappagh River (July), showing annual growth rings, plus growth, focus and spawning mark (SM).

In addition to estimate of abundance, it is useful to determine fish growth rate and growth patterns, for a given population. Concentric rings (circuli) are laid down on scales as a fish grows—like tree rings—and as growth slows (typically in the autumn or winter) these circuli crowd together and form an annulus, indicating one year of age (Plate 5.2). There is a liner relationship between the growth of trout, in terms of its length and the increase in the size of its scales. Therefore the annulus formed every winter can be used, with the fish length at capture, to calculate fish growth over its life span (Plate 5.2). The plus growth corresponds to the growth between the previous winter and its capture in July. The spawning mark (SM) is due to the absorption of the scale caused by the stress of spawning.



	1	2	3	4	5	6	7
Cappagh River	5.4	13.4	19.1	24.9	28.7	32.5	38.3
R. Avonmore	6.0	12.0	15.6	17.8			
R. Suir	7.6	15.6	22.7	29.5	34.5		

Figure 5.4. Back calculated length at age of a 40.2cm trout captured in the main stem of the Cappagh River in July and growth patterns from 3 other Irish trout populations.

The growth pattern of the 40.2cm Cappagh river trout lies between the fast growing fish from the River Suir and the slow growing trout from the Avonmore River (Figure 5.4). These growth rates can be related to the underlying geology of the region with the slate/ pyrite/schist complex of Wicklow (Avonmore River) being nutrient poor compared to the nutrient rich catchment of the River Suir which lies over a pure limestone/shale/sandstone complex. The Cappagh River lies over a mudstone/siltstone sedimentary complex which while more fertile then slate/ pyrite/schist is prone to nutrient leaching and less fertile then the limestone rich catchment of the River Suir.

5.1.2.2. The Deel System (Deel CDS)

The River Deel rises near Drumina in north Cork and flows north through Co. Limerick to its outfall in Askeaton on the Shannon Estuary. The river was drained in the late 1960's and there are 276km of OPW drained channel in the Deel catchment with 36km of main Deel channel (C1). There are a large number of small drains and streams in the catchment. During the FPI survey undertaken in July 2009, 12 bank sites were surveyed throughout the catchment and 5 boat sites were surveyed between Broken Bridge and Bunoke Bridge on the main stem (C1) (Appendix 2b).

Trout, minnow, stickleback and stoneloach, in this order, were the most abundant species encountered in the survey making up 99% of captured species (Figure 5.5). Crayfish, salmon, perch and gudgeon were also encountered, but in very low numbers (<5).

Approximately 1% of the trout population captured in the main Deel River are 0+ fish. This may therefore suggest that few adult trout are spawning within the Deel main channel. If this is indeed the case trout recruitment may be dependant upon the Deel tributaries or the headwaters of the main channel. Four important spawning locations were highlighted during the course of this survey, the main channel above Milford (C1), the Bunoke River (C17), the Arra River (C12) and the Slewnaun River (C8), all having relatively good numbers of 0+ and 1+ trout.

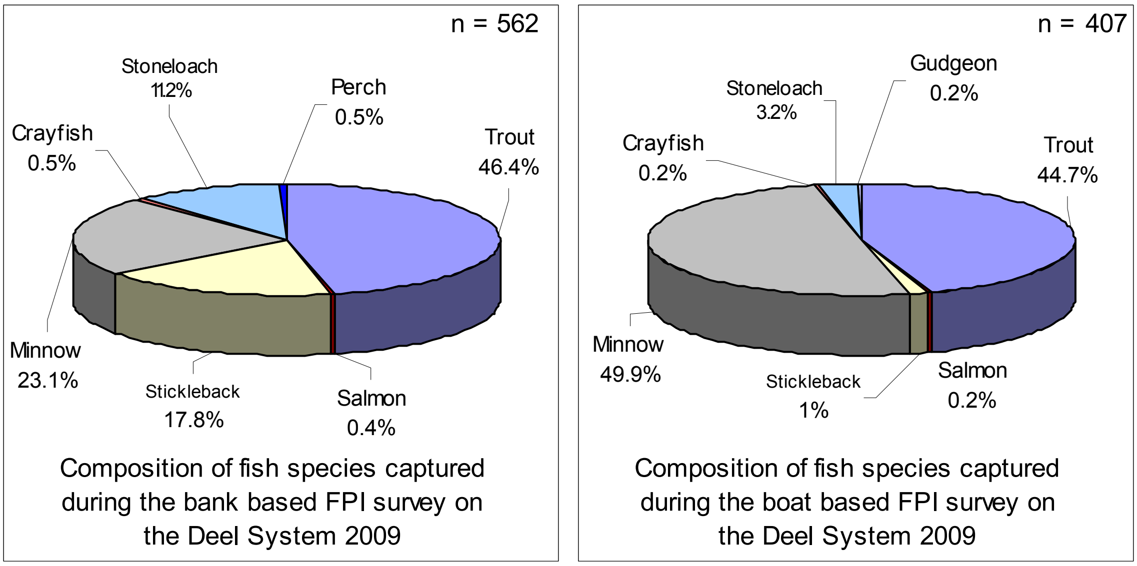


Figure 5.5. Composition of fish species captured during the boat and bank based FPI survey on the Deel system 2009.

The Arra River and its tributaries, which flow through Newcastlewest, have a good standing crop and age distribution of trout. Trout captured in the Newcastlewest Arra site (Plate 5.3) were all 1+ or older with no 0+ trout present, possibly because this section of channel is over bedrock without spawning gravels. This location supported a large standing stock of adult brown trout, because of the hydrology created by the bedrock. The bedrock was not modified during arterial drainage so the original instream complexity is still present providing excellent salmonid habitat. This section of the river is a complex assortment of pools and riffles, giving living space and a food supply to the fish. The mature tree lined right bank provides shade, food and cover for life on the river corridor and falling insects provide an alternative food supply for trout.

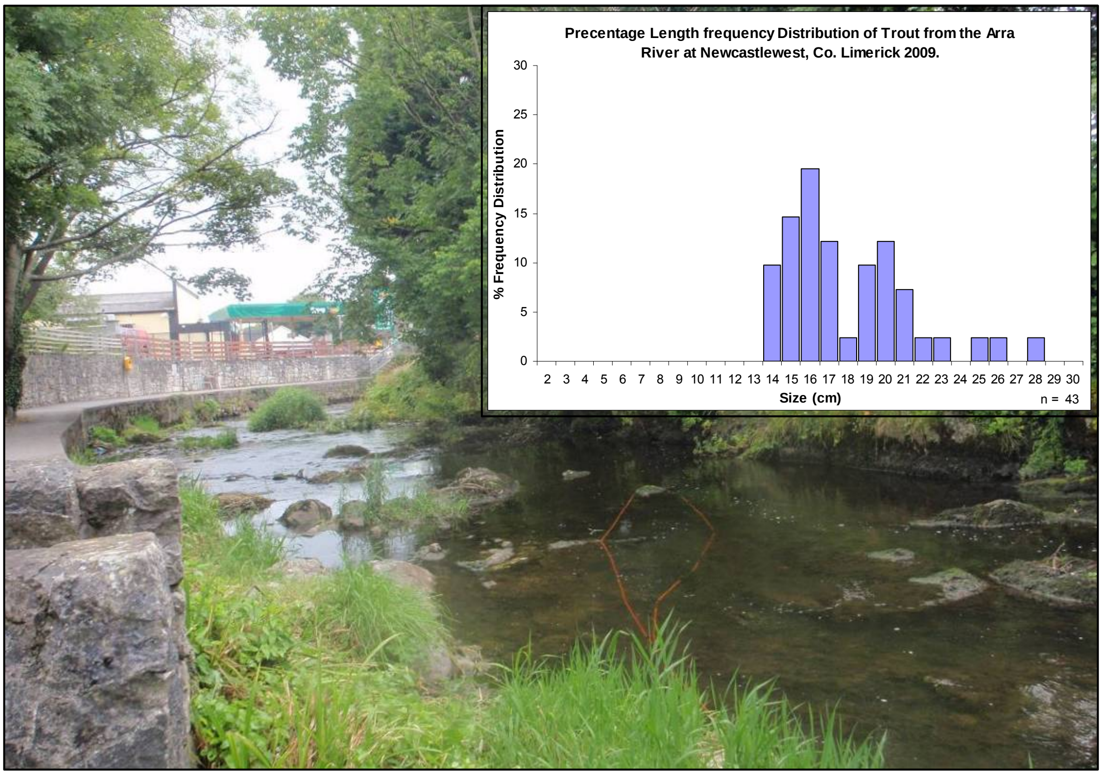


Plate 5.3. Showing the site on the Arra River (C8) in Newcastlewest and the percentage length frequency distribution of trout captured.

Only 3 salmon were captured in the survey, possibly due to the semi impassable weir in Askeaton (Plate 5.4). According to Augustus Grimble (1903) salmon angling has declined since ~1898 when a weir was constructed at Askeaton. This weir represents a semi passable barrier to salmon and probably a total barrier to sea lamprey migration.

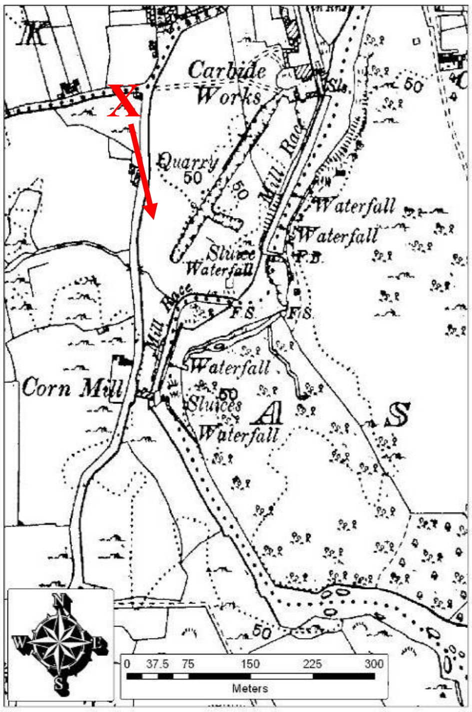


Plate 5.4. Showing an aerial picture and 6 inch map of the weirs on the River Deel at Askeaton, Co. Limerick (X and arrow shows aspect of aerial image).

5.1.3. Maine River – comparison of fish stocks in a drained and undrained section.

Drained and undrained sections of the Dirtoge Stream (C1/34) were selected (Figure 5.6 & Plate 5.5) for this experiment, to allow for the comparison of pre and post enhanced drainage maintenance and its effect on the hydrology and the streams fish species composition and abundance. An evaluation of the effect of drainage and successive maintenance cycles on the fish species and hydrology of the channel are discussed here.

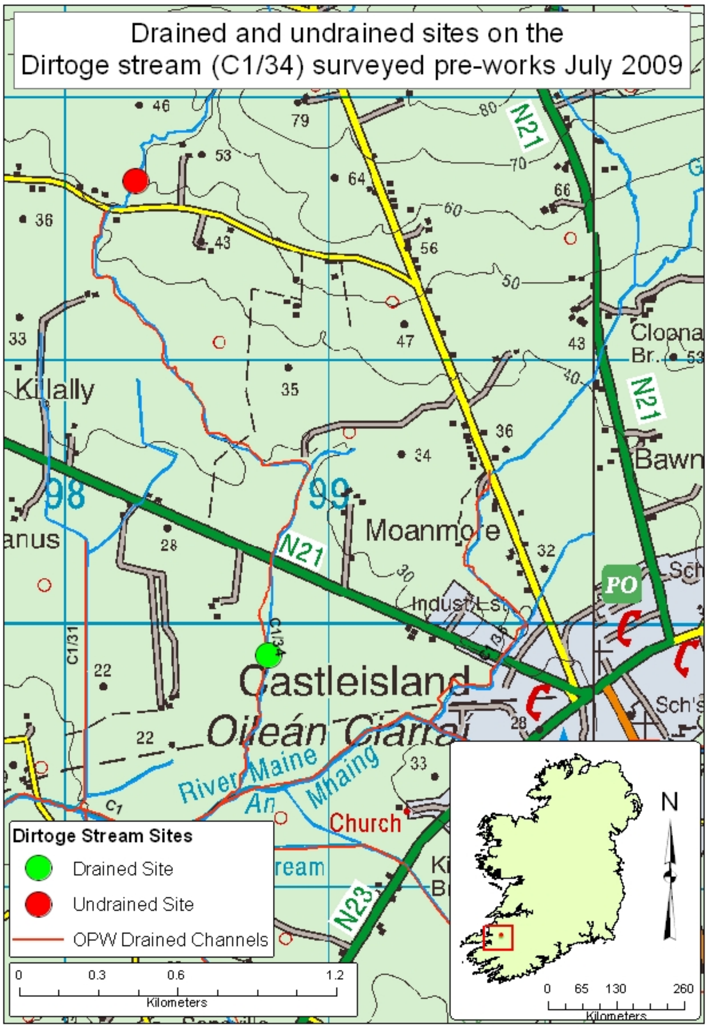


Figure 5.6. Location of the drained and undrained experimental sites on the Dirtoge stream (C1/34), River Maine Tributary, Co. Kerry

The fish survey in the drained site had five 30m replicates, while the undrained site had three 30m replicates. This was due to difficult fishing conditions in the undrained site.

Plates 5.5. Showing undrained (Left) and drained sites (Right) on the Dirtoge stream (C1/34), Co. Kerry.

In the drained site seven species were present (salmon, trout, eel, stickleback, flounder, minnow, stoneloach), while at the undrained site only salmon and trout were captured (Figure 5.7).

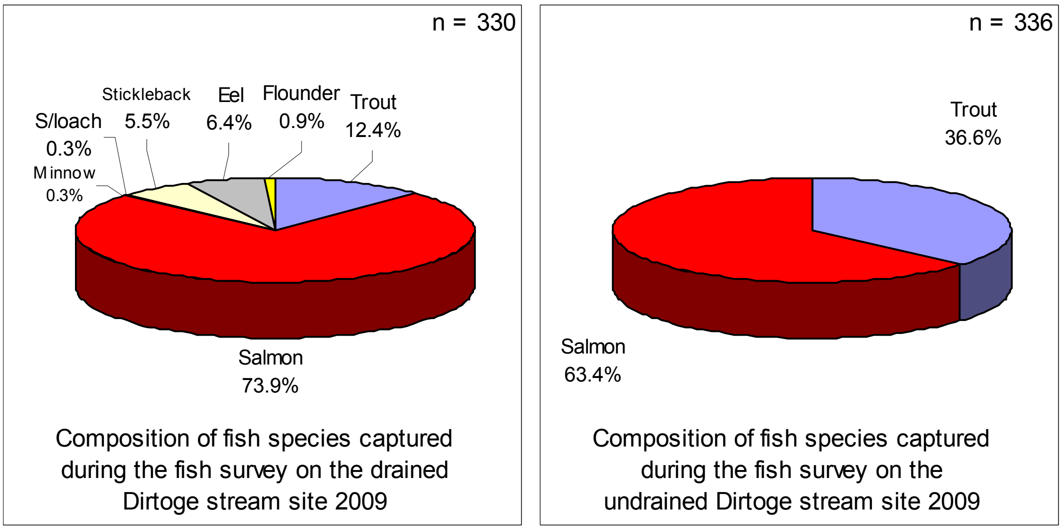


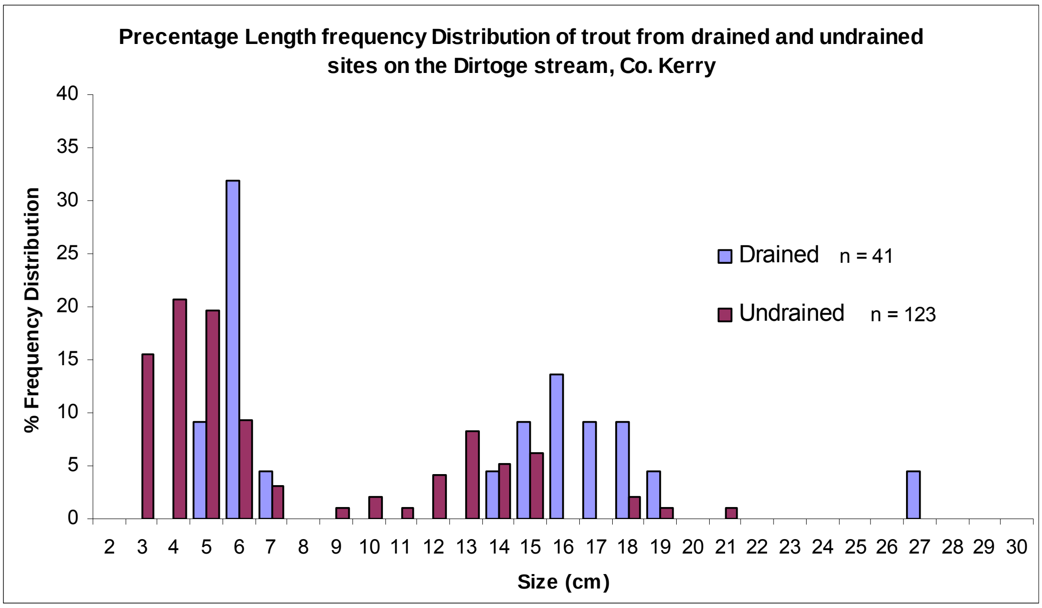
Figure 5.7. The composition of fish species caught in the drained and undrained experimental sections of the Dirtoge stream, Maine catchment Co. Kerry 2009.

The flounder found at this site, while in low numbers would not be uncommon. Juvenile flounder leave the estuaries in their first year of life and migrate upstream to feed, spending up to a year in freshwater. The flounder originated ~20 km away in the estuary. This is not a long journey for them as they have been recorded up to 50km upriver in the Tweed (UK). At the drained site the river bed is composed of fine sand and gravel and is excellent habitat for flounder. No flounder were captured in the undrained site, possibly because of a weir downstream of the road bridge which would prevent upstream migration.

The habitat type in the undrained site which is fast flowing over a small cobble/ gravel bed favours salmonids, especially salmon. The trout and salmon populations in both sites have similar length distributions (Figure 5.8). However the number of trout captured in the drained site is significantly less than the undrained (Trout *D*, 0.33, *P*: 0.003). Comparing average salmon /trout per m^2 there are 6.2 times more trout and 2.2 times more salmon in the undrained section compared to the drained section (Table 5.3).

Table 5.3. Mean number of trout and salmon per m^2 in the drained and undrained sites on the Dirtoge Stream

	Drained	Undrained
Average trout per m^2	0.06	0.37
Average salmon per m^2	0.29	0.64



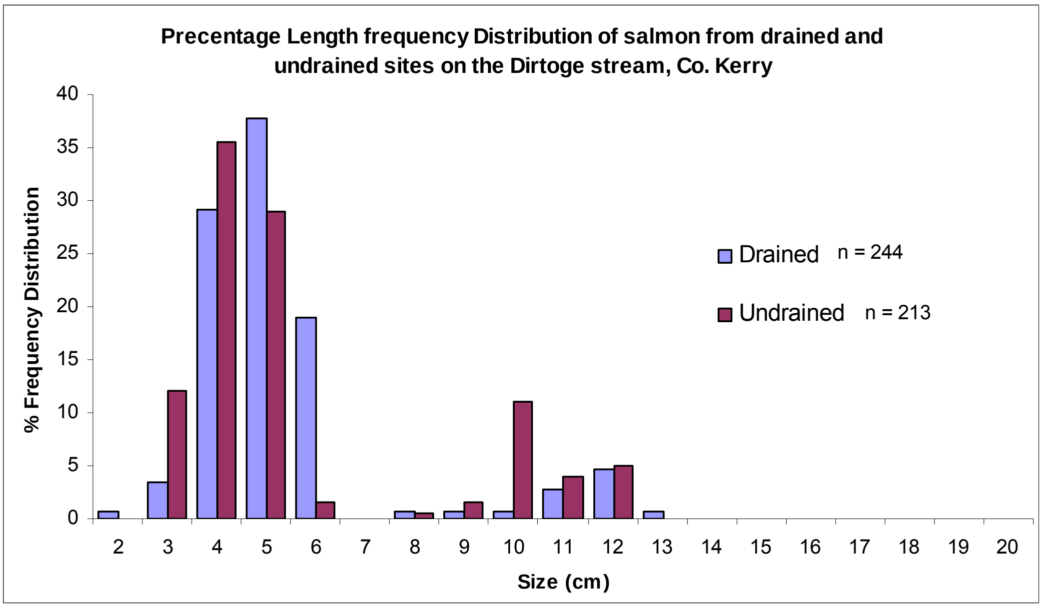


Figure 5.8. Percentage length frequency distribution of brown trout and salmon from the drained and undrained sites on the Dirtoge stream (C1/34) Co. Kerry.

Trout and salmon densities along with 95% confidence intervals are calculated for three life stages in trout (0+, 1+ and >1+) and 2 for salmon (0+ and 1+). A comparison of trout and of salmon life stages in the drained and undrained sites (Figure 5.9) indicated no statistical difference in the minimum densities of specific age groups.

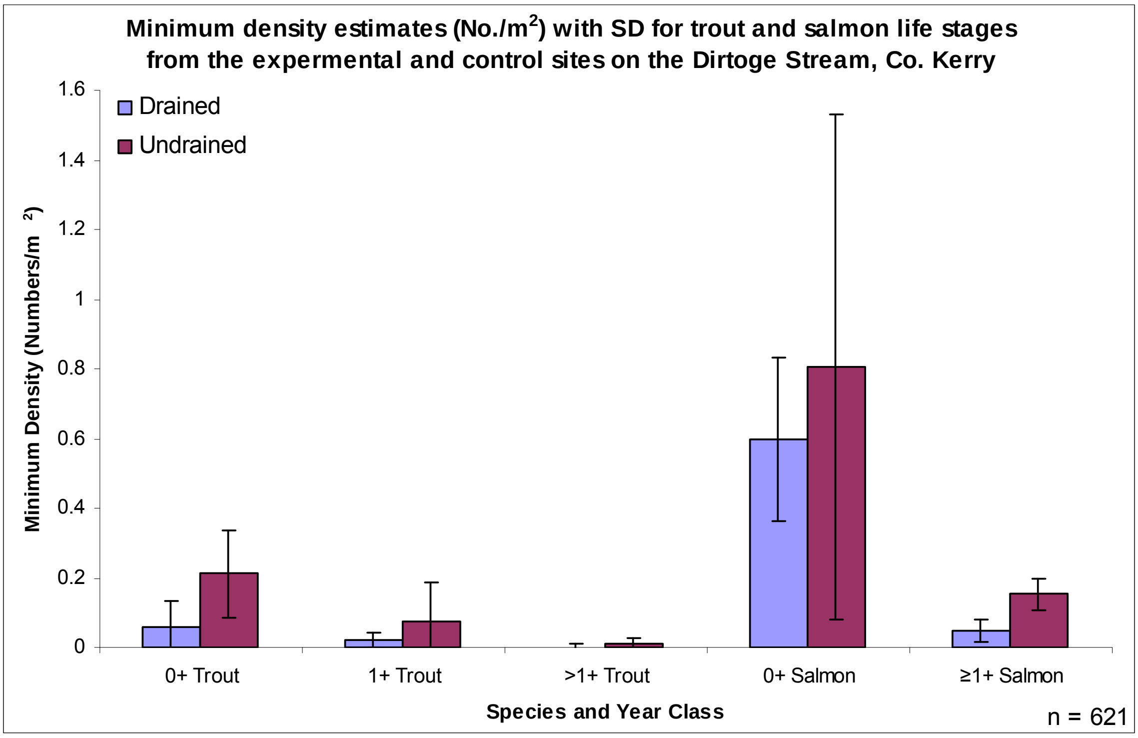


Figure 5.9. Minimum density estimates for trout and salmon (No. /m^2) at different life stages with relevant standard deviations, for the drained and undrained sections on the Dirtoge Stream (C1/34), Maine Catchment, Co. Kerry

No statistical difference in age or size distributions were found when comparing the trout and salmon populations from the drained and undrained sites. However, greater numbers of salmon and trout were present in the undrained section. Loss of suitable habitat type, post drainage, in the drained section may be responsible for its reduced salmonid numbers.

The undrained site has more diverse instream features with a complex riffle, pool glide sequence. In comparison the drained site consists mainly of an undulating glide with one small riffle section. The complexity in the undrained site supports higher salmon and trout numbers, with extensive riffles providing areas of invertebrate food production and pools for larger fish to live.

5.2. Botanical Surveys

5.2.1. Pre and Post Works

5.2.1.1. Capital Works Programme - River Dee, Louth

Two sites (one experimental and one control) on the River Dee were subject to botanical surveys before (2008) and after (2009) capital enhancement works were implemented.

Riparian Vegetation: There was no change in riparian species richness, or species number, between the 2008 and 2009 surveys on the control site. However, the experimental site saw a substantial increase in species number following the works process (Figure 5.10). This change in species composition is reflected in the outcome of the Sorenson and Bray Curtis similarity indices (Table 5.4). Bray Curtis is a statistic used to quantify the similarity between different sites based on both species composition and cover abundance, whereas Sorenson is concerned with similarity of species composition only. Bray Curtis returns a score on a scale of 0-1. The higher the score, the greater the dissimilarity or alternatively, when subtracted from 1 the greater the similarity (as is presented here). It is useful here because detailed quantitative data is available.

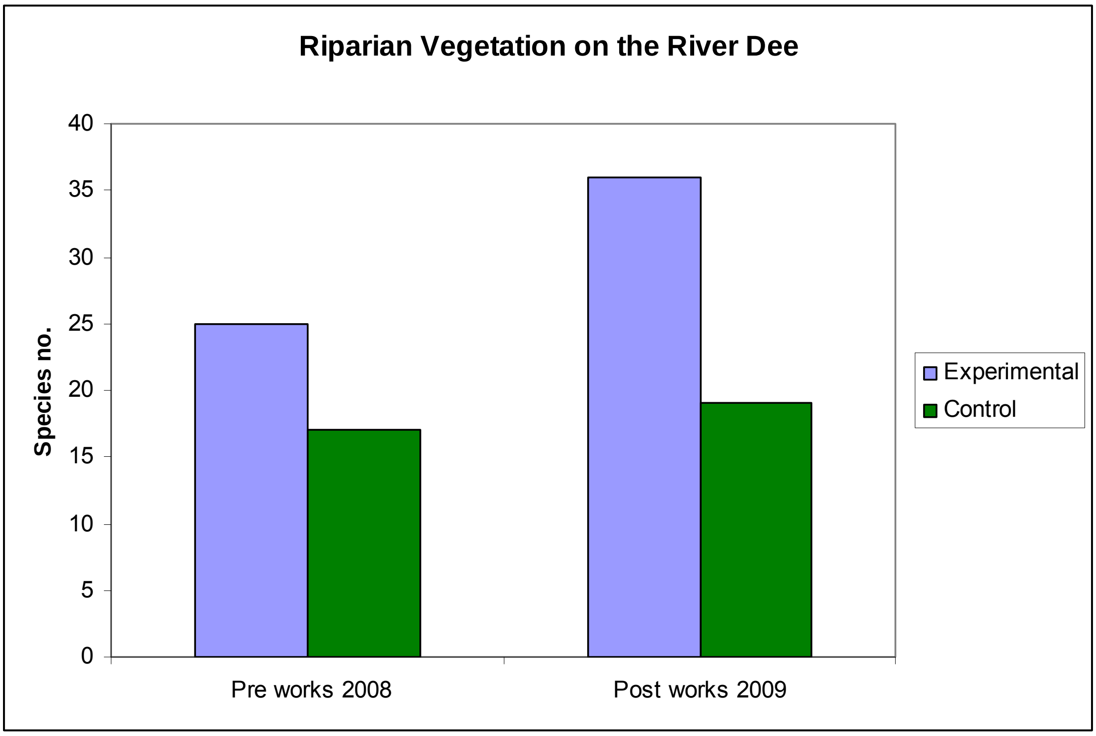


Figure 5.10: Species number pre and post works on the River Dee.

The observed change in the experimental section is likely due to a combination of fencing and the creation of new, reprofiled bank slopes that were initially bare (Plate 5.6). The new fencing allowed plants to establish without being grazed/trampled by livestock. Previously, large parts of the banks were heavily eroded and under pressure from livestock. This kept the banks bare in places. Plants associated with early colonisation such as Rape Seed (*Brassica napus)* and other meadow species have now established with greater frequency on the river banks. These plant species are occurring alongside the flora that already existed in areas not subject to works.

Plate 5.6: River banks on the River Dee pre and immediately post works.

The species composition pre- and post-works on the control site was reasonably similar, based on the Sorensen index, given natural variation (Table 5.4). However, there was a noticeable change in species abundance (Bray Curtis). This may be a consequence of a change in land use next to the site from pasture/tillage to cropland. The crop in question was maize which can grow to 2.5m approx resulting in a large increase in shade which may have affected the relative abundance of individual species.

Table 5.4: Similarity indices (converted to %) for riparian vegetation on the River Dee

Site	Bray-Curtis (1-BC)	Sorensen
Experimental pre & post works	55	60
Control pre & post works	61	76
Experimental V Control pre works	39	36
Experimental V Control post works	33	46

Aquatic Vegetation: It was not possible to survey the aquatic vegetation of the control site as the area was in flood in both 2008 and 2009. Although the experimental site experienced no change in aquatic species (Table 5.5) composition there was some change in percentage species cover and in extent of bare substrate (Figure 5.11) post works.

Table 5.5: Similarity indices scores (converted to %) for aquatic vegetation in the experimental site

Site	Bray Curtis	Sorenson
Experimental pre & post works	74	100

This is highlighted by a Bray-Curtis similarity score of 74%. The increase in bare substrate is to be expected initially following pool excavation and the creation of rubble mats. Results indicated a substantial decrease in the Water Crow Foot *(Ranunculus pencillatus)*. This was the dominant species pre-works. The non-native Canadian Pondweed *(Elodea canadensis)* appeared to be increasing, having doubled its cover. Canadian Pondweed is commonly regarded as a nuisance aquatic and is very invasive. Canadian Pondweed may be increasing on its own as a result of its competitive abilities, regardless of any disturbance caused by enhancement works. However, the creation of bare substrate and disturbance of other aquatic species is likely to favour Canadian Pondweed in the medium to long term. This will be monitored in the coming years.

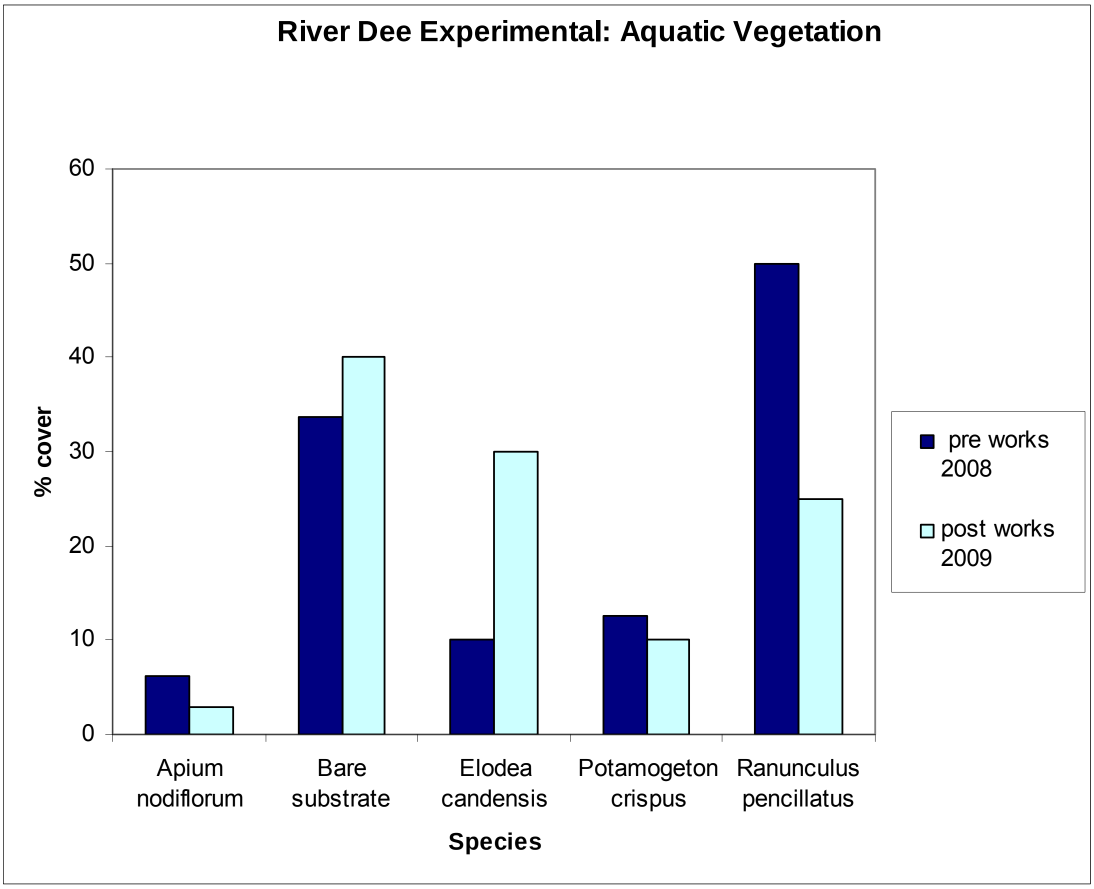


Figure 5.11: Percentage cover of channel bed pre and post works for aquatic vegetation and areas of bare substratum

5.2.1.2. Enhanced Maintenance Maintenance - Gloshagh River, Limerick

Two wooded sites (a control and experimental) on the River Gloshagh were subject to a botanical survey pre enhanced maintenance works in 2008 and post works in 2009. The experimental site had a substantial number of mature trees removed (Table 5.6). This was to allow light penetration into the river channel to promote instream vegetation and to determine the effect of tree removal on the riparian flora.

Table 5.6: Approximate tree numbers pre and post maintenance works

Site/Year	Young	Mature	Total
Wooded Experimental pre works 2008	26	101	127
Wooded Experimental 2009	13	60	73
Wooded Control pre works 2008	41	107	148
Wooded Control post works 2009	40	100	140

No instream or marginal vegetation was present in the experimental site in 2008. A small amount of Fools Water Celery *(Apium nodiflorum)* was the only aquatic/marginal vegetation recorded in 2009.

The surveys in 2009 returned more riparian species in both the experimental and control (Figure 5.12) compared to 2008. As expected, the control sites show the highest degree of similarity pre and post works taking account of natural variation (Table 5.7). The experimental has exhibited more pronounced change following works. A number of species typically associated with open habitat were recorded in 2009 on the experimental site. This is likely to be a result of a combination of tree removal, which increased light levels, and disturbance of the banks by machinery, which facilitated establishment. The experimental and control were markedly different pre works. However, their similarity increased post works. The control site was originally more open than the experimental. Post works, the light regime may be more alike, thus allowing for greater convergence of species composition.

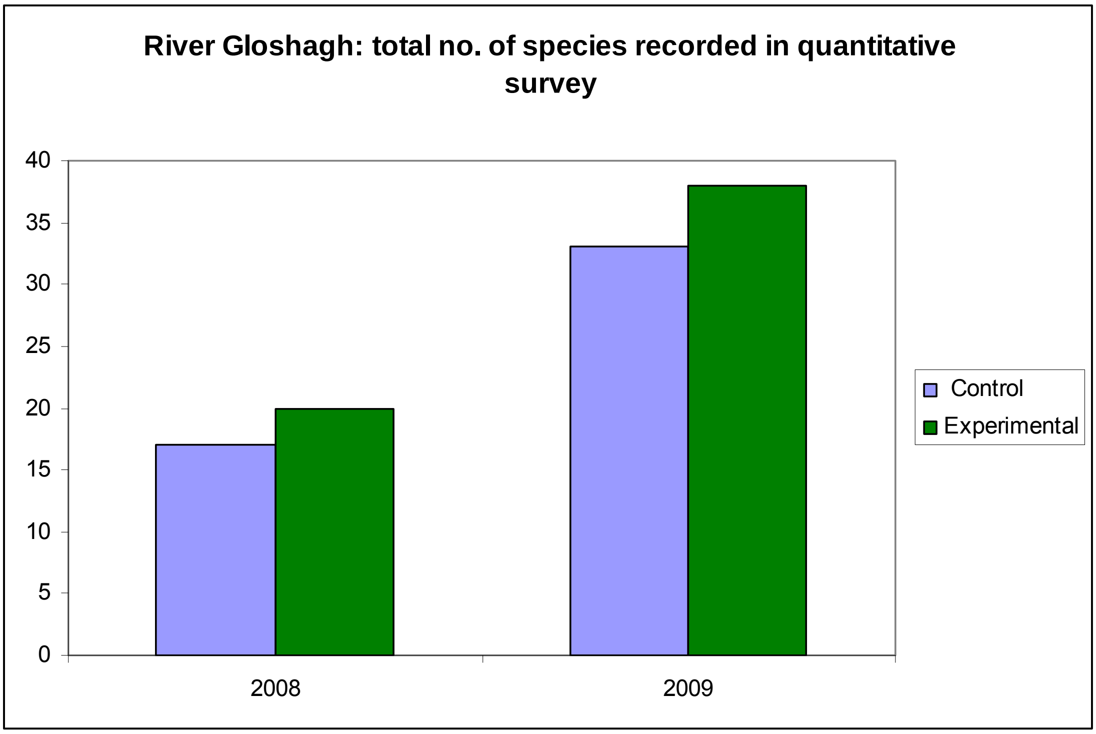


Figure 5.12: R. Gloshagh riparian plant species abundance pre (2008) and post works (2009) in wooded sites.

Table 5.7: Similarity indices scores (converted to %) for riparian vegetation on the Gloshagh River.

Site	Bray-Curtis (1-BC)	Sorensen
Experimental pre & post works	47	53
Control pre & post works	69	73
Experimental V Control pre works	38	56
Experimental V Control post works	54	55

5.2.2. A comparison of drained and undrained river sections

5.2.2.1. General Overview

A number of river sections were surveyed in 2008 and 2009 for the purpose of comparing flora within arterially drained and undrained areas of river corridor within individual channels. The selected channels lay within the Corrib (Nanny), Boyne (Boyne main stem), Maigue (Morningstar) and Maine (C1/34) catchments. Apart from the evident difference in species richness at the Boyne paired sites, no substantial differences were recorded, in terms of species numbers, between drained and undrained paired sites in respect of riparian vegetation (Figure 5.13).

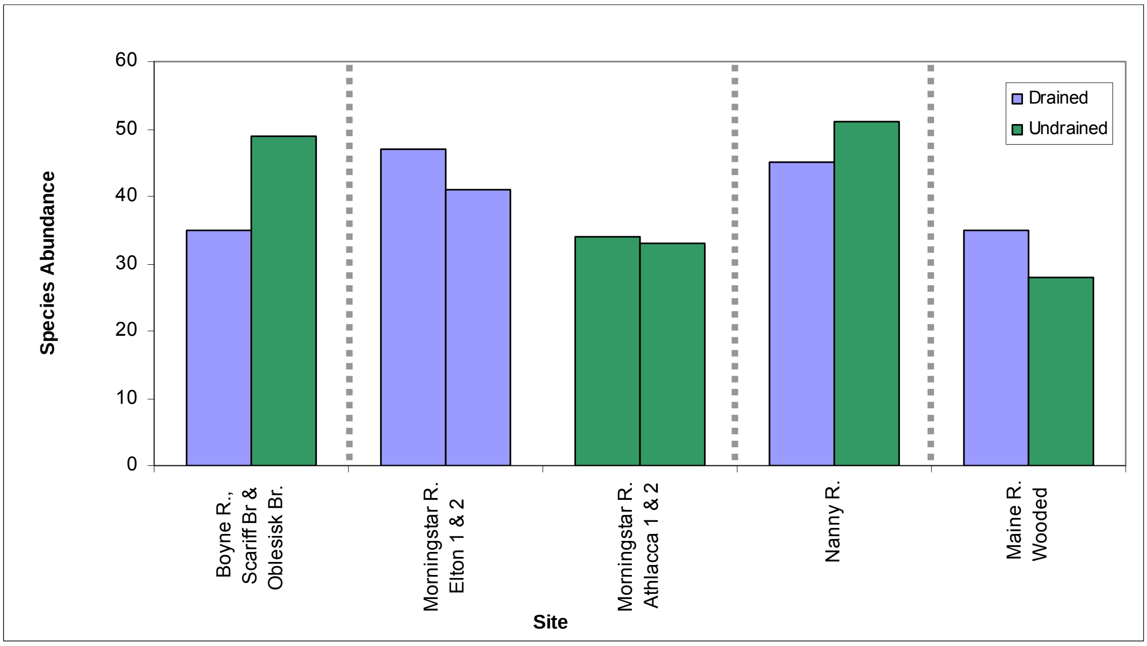


Figure 5.13: A comparison of riparian plant species abundance in sites on drained and undrained channels in 2009.

However, there were noticeable differences in species composition between the drained-undrained pairs when these pairs were examined using the Sorensen's similarity index (Table 5.8).

Table 5.8: Sorensen similarity index scores for drained and undrained paired sites

River	Score (%)
Nanny	22
Maine	55
Boyne	32
Morningstar (Average)	44

The River Nanny and River Maine had paired sites that were adjacent whereas the Boyne and Morningstar drained – undrained pairs were at a distance from each other. Two pairs of drained V undrained sites were available on the Morningstar River. Comparisons using the Sorensen index indicated that the two drained sites on the Morningstar were the most similar, at 60%, indicating a naturally-high degree of variation. The results in Table (Sorensen) might best be seen in the context of a potentially high natural degree of variation. Thus the wooded undrained and drained sites on the River Maine, at 55% similarity, might be seen as essentially similar whereas the low similarity index values between the Nanny drained and undrained pair and the Boyne drained and undrained pair may indicate a substantial degree of difference.

5.2.2.2. Selected Catchments

R. Boyne main channel

The riparian vegetation on the undrained and drained sites differed considerably in terms of the plant communities they support (Sorensen's similarity index = 32%). Some of this difference can be accounted for by natural variation and local environmental factors. However, the physical dimensions of the river banks are very different and subject to very different flood regimes. The drained site has a bank slope length of 5m high whereas the undrained site river bank slope length rarely exceed 1.5m from the wetted area. The vegetation on the undrained banks is subject to flooding, particularly when the river spills out on to its flood plain. In addition, areas of sunken bank and other niche microhabitats offered greater diversity of habitat for plant species to colonise. In contrast the drained channel is highly uniform and is designed to overtop its banks with a considerably reduced frequency. Thus the vegetation further up the bank slope on the drained section may never experience flooding. This is reflected in the species composition. The drained section supports species typical of dry neutral/calcareous grassland such as knapweed *(Centuaria nigra),* bird's foot trefoil (*Lotus corniculatus*) and red clover (*Trifolium pratense*). In contrast, many species associated with wetter habitats were present on the undrained site. These included sweet grass (*Glyceria* spp), red shank (*Persicaria maculosa*) and amphibious bistort (*Persicaria amphibia*), Yellow Iris (*Iris pseudacorus*) and Yellow Loosestrife (*Lysimachia vulgaris*).

On the River Boyne main stem, a number of rare species were recorded on the banks of the undrained section. These included:

English scurvy grass (*Cochlearia anglica*): Referred to as scurvy grass because of its use in treating the condition on account of its high vitamin C content, it is normally a plant of salt marshes and muddy tidal shores. It is rare in Ireland, particularly inland.

Great water dock (*Rumex hydrolapathum*): This is one our largest docks, to 2m, that occurs along freshwater margins and marshes. It has a limited distribution in Ireland, particularly on the east coast.

One species of interest that did occur on a drained section of the Boyne is Elecampane or horse-heal (*Inula helenium*). This is a tall stately plant to 2.5m, with large yellow flowers that was formerly used to treat cuts/grazes on horses. Despite being long established in Ireland, is quite rare.

River Nanny, Galway

In 2009 the area above Birmingham Bridge on the River Nanny, to the east of Tuam, was the target of new maintenance works, with the river below the bridge having been arterially drained in the Corrib Clare drainage scheme (Figure 5.14). As a consequence of differing water tables, due to drainage, upstream and downstream of Birmingham Bridge supported significantly contrasting ecological habitats. The general area was subject to a botanical survey in June and July of 2009.

Below the bridge, the landscape is dominated by improved agricultural grassland (Table 5.9). This is intensively managed agricultural grassland that has been reseeded and regularly fertilised. It is now heavily grazed and/or used for silage making. Within the river corridor, there were significant river bank slopes on either side (3.5m approx in length) following drainage. The river banks support a variety of grasses and broad leaved herbs that are indicative of free draining limestone soils and may be classified as dry calcareous grassland.

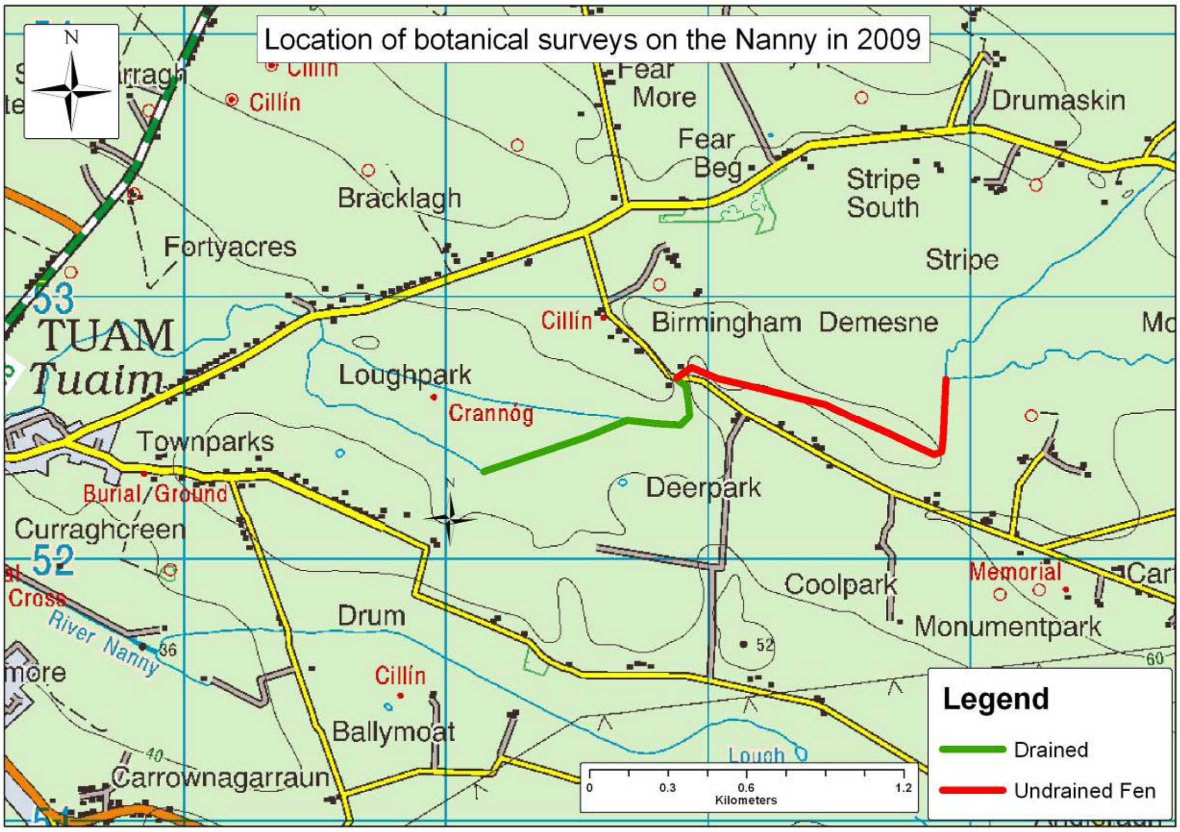


Figure 5.14: General location of survey area including fen area.

The riparian zone upstream of the bridge supports a variety of habitats including wet grassland, marsh, fen and some blanket bog (Table 5.9). Immediately above Birmingham Bridge is an area of species rich fen. Fens represent a rare and threatened habitat in Ireland with 79% of this habitat having been lost. The fen is abundant in orchids, diverse in sedges (11 species were recorded whereas 1 species was present below the bridge) and supports a significant number of rare or declining plant species including

- **Early marsh orchid (*Dactylorhiza incarnata* ssp. *pulchella*):** This orchid has suffered a decline in recent decades and has a limited distribution nationally (Figure 5.15).

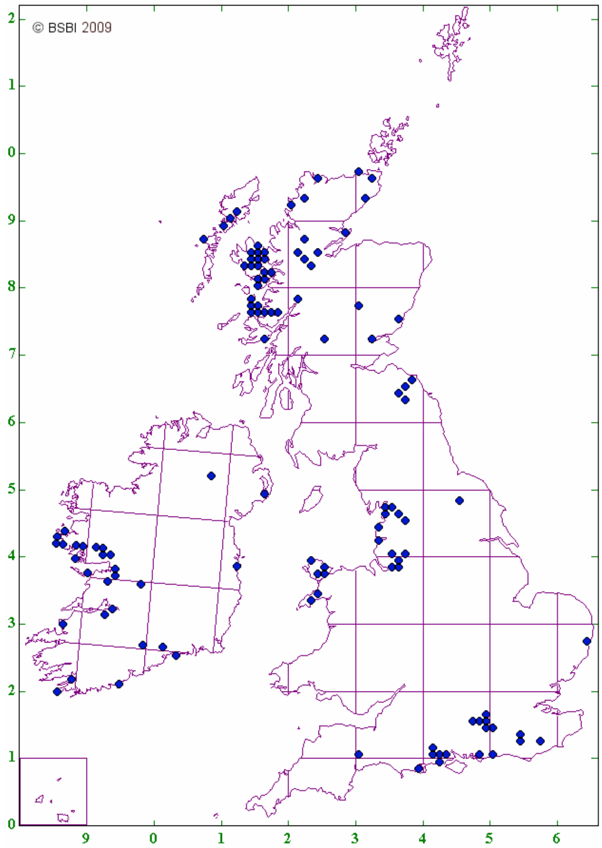


Figure 5.15: Hectad distribution map of the Early marsh-orchid (*Dactylorhiza incarnata* ssp. *pulchella*) in Britain and Ireland from 2000-present (BSBI, 2009).

- **Grass-of parnassus *(Parnassia palustris)***: It is mainly found in West and central Ireland. It has experienced a decline in recent years.

- **Meadow thistle (*Cirsium dissectum*)**: This is another plant that has experienced a significant decline in recent years.

The fen in question can be categorised as a flood plain fen that is the product of flooding and seepage. This fen type is now rare in Ireland, as many sites have disappeared as a result of arterial drainage. Given that a fen is a wetland with a permanently high water level, the flora and associated fauna require moist conditions to survive. At the time of the surveys, it was observed that the drainage works had lowered the river water level by up to half a metre. This is likely to have a negative impact on the ecology of the fen habitat in the short term. It will reduce the influence of flooding and seepage on the fen, drying out the upper layers of the soil. If maintenance is continued and the area is not allowed to recover to its original status, this impact will be permanent. Crucially, it should be understood that any physical works that lower a river bed impact not only on the immediate environment, but also at a landscape level.

OPW hold the view that in this particular case the wetland had developed over time from a combination of a man made control weir placed in the river to provide an overflow to the old water intake storage and a general deterioration in the channel condition. The removal of this weir and the maintenance of the channel have restored the original drainage condition. This channel was drained and maintained in the past but not as part of the Corrib Clare Arterial Drainage Scheme.

The recent maintenance works were carried out having regard to the recommendations set out in an EIS which was undertaken in 2000 for a Flood Relief Scheme for the Upper Nanny, a scheme which subsequently fell on economic grounds. In addition salmonid enhancement measures were incorporated into the maintenance works undertaken in 2009.

Table 5.9: Most abundant species recorded in drained and undrained sites on River Nanny (DAFOR scale: D = Dominant A = Abundant F = Frequent O = Occasional R = Rare)

DAFOR	Species	Habitat	Site Type	
F	*Trifolium repens*	Dry Grassland	Drained	
O	*Achillea millefolium*	Dry grassland	Drained	
F	*Arrhenatherum elatius*	Dry Grassland	Drained	
O	*Centaurea nigra*	Dry grassland	Drained	
F	*Cynosurus cristatus*	Dry Grassland	Drained	
F	*Dactylis glomerata*	Dry Grassland	Drained	
A	**Dactylorhiza fuchsii*	Dry/wet alkaline grassland	Drained	Undrained
O	*Galium verum*	Dry grassland	Drained	
F	*Holcus lanatus*	Dry Grassland	Drained	
F	*Lotus corniculatus*	Dry grassland	Drained	
O	*Potentilla anserina*	Dry Grassland	Drained	
O	*Succisa pratensis*	Dry grassland	Drained	
O	*Carex flacca*	Wet grassland/Peatland		Undrained
A	*Cirsium dissectum*	Wet grassland/Peatland		Undrained
O	*Dactylorhiza incarnata var. pulchella*	Wet grassland/Peatland		Undrained
O	*Deschampsia cespitosa*	Wet grassland/Peatland		Undrained
F	*Equisetum fluviatile*	Wet grassland/Peatland		Undrained
O	*Eriophorum angustifolium*	Wet grassland/Peatland		Undrained
O	*Filipendula ulmaria*	Wet grassland/Peatland	Drained	Undrained
O	*Galium palustre*	Wet grassland/Peatland		Undrained
F	*Iris pseudoacorus*	Wet grassland/Peatland		Undrained
O	*Juncus effusus*	Wet grassland/Peatland		Undrained
A	*Phalaris arundinacea*	Wet grassland/Peatland		Undrained
F	*Ranunculus flammula*	Wet grassland/Peatland		Undrained
F	*Valeriana officinallis*	Wet grassland/Peatland	Drained	Undrained

R. Morningstar, Limerick

The Morningstar sites included two undrained sections and two drained sections. The drained sections were the most similar in terms of riparian species composition, whereas the undrained where less similar (Table 5.10).

Table 5.10: Sorensen similarity index scores for the Morningstar drained and undrained riparian vegetation

Site	Score (%)
Morning Star Athlacca 1 & 2 undrained	45
Morning Star Elton 1 & 2 drained	60
Morning Star drained & undrained (Average)	40

The drained sections also supported more species (Figure 5.14). It is important to note, however, that the undrained and drained are on average 40 % similar. Species such as Meadowsweet (*Filipendula ulmaria*), Wild Angelica (*Angelica sylvestris*), Marsh Woundwort (*Stachys palustris*) were recorded across drained and drained sites and are typical riparian species. Other recorded species that frequently occur by rivers/streams included *Rumex* sp., Water drop wort (*Oenanthe* sp), Water figwort *(Scrophularia auriculata)*, Square Stalked St. John's-wort *(Hypericum tetrapterum)* and Greater Willow Herb *(Epilobium hirsutum)*.

There is natural variation between sites. However, the land management adjacent to the rivers e.g. fencing-grazing, will also impact on the riparian vegetation. Elton site 1 (drained) is fenced and not subject to any grazing pressure. In places, it is typically dominated by tall herbaceous vegetation including reed canary grass (*Phalaris arundinacea*), greater willow herb (*Epilobium hirsutum*) and nettles (*Urtica dioica*). Elton site 2 (drained) and Athlacca site 2 (undrained) are both unfenced and subject to grazing. Athlacca site 2 is well drained, heavily grazed grassland. In addition to low growing herbaceous species that are graze-tolerant, other prevalent plants included field buttercup (*Ranunculus acris*), Ragwort (*Senecio jacobea*), and thistles (*Cirsium sp.*). The latter species are not grazed on account of their indigestibility. Athlacca (undrained) site 1 is unfenced with tillage on one side and parkland on the other. Medium to tall rank vegetation is present here with Rape seed oil (*Brassica napus*) and greater willow herb *(Epilobium hirsutum)* dominant. There may have been some disturbance of the river banks here given the abundance of Rape seed oil which is regarded as early coloniser.

The marginal and aquatic vegetation presented the most striking difference between the drained and undrained sites. The undrained sites supported substantially more marginal and aquatic species than the drained sites (Figure 5.16). Furthermore, the aquatic vegetation cover ranged from 60 - 75% at the undrained sites, in contrast to the drained sites where cover ranged from 0-20%. The flow regime was similar in the drained and undrained sites (moderate to high gradient), but the undrained sites are on bedrock whereas gravels and silt are present in the drained sites. This is surprising, given that aquatic species would be expected to establish with greater ease where gravel/silt are present. It is likely that maintenance works may have impacted adversely on the plant biodiversity at the drained sites and reduced the instream vegetation cover as well as the species diversity.

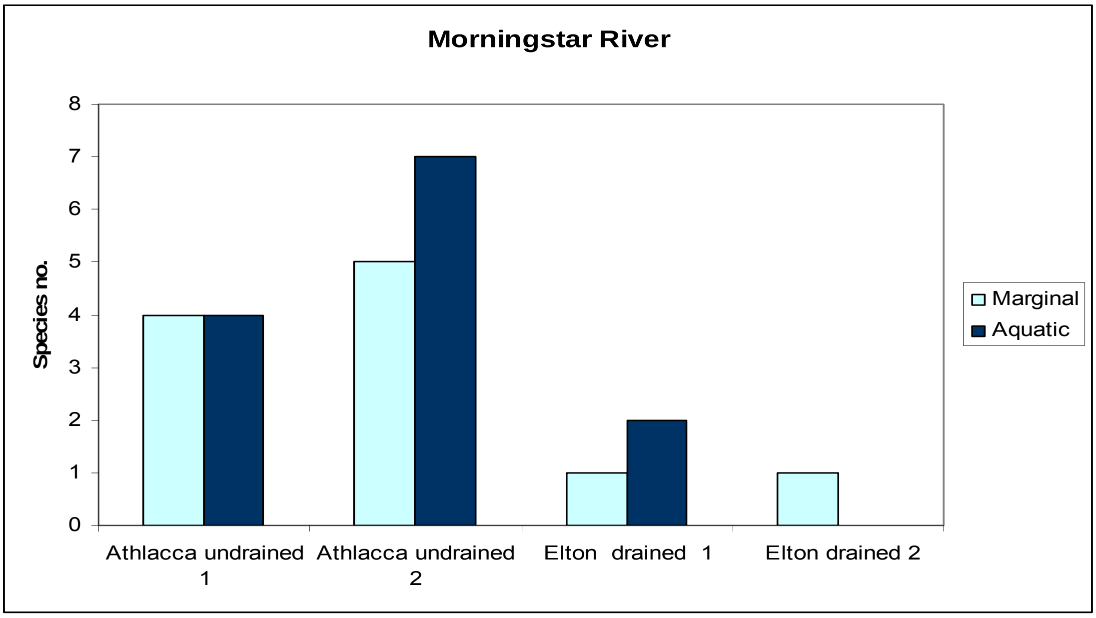


Figure 5.16: Marginal and aquatic species diversity on drained and undrained sites on the Morningstar river.

C1/34, Maine

The drained and undrained sites on the River Maine tributary are both heavily wooded. The riparian vegetation was similar in terms of species abundance (Figure 5.13) and had a similarity index of 55% in terms of composition (Table 5.8). Very little instream or marginal vegetation was present, most likely a consequence of the shading. The similarity was largely reflected in the understorey flora with species typical of woodland and shaded habitats present at both sites. Where there is variation in species composition between sites, the species occurring only in one site are those that are typically associated with shaded habitats such as woodland and hedgerows. The exceptions, typical grassland species, occurred at very low densities and occurred where there were breaks in the canopy. One important difference was the presence of the non native species Montbretia *(Crocosmia X crocosmiiflora)* in the drained site where it was the dominant understorey species. The tree species were similar across sites with Ash (*Fraxinus excelsior*) and Hawthorn (*Crataegus monogyna*) dominating.

5.2.3. Drains

A number of drainage ditches were surveyed in 2009 for the purpose of establishing their botanical value (Table 5.11). Collectively, these drains were relatively species poor (Figure 5.17). In spite of this, their species richness is comparable to a number of river corridor sites surveyed nationally, which are subject to a similar management regime. As with the river sites, the drains were also different in terms of species composition from each other (the highest Sorensen similarity score was 54%).

Table 5.11: Drains surveyed in 2009

CDS	Location and Code	No. of drains surveyed
Swilly	Blanket Nook E6 & E2	2
Feale	R. Feale (C1/14) drain 19 &20	2
Maigue	Morningstar tributaries C1/31/11/5 & C1/31/11/1	2

Riparian: The riparian vegetation of the drains was characterised by semi- to improved grassland and areas of scrub/woodland. The grassland was often dominated by tall grasses such as False oat grass and Cocks foot (*Dactylis glomerata*) and tall herbs like Great willow herb *(Epilobium hirsutum)* and nettles *(Urtica dioica)*. The scrub component was represented by brambles (*Rubus fruticosus* agg.) or gorse (*Ulex* sp) and the woodland by Ash (*Fraxinus excelsior*) and Whitethorn (*Crataegus monogyna*).

The riparian vegetation was often transitional in nature with intermediate types frequently present (Plate 5.7). This is a product of their management regime. The drains are not subject to the same intensity of management as the surrounding landscape which accounts for their transitional nature. Nevertheless, they are maintained regularly enough by the OPW to reset the successional process, whereby the pattern of colonisation and competition is repeated.

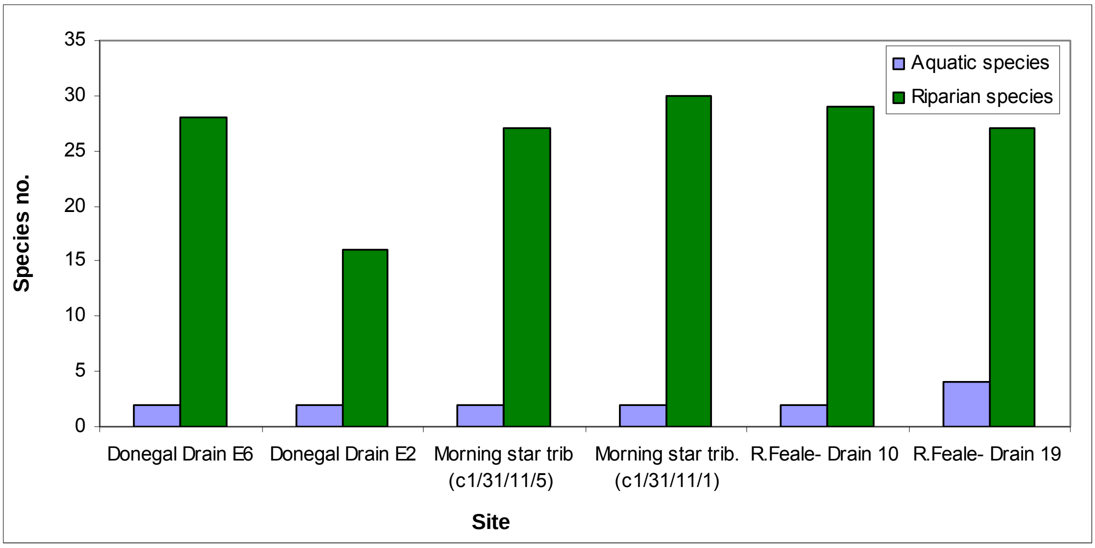


Figure 5.17: Riparian and aquatic plant species numbers in drains examined in 2009

Plate 5.7: Drains on the Morningstar (left) and Blanket Nook scheme (right) with riparian vegetation characterised by semi/improved grassland, scrub/woodland and intermediate types.

Aquatic: The aquatic vegetation of these drains was particularly species poor and typically dominated by one or two species that thrive in stagnant/slow moving water e.g. Fools water celery (*Apium nodiflorum),* Starwort *(Callitriche stagnallis)* and the emergent Reed canary grass (*Phalaris arundinacea*). Duck weed *(Lemna minor)* dominated where there was limited light penetration of the channel. The River Feale provided an opportunity to assess differences between an unmaintained and recently-maintained drain. The drain not subject to maintenance was typically dominated by Fools water cress and Reed canary grass. In contrast, the recently maintained drain had a greater diversity of aquatic plants (4 species as opposed to 2 species in all other drains) due to the removal of dense stands of Fools water cress and Reed canary grass. However, the most abundant plant here was the invasive, Canadian pondweed (*Elodea Canadensis*), which thrives in such conditions. Canadian pondweed was probably already present at a low density but had become abundant following the removal of the previously dominant species.

Drains and back channels, such as those examined in 2009, have the potential to harbour high plant biodiversity, as shown in studies in the UK. However, the conditions to facilitate such biodiversity development may include a long time span between maintenance events. In addition, many of the drains are very narrow and may be subject to shading by bankslope vegetation. In many instances the drains serve a critical water level management function and require constant cleaning to facilitate land drainage outfall. The time span between OPW's maintenance events may not facilitate optimum biodiversity development. Further drains will be examined in 2010 to develop a larger perspective of the riparian and instream flora of drains within OPW's channel network. It is also hoped that a number of these drains could be identified as experimental sites where the maintenance cycle regime could be extended and changes in the flora composition monitored.

5.2.4. Invasive Plant Species

After habitat destruction invasive alien species are the biggest threat to native biodiversity. Given the threat invasive plants represent, the Wildlife (Amendment) Act 2000 states that "anyone who plants or otherwise causes to grow in a wild state in any place in the State any species of (exotic) flora, or the flowers, roots, seeds or spores of (exotic) flora shall be guilty of an offence". Unfortunately, a number of invasive plant species have been recorded on OPW channels during botanical surveys in 2008/2009. These are briefly described below.

Plate 5.8: Himalayan balsam forming extensive patches over an OPW track way and spoil heap in Blanket Nook, Donegal.

Japanese Knotweed *(Fallopia japonica),* Himalayan balsam *(Impatiens glandulifera*) and **Giant hogweed *(Heracleum mantegazzianum)*** are non-native species that have been introduced to Ireland. They occur along watercourses, ditches and transport routes. Many elements of their ecologies are similar – they have growth habit that aerially dominate or preclude other plant species from growing as an understorey. They grow rapidly, spread easily, out-compete native flora and readily colonise new areas. As such, they pose a threat to the native floral biodiversity along impacted river corridors. Giant hogweed is also harmful to humans as the sap can cause third degree burns. All species die back in winter leaving river banks very vulnerable to erosion during winter floods. This is a particular problem with Himalayan balsam (Plate 5.8) and Japanese Knotweed (Plate 5.9) which can form extensive stands over large areas. The plants can be dispersed by humans in two main ways. Firstly, by contaminated machinery/shoes or the moving of soil, or, secondly through disturbance of water courses (e.g. in maintenance) allowing fragments/seeds to float downstream and establish in new areas.

Plate 5.9: Japanese Knotweed is the dominant riparian vegetation on stretches of the River Maine, Kerry.

These plant species are an acute problem given the mechanical nature of OPW maintenance works. Such work fragments vegetation, contributing to dispersal opportunities. Removal leads to extensive areas of bare soil on bank slopes and bankfull lines, due to absence of any plant understorey. This can lead to destabilisation of bank areas and loss of sediment into the channel. From a fisheries perspective, an increased sediment load, from bank erosion, entering the channel represents a significant threat to salmon and trout spawning. It is crucial that a strategy is developed for OPW maintenance works that limits the spread of invasive species and minimises the 'disturbance' associated with their management and removal. The recommendations given below follow the best practice management documents produced by the Invasive Species Ireland project (a joint venture between Northern Ireland Environment Agency, NIEA, and the NPWS – (http://www.invasivespeciesireland.com/downloads/).

At the minimum, for all sites, the following two steps would be recommended in an attempt to help prevent the spread of plant species:

1. Write a Management Plan to guide work and make sure all staff working in the area are aware of it.

2. Ensure that everyone working on the site is aware and briefed on the Management Plan concerning invasive species and adheres to good site hygiene such as:

- Marking out of contaminated areas.
- Ensuring that vehicles with caterpillar tracks do not work within contaminated areas.
- Treating contaminated soils carefully.
- Limit use of tracked machinery at infested sites.
- Cleaning machinery or equipment that could be contaminated.

At present, OPW has a policy of washing down, on-site, machinery before it is transported away to another channel. This is a positive first step in managing the invasive plant issue in channel maintenance. However, it is essential that further strategies are developed, along the lines indicated above, and incorporated into existing SOPs. The development of such strategies could be investigated through experimental work undertaken within the EREP project.

While the above proposal should help reduce the spread of such invasives by OPW work programmes it would perhaps be more constructive to have a nationally co-ordinated approach to the management of invasive species involving all the appropriate authorities (NPWS, LA's and OPW), through which a national invasive species management programme could be developed and implemented.

5.2.5. Other Plant Species of Interest

A number of other plant species that are rare or in decline were recorded at various OPW-maintained channels around the country. They included:

1. A channel (code C5A, Inny CDS)) close to the Annnagh pumphouse on Lough Ree supported a diverse range of plants. The following species are of conservation importance:

Cow Bane *(Cicuta virosa)*: This plant is a semi-aquatic that grows in slow moving water, ditches and on the banks of lakes and rivers. At one time it was common in Ireland, but it has suffered a substantial decline largely due to drainage schemes and habitat loss.

Frog Bit *(Hydrocharis morsus-ranae)*: It is a free-floating herbaceous annual aquatic that resembles a tiny water lily. It does well in calm open waters, and can be found in marshes, ditches and rivers and coves. Frog Bit is a rare species that is in decline (Plate 5.10).

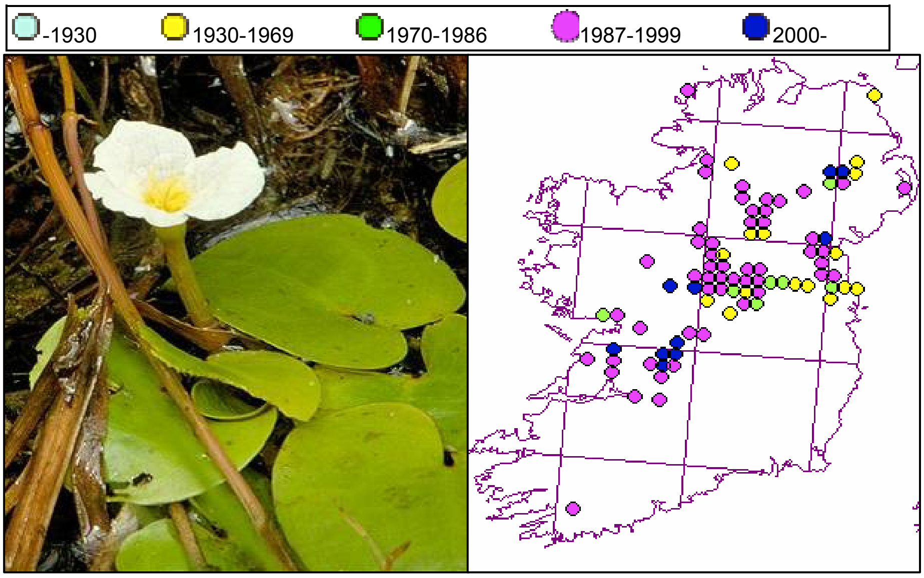


Plate 5.10: Frog Bit *(Hydrocharis morsus-ranae)*, (BSBI, 2009)

Tufted Sedge (*Carex elata*) (Plate 5.11): This is a sedge of marshes, wet places and bogs. It is generally limited to the centre of Ireland, occurring very occasionally in the south.

2. Slender Sedge *(Carex lasiocarpa)* (Plate 5.11): This plant generally occurs in marshes, bogs and exposed lakeshores. It was recorded on the banks of the Enfield Blackwater in the east of the country where it is rare. It normally ranges from the west to the middle of Ireland.

Plate 5.11: The tufted sedge (Annagh Pumphouse) and slender sedge (Enfield Blackwater) are two species of conservation value.

3. Sea Brookweed (*Samolus valerandi*): This is a species of water pimpernel native to Ireland. Where present, it normally occurs at a low density. It prefers shallow water and wet soils, especially by the sea. Nonetheless, it was recorded growing inland on the banks of the River Gloshagh (C1/30, Maigue CDS) and at the base of a spoil heap on the River Glore (Moy CDS).

4. Green spleenwort (*Asplenium viride*): This fern occurs mainly in hilly and upland areas and less often at lower altitudes. One individual was recorded on a spoil heap by the River Glore (Moy CDS). It was present in a hollow in between two limestone slabs. This represents optimum lowland habitat given that it is permanently moist and sheltered from direct sun and rain splash.

5.3. Bird Population Studies

River corridor biodiversity monitoring for EREP was extended in 2009 to include bird survey work. The possible impacts that drainage maintenance may have on bird populations encountered within the channel and along the river corridor have not been fully studied in Ireland up to now. OPW drainage works have the potential to disturb wildlife habitat, foraging areas and breeding grounds and to alter species composition and abundance. In response to national and international legislation (Habitats Directive, Birds Directive, National Biodiversity Plan), regarding wildlife in general, OPW are implementing a drainage maintenance policy that will be considerate of these issues, and where possible reduce the impact of such works.

Prior to establishing a monitoring programme which would consider the likely impacts of drainage maintenance, enhanced maintenance and capital works on bird populations within OPW channels the EREP team carried out a number of general baseline bird surveys which would provide information regarding species distribution, abundance and diversity. This survey work focused on 13 rivers (Table 5.12 & Figure 5.18). All rivers included in these surveys reflected a number of river characteristics thought to impact on bird population structure (Table 5.13).

Table 5.12. Rivers and sites for all bird surveys in 2009. All sites were located on channels which had been arterially drained in the past.

Code	District	Catchment	River	Channel Code	Site
1	East	Boyne	Deel	C1/37	Deel (Boyne)
2	East	Boyne	Boyne	C1	Boyne
3	East	Boyne	Boycetown	C1/15	Boycetown
4	East	Boyne	Enfield Blackwater	C1/36	Enfield Blackwater lower site
5	East	Boyne	Enfield Blackwater	C1/36	Enfield Blackwater 2 Upper farmer A
5	East	Boyne	Enfield Blackwater	C1/36	Enfield Blackwater 2 Upper farmer B
6	East	Broadmeadow	Broadmeadow	C1	Broadmeadow
7	East	Inny	Creggy	C7	Creggy
8	South - West	Cappa-Kilcrow	Duniry	C2/10	Duniry
9	South - West	Deel	Deel	C1	Deel (Bunoke Bridge)
10	South - West	Maigue	Camoge	C1/25	Camoge
11	South - West	Maigue	Morningstar	C1/31	Morningstar
12	West	Corrib	Robe	CM4	Robe
13	West	Moy	Castlebar	C1/21/1/5/2	Castlebar 1
14	West	Moy	Castlebar	C1/21/1/5/2	Castlebar 2
15	West	Moy	Glore	C1/30	Glore

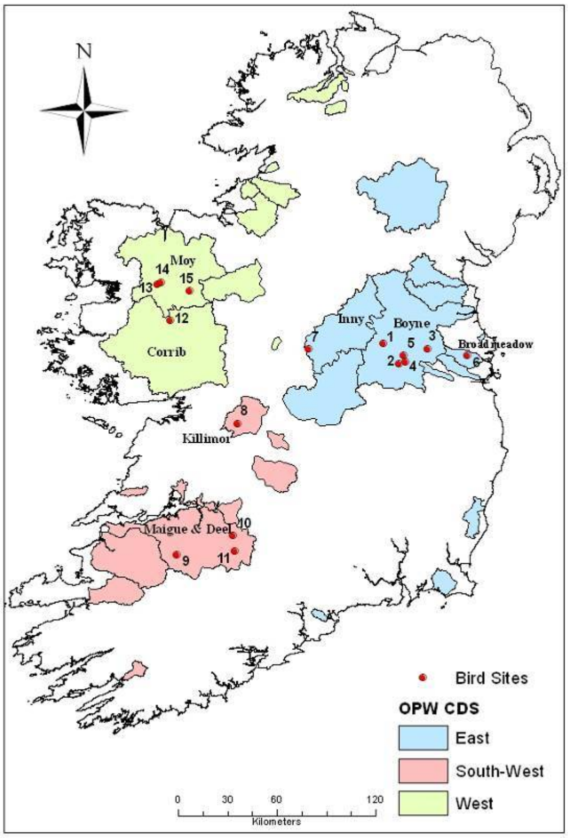


Figure 5.18. Location of each bird survey site within each OPW CDS.

Table 5.13. Channel groupings used for bird survey work.

Code	Habitat Type	River Catchment	Channel Name	Channel Code
1	High gradient & heavy tree cover	Cappagh-Kilcrow	Duniry	C2/10
		Boyne	Enfield Blackwater 1	C1/36
		Boyne	Boycetown	C1/15
2	Low gradient & heavy tree cover	Moy	Castlebar 1	C1/21/1/5/2
		Inny	Creggy	C7
		Boyne	Deel	C1/37
3	High gradient & no tree cover	Maigue	Morningstar mc	C1/31
		Broadmeadow	Broadmeadow	C1
		Boyne	Enfield Blackwater 2	C1/36
4	Low gradient & no tree cover	Boyne	Upper Boyne	C1
		Deel (Limerick)	Deel	C1
5	Heavy marginal vegetation	Maigue	Camogue	C1/25
		Robe	Robe	CM4
		Moy	Castlebar 2	C1/21/1/5/2
		Moy	Glore	C1/30

5.3.1. Bird Survey Results and Observations

16 sites across 13 rivers were surveyed in the summer of 2009. The sites were well distributed nationally with regard to OPW channels (Figure 5.18). A range of parameters were measured and recorded that have the potential to influence bird abundance and diversity (Table 5.14). It was hoped that analyses of the 2009 data would identify the more critical parameters and thus reduce the number of existing measured variables thereafter. The results would then be used to determine channel types that should be included in a monitoring programme going forward in 2010.

Table 5.14. Parameters recorded during bird surveys

Dependent Variables	Independent Variables
• Combined species diversity • Combined bird abundance	• Gradient • Stream order • Channel widths • Geology • Instream cover • Habitat type • Marginal cover • Degree of tree/scrubland cover • Presence/absence of treeline/scrub • Land use • Average depth • Average bank height • No. of field boundaries • No. of inflowing tributaries • Riffle/Glide/Pool presence/absence • Geographic location

Species that are specifically associated with the aquatic environment of a river such as mute swan, mallard duck, kingfisher and heron were recorded during the 2009 surveys. In total 20 bird species typically associated with the river corridor were recorded (Table 5.15), of which the grey wagtail was the most abundant species and was recorded in 11 of the 16 sites surveyed. Other species such as coots and dippers were recorded outside of formal surveys, albeit at very low numbers. There is evidence (D'Amico and Hémer, 2007) that dippers do not actively feed during high water levels because they cannot forage in riffle areas. Given this, they may not have been very active last summer on account of the high rainfall and therefore were not detected.

Table 5.15. Bird species recorded that typically inhabit the river corridor.

Species	
Coot*	Moorhen
Cormorant	Mute Swan
Dipper*	Pied Wagtail
Goldfinch	Reed Bunting
Grasshopper Warbler	Sand Martin
Grey Heron	Sedge Warbler
Grey Wagtail	Snipe
House Martin	Swallow
Kingfisher	Swift
Long-tailed Tit	Willow Warbler
Mallard	
* species not recorded during formal surveys	

All independent variables were tested for their effect on bird abundance and species diversity. Only two variables, 'presence/absence of treeline/scrub' and 'degree of tree/scrubland cover' were found to have a statistically significant effect (Table 5.16). It is not surprising that these two related variables were significant, given that trees/scrub provide food, shelter and nesting sites for many bird species. Furthermore, sites with heavy tree cover supported higher bird numbers and species diversity (Figure 5.20).

The ordination technique, principal component analysis (PCA), was used to see if there was any relationship between the bird communities at the different sites. A relationship between sites is only expressed if the species are positively or negatively correlated, when using PCA. As with species diversity and abundance, presence or absence of tree cover was the main determining factor of bird community composition based on the data collected (Figure 5.19). The open (no tree cover) sites were relatively homogenous in terms of their species composition. Sites with some level of tree cover recorded greater variation in species composition. For example, community composition on the Creggy (heavy tree cover) and Castlebar Rivers (no tree cover) are quite different from each other. Nonetheless, the sites with tree cover are generally more similar to each other than they are to the open sites.

Table 5.16. Results of statistical tests for environmental variables that had a significant effect on bird abundance and species numbers.

Test variables	Test	Significance (P)
Bird Abundance and Tree Cover	Kruskal-Wallis Test	0.005
Species Diversity and Tree Cover	Kruskal-Wallis Test	0.019
Bird abundance and presence/absence of treeline/scrub	Kruskal-Wallis Test	0.001
Species diversity and presence/absence of treeline/scrub	Kruskal-Wallis Test	0.002

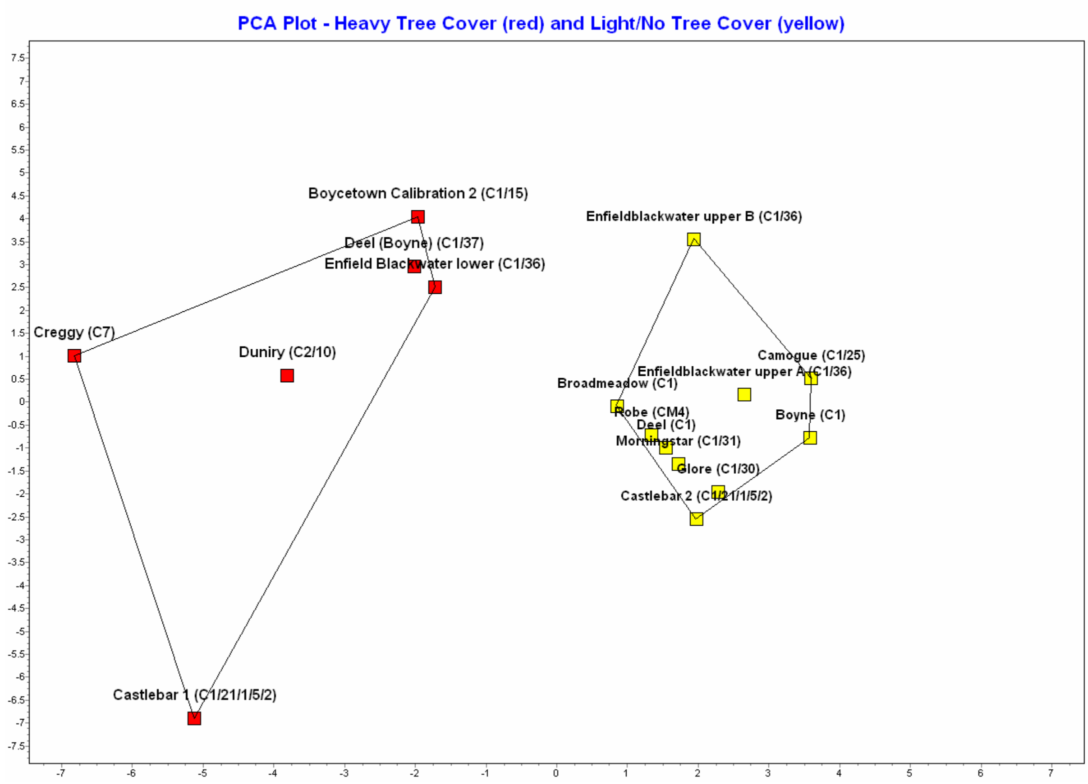
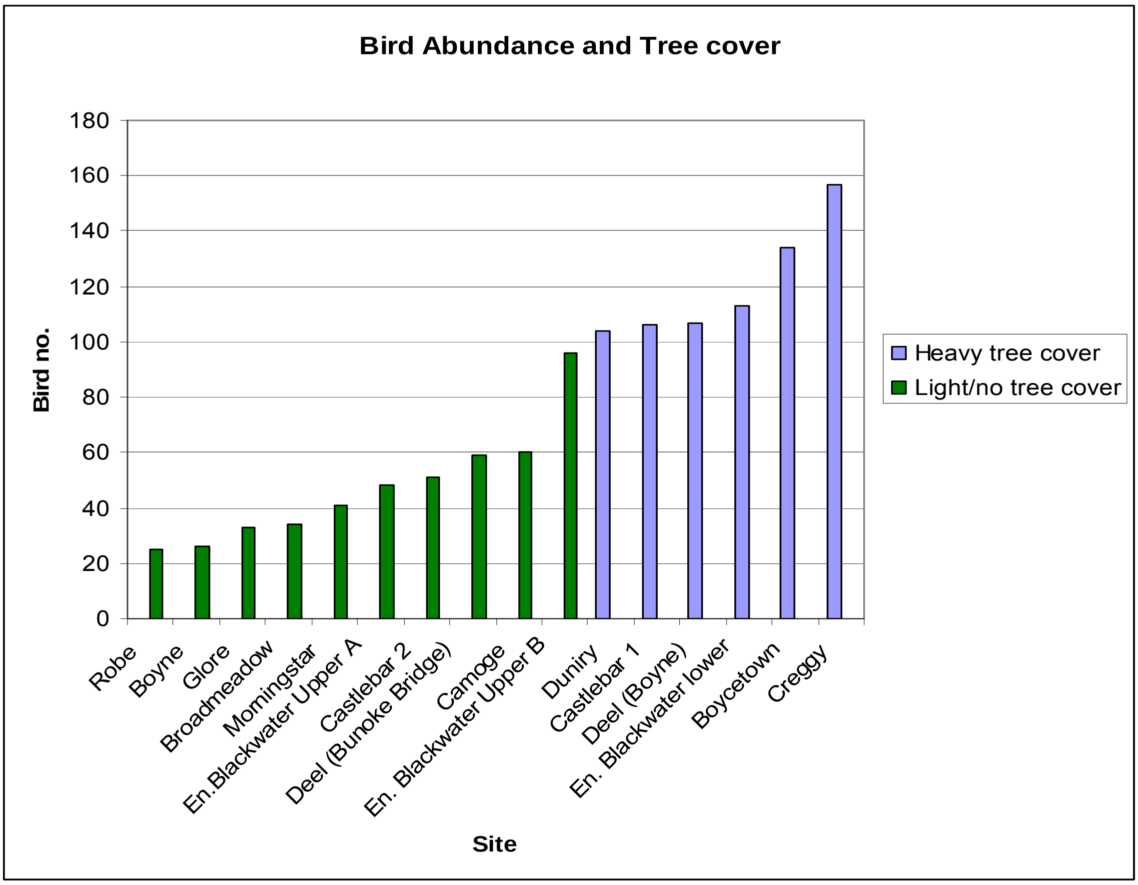
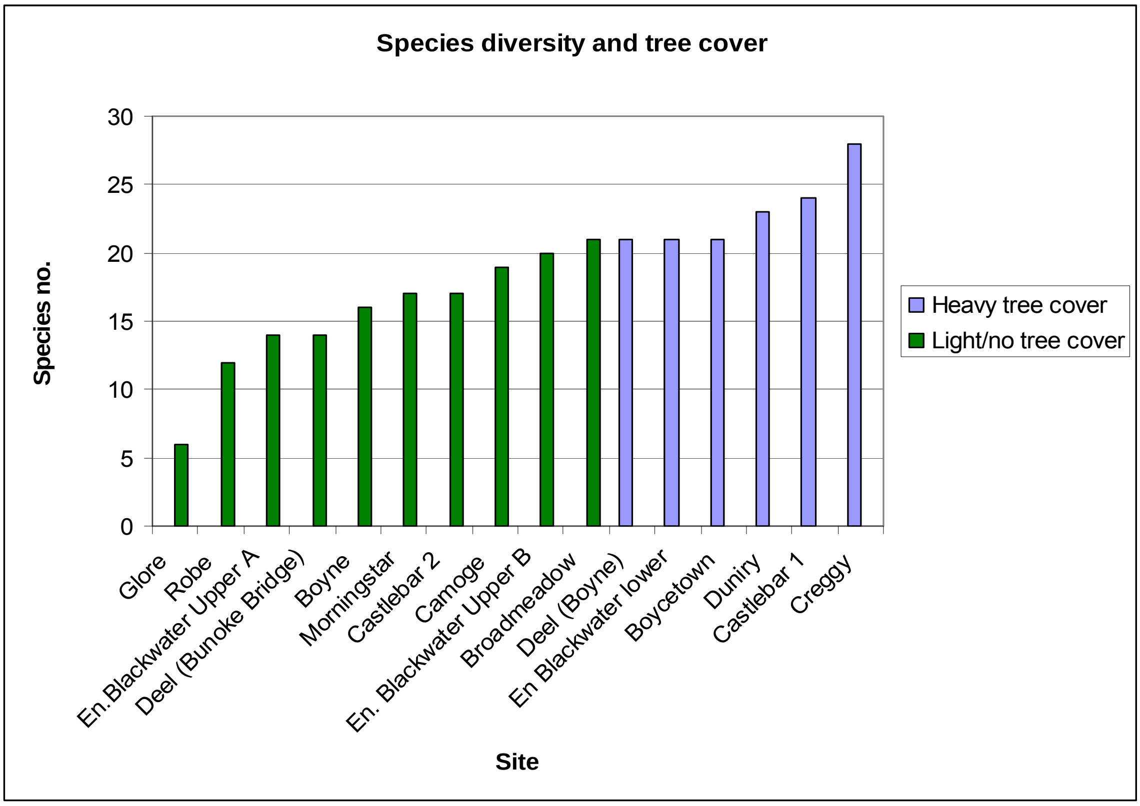


Figure 5.19. Principal Component Analysis for birds sites and tree cover, surveyed in 2009.





Figures 5.20: Bird species abundance and sites with/without tree cover (top). Species diversity and sites with/without tree cover (bottom).

A number of species including warblers (sedge, reed and grasshopper), reed buntings and long tailed tits use reed beds and marginal vegetation. However, no relationship was observed between the presence/absence of marginal vegetation and bird abundance or species diversity. This is probably due to a lack of replicate sites and warrants further investigation in the future.

The information gained form the 2009 bird surveys have provided the project with a bird species list for each of the sections looked at. Data analyses have indicated that the most important factor related to species composition and abundance is related to tree/scrub cover. The closeness of tree/scrub cover to the river itself does not seem to be overly important, within reason. The current survey work would suggest that tree/scrub cover within 50m of the river will significantly impact on the numbers and species of bird populations likely to occur within this area. Indeed the presence of even stone walls and side drains showed some evidence of increasing bird biodiversity around these rivers. It is likely that a number of other variables are closely associated with species diversity and density, such as marginal vegetation. Information regarding these factors should come to light with the inclusion of additional sites that will facilitate the necessary analyses.

Geographical location was not a factor found to be significantly important in the analysis. Though there were two species recorded that did show some geographical preference. These were the yellow hammer, only recorded in the east of the country, and the stonechat, in the west and southwest of the country. However the general distribution range of these species in Ireland is not as specific as this but is somewhat similar.

5.3.2. Conclusions

In terms of species abundance and diversity it is obvious that suitable habitat type (ie tree/scrub cover) is a critical determining factor. This is strongly reflected in the survey results. Sites with tree cover supported more species and greater abundances. The importance of trees and the habitat heterogeneity they provide should not be underestimated given the absence of tree cover over substantial lengths of Irish arterially drained rivers. The same is also probably true of tall marginal vegetation which can offer cover, nesting areas and food. This will be looked at when a more complete data set is available. Maintenance works that encourage a mosaic of habitats and associated micro-habitats can provide diverse conditions likely to increase diversity of not only birds, but a range of biota. Provision for tree cover is crucial in that context.

The baseline data compiled in relation to bird populations in drained river corridors in 2009 will enable the CFB to design a monitoring programme which will highlight the positive and/or negative effects of experimental drainage maintenance and capital works programmes on birds.

5.4. Macro-invertebrate Monitoring

Aquatic macroinvertebrate samples were taken at a number of sites pre-works (2008) and post work (2009) to assess the impact of maintenance works on the macroinvertebrate community. Two sites on the River Gloshagh, representing a control and experimental pair, had heavily shaded riparian zones that were scheduled for maintenance. The sites were chosen to see if tree removal would have any effect on the macroinvertebrate community, in terms of species diversity and functional feeding groups. The concept of functional feeding groups categorises species according to the way they exploit food resources e.g. grazer, predator or shredder (of leaf litter) (Plate 5.11).

Plate 5.11. The freshwater shrimp *(Gammarus duebeni)* is a shredder and the caddis fly *(Rhyacophila dorsalis)*, pictured with pupa, is a predator.

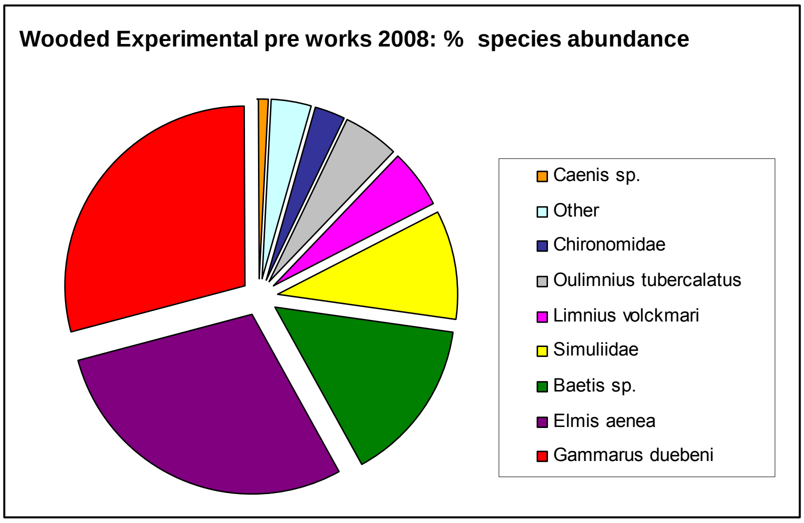
Sorensen's similarity index, which is a measure of homogeneity in terms of species composition was used to compare among sites (pre and post works) and between sites (control v. experimental) (Table 5.17). Species composition at the control site, pre and post works, was relatively similar given natural variation. Whereas some pronounced variation was evident pre and post works in the experimental site.

Table 5.17. Similarity index scores (converted to %) pre (2008) and post works (2009)

Site	Sorenson %	Bray-Curtis % (1-BC)
Experimental pre & post works	55	66
Control pre and post works	78	69
Experimental v. Control pre works	77	80
Experimental v. Control post works	78	84

This suggests that some change may be taking place in the experimental site as a consequence of maintenance works. At the same time, it must be appreciated that these works were only carried out 4-5 months prior to sampling. Therefore, it is only possible to comment on the possible causes of change at this stage. However when one compares the similarity index for the control and experimental pre works (77%) and the control and experimental post-works (78%) it suggests that the control and experimental sites pre and post works still have similar species composition. The Bray Curtis Dissimilarity Index was also used on this dataset (and then converted to a similarity index using 1-BC). With this method not only is the species composition taken into account, as is the case with the Sorensens Index, but also the relative abundance of those species present. Similar results are evident from these calculations (Table 5.17).

Gammarus duebueni (shredder), *Elmis aenea* (deposit/gather) and *Baetis* sp (deposit/gatherer) remained the three most abundant species in both the control and experimental sites, pre and post works (Figures 5.21 & 5.22). Some species recorded in the 2008 samples were absent in 2009 and vice-versa. These species occurred in very low numbers where they were present. For example, two mayfly species, *Caenis* and *Baetis* were observed in the experimental site. However, *Caenis* was recorded pre works only (0.9 % abundance) whereas the opposite was true of *Baetis* (1.3% abundance post works). In light of this, it is too early to determine whether this is a product of maintenance works, natural variation or sampling effort.



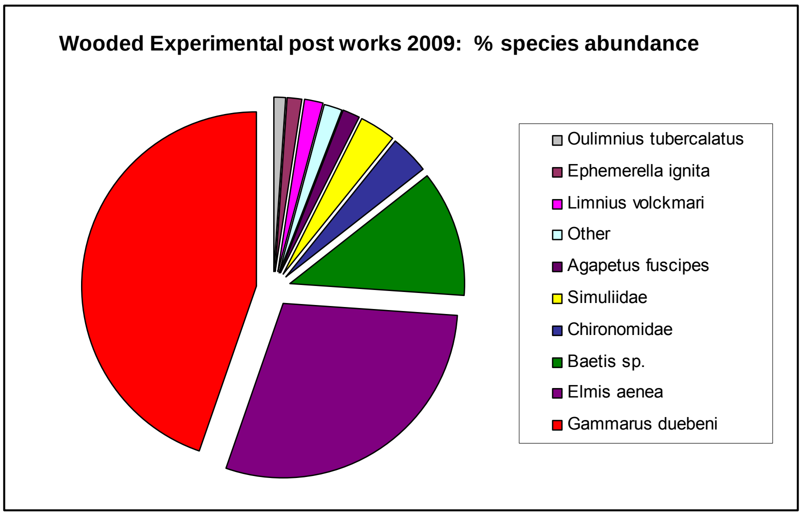
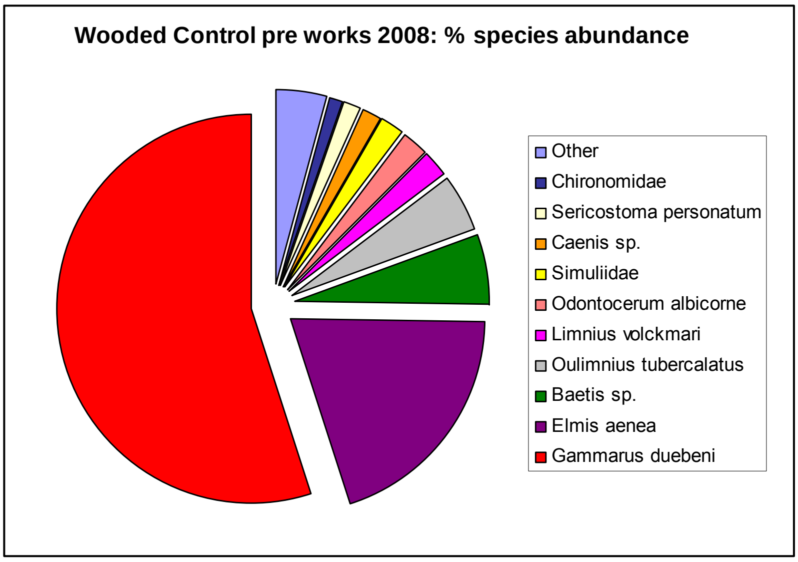


Figure 5.21. Wooded experimental pre (2008) and post works (2009).



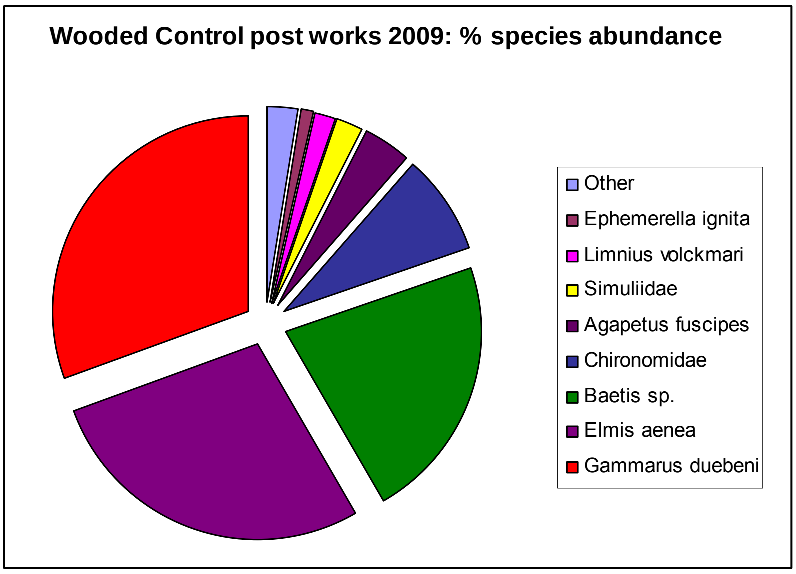


Figure 5.22. Wooded control pre (2008) and post works (2009).

With regard to functional feeding groups, the shredders, namely the freshwater shrimp, *Gammurus duebueni*, increased substantially in the experimental site following works (Figure 5.23). One would expect shredders to decrease in number following the removal of trees and thus the reduction in leaf litter input into the channel, but was not the case here. Maintenance works occurred in the Spring of 2009 and any substantial decrease in leaf litter input would not have occurred until October, when trees would shed their leaves. In addition, *Gammarus* spp. have demonstrated considerable plasticity in feeding behaviour (Duffy & Hay, 1991 & 1994; Friberg & Jacobsen, 1994) and tolerance to disturbance (Conlan, 1994; MacNeil *et al.,* 1997). *Gammurus duebueni* may in fact have increased in abundance following maintenance works given its ability to resist disturbance and quite possibly capitalise on it. In contrast, *G. duebueni* has decreased in the control where there had been no works (Figure 5.24).

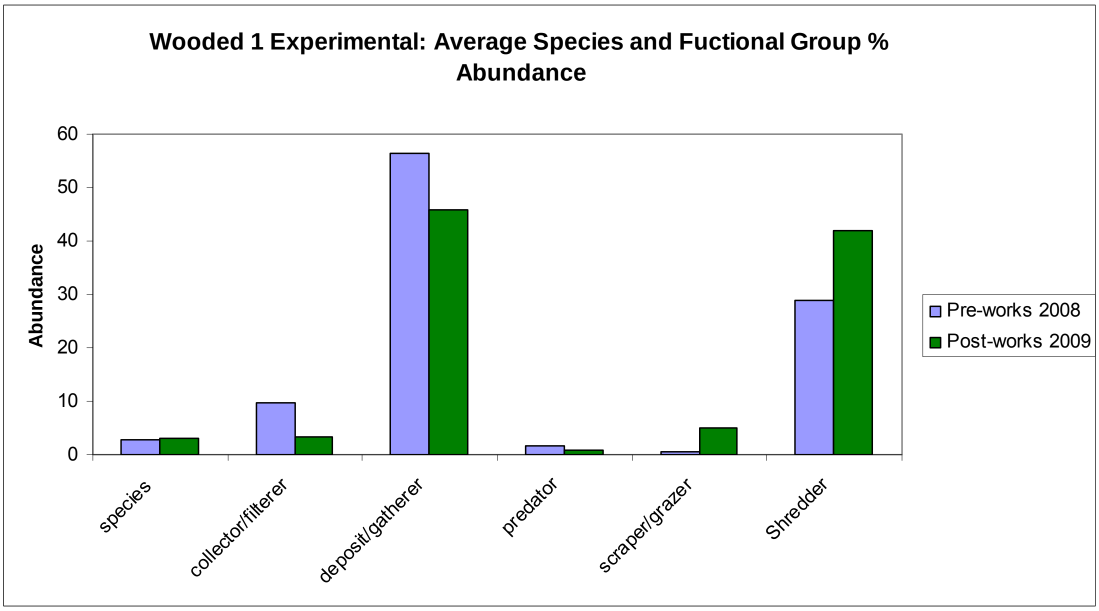


Figure 5.23. Abundance (%) of functional feeding groups for the wooded experimental site.

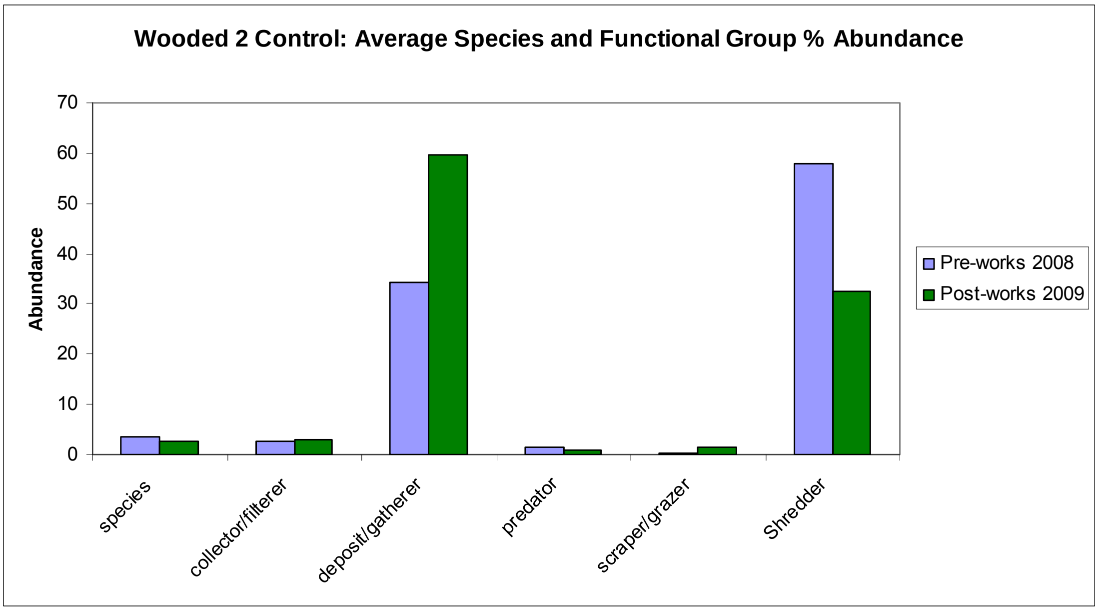


Figure 5.24. Abundance (%) of functional feeding groups for the wooded control site.

At present, as noted before, it is only possible to make general observations given the short period between sampling and the completion of maintenance works. The full influence of maintenance works on the macroinvertebrate community will become clearer following sampling in the coming years.

5.5. Hydromorphology and Physical Assessments

5.5.1. Capital Works Programme – R. Morningstar Post Works Survey

Through the experimental site (Plate 5.12) four vortex weirs were built, differing slightly from the original submitted plans. Vortex stone weirs should be constructed at least seven channel widths in distance apart and it was felt in this case, five weirs would have been too close together.

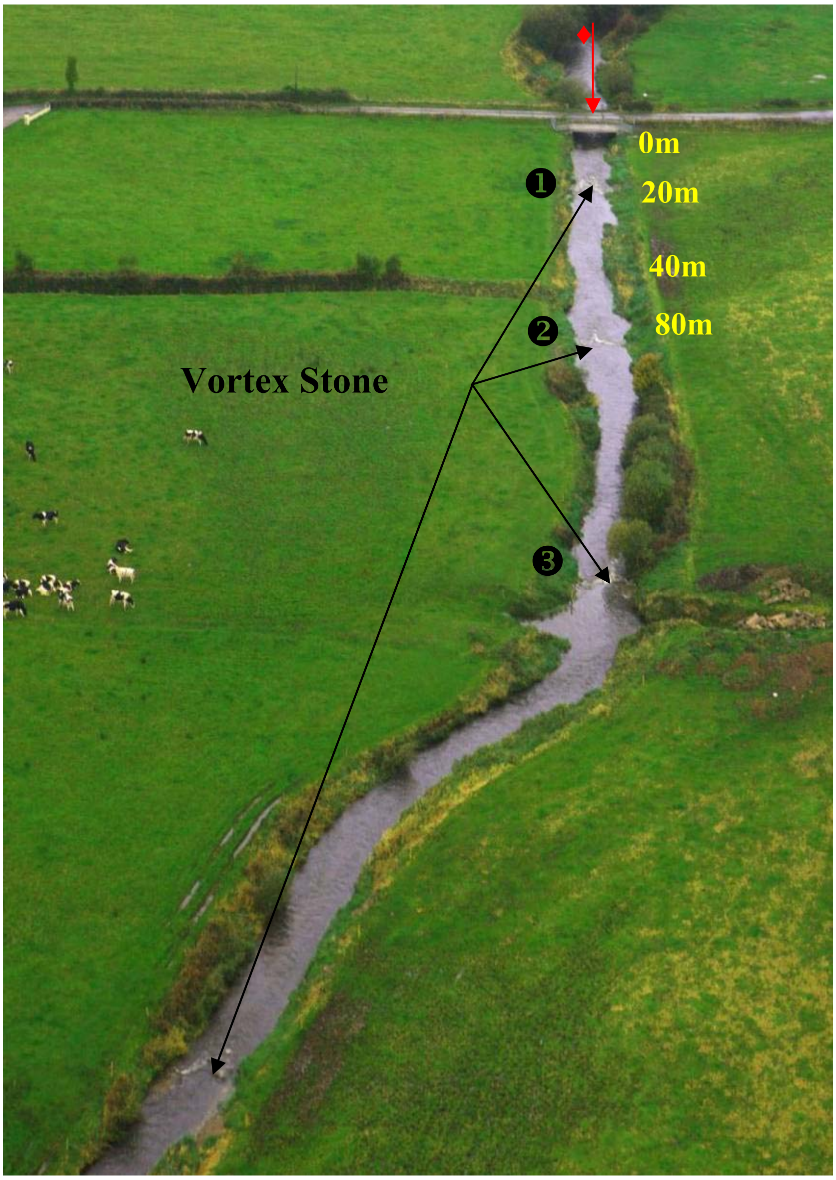


Plate 5.12. Aerial view of the experiment site post works, with the locations of the 0, 20, 40 and 80 meter cross sections (♦ and arrow indicates aspect of pictures in plate 5.1).

Cross Sectional Profiles

Pre works cross sectional profiles were recorded at 20m intervals upstream of the bridge (Plate 5.12) starting at zero. These were repeated post works. The four cross sectional profiles (Figure 5.25) show pre and post works at 20 and 80m where pools were dug and at 0 and 40m were no works were done.

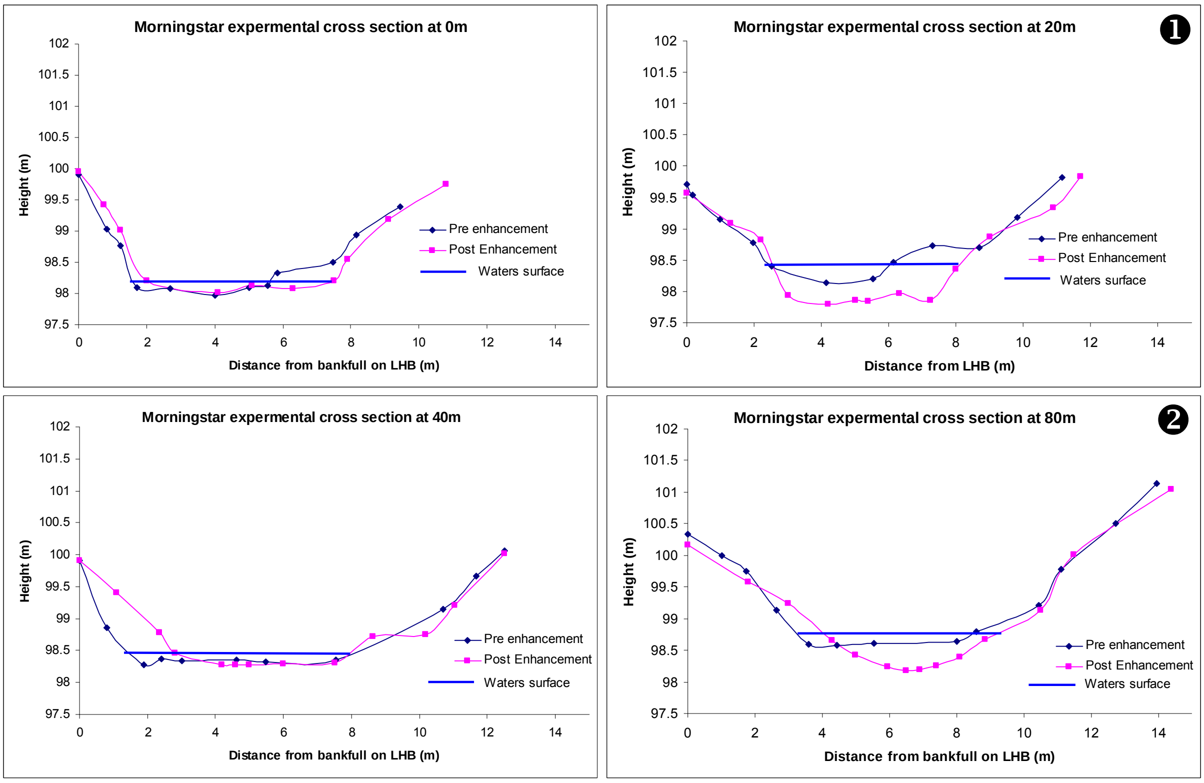


Figure 5.25. Four cross sectional profiles of pre and post works on the Morningstar River (C1/31), Maigue CDS.

At 0 and 40m maintenance works were carried out resulting in changes to the cross sectional profile. A berm was removed at 0m on the RHB and the channel made more central at 40m but in both cases the cross section was still through a shallow glide. At 20 and 80m pools were dug downstream of the newly constructed vortex weirs. This has doubled the pre work water depth at 20m and tripled the water depth at 80m (Figure 5.25). This added depth will provide living space and lies for spawning salmonids which would have been absent in the pre works riffle/glide. The pools will also provide a habitat for adult trout at summer water levels, which prior to works, did not exist in this zone. In extreme drought conditions the pools will provide the only available habitat for all fishes living in this river reach. Gravels moving downstream will precipitate out in mounds immediately downstream of these pool structures.

Longitudinal profile

A longitudinal profile for this reach was recorded both pre and post works (Figure 5.26). Measurements were started at 0 and were recorded thereafter at 5m intervals to the most upstream vortex weir in the site, at 240m upstream (Plate 5.12).

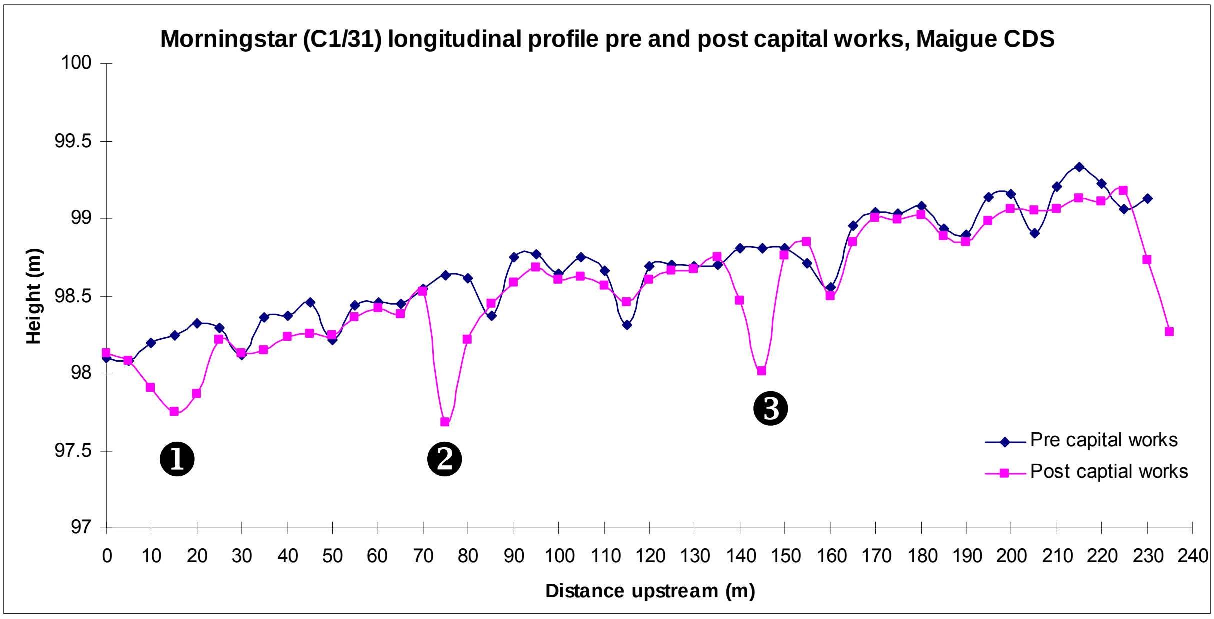


Figure 5.26. Morningstar longitudinal profile pre and post works, Maigue CDS.

The longitudinal profile clearly shows the vortex weirs/pools (numbered 1 to 3 in Figure 5.26 and Plate 5.12) constructed in the experimental section. Each one is slightly different in shape and will continue to change after successive flood events with gravels continuing to accumulate downstream of the pools.

Examining the depth contour plots (Figure 5.27) for the first 100m of the experimental reach, the changes in the depth profile are obvious. The pools dug are evident in the post works depth contours at 15 and 75m.

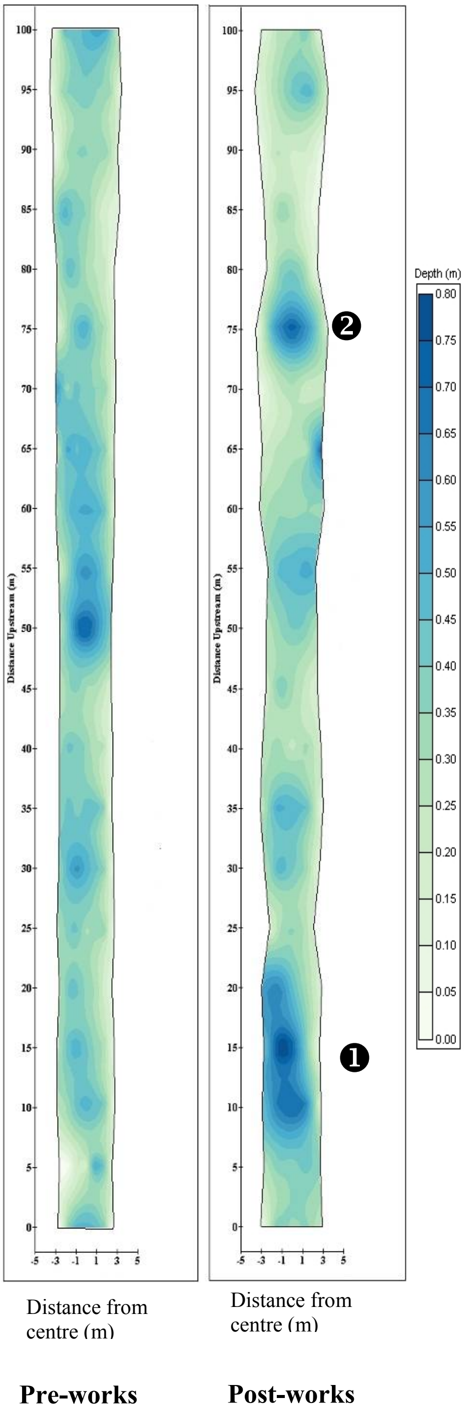


Figure 5.27. Morningstar experimental depth contour plots for pre (Left) and post (right) works (1 and 2 correspond to numbers in Figures 5.25 & 5.26 and Plate 5.12).

No significant difference was recorded for depth and width data between pre and post works using the K-S test (depth - *D*, 0.1347 *P*: 0.20 and width - *D*, 0.2627 *P*: 0.31) for the overall reach as a whole. However the maximum depth had increased in the post works site from 0.72 to 0.85m.

When this programme was at works stage the excavator (a 14 tonne machine) had difficulty excavating the hard boulder clay bed in the reach. This illustrates why the natural physical features (pools and gravel shoals) of this channel section had not recovered following the original drainage scheme. Silt, gravels and small cobbles would have washed through this straight reach because of the laminar flows. Insufficient hydraulic energy is available to scour this hard bed. Therefore without the intervention of the EREP capital works programme, this channel may not have regenerated naturally for a very long period of time.

This reach of the Morningstar is typical of many salmonid reaches in drained Irish Rivers i.e. post drainage an exposed, hard, boulder clay bed is subject to little or no erosion. Consequently the channel cannot regenerate its natural morphological features (a defined thalweg and riffle/glide/pool sequences). The objective of this programme was to correct these physical imbalances and, over time, to monitor both their physical stability and ecological contribution to the river.

The outcome of this study in the long term will reflect the effectiveness of such enhancement programmes over many hundred kilometers of channel.

5.5.2. Physical Assessments of drained and undrained sections of the Dirtoge Stream (C1/34), Maine CDS.

Both the drained and undrained sites have steep sided banks (>2m) with the stream being entrenched into the landscape, due to natural erosion on the undrained site but to drainage on the drained site (Plate 5.5). The undrained site has heavy tunnelling due to a fence on the left hand bank and is in contrast to the virtually treeless drained site. Both sites were physically surveyed with long sections and depths recorded.

Examining the depth contour plots (Figure 5.29) it is possible to see the difference between the two sites. Zero on Figure 5.29 corresponds to 30m on the longitudinal profile (Figure 5.28). The drained and undrained sites are statistically different both in terms of width (D, 0.396, P: 0.028) and depth (D, 0.254, P: 0.001). The drained site had a greater depth and width than the undrained site. The large riffle sections in the undrained site account for its shallowness and the original drainage works account for the greater width of the drained site.

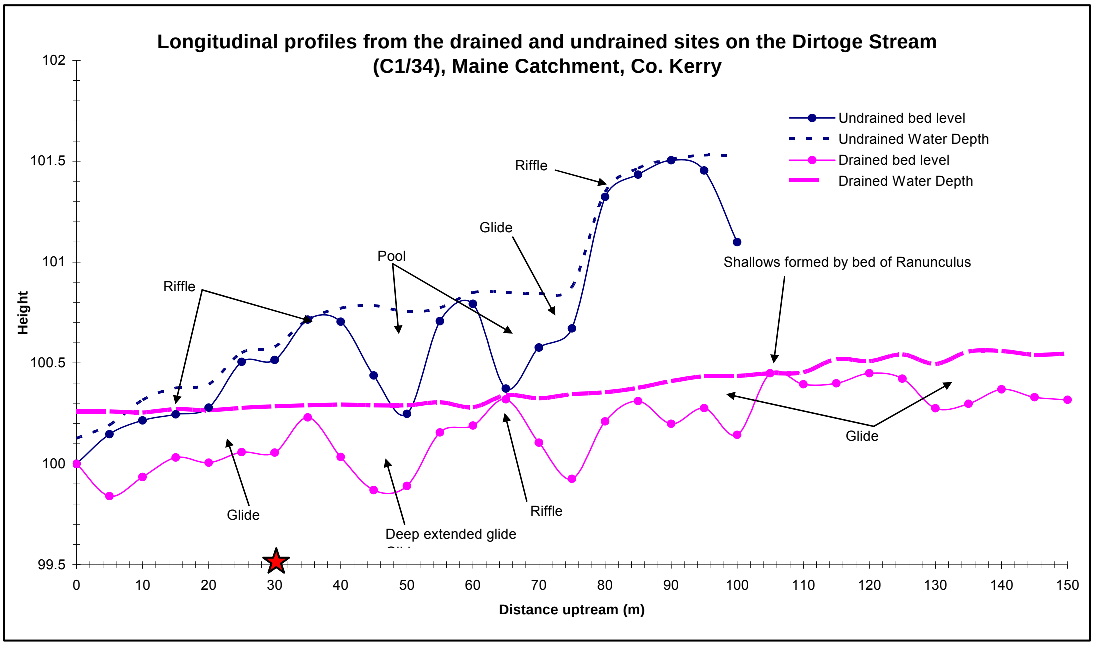


Figure 5.28. Compares the longitudinal profile from the drained and undrained sites on the Dirtoge Stream, Co. Kerry (★ = 0m in depth contour plots Figure 5.29).

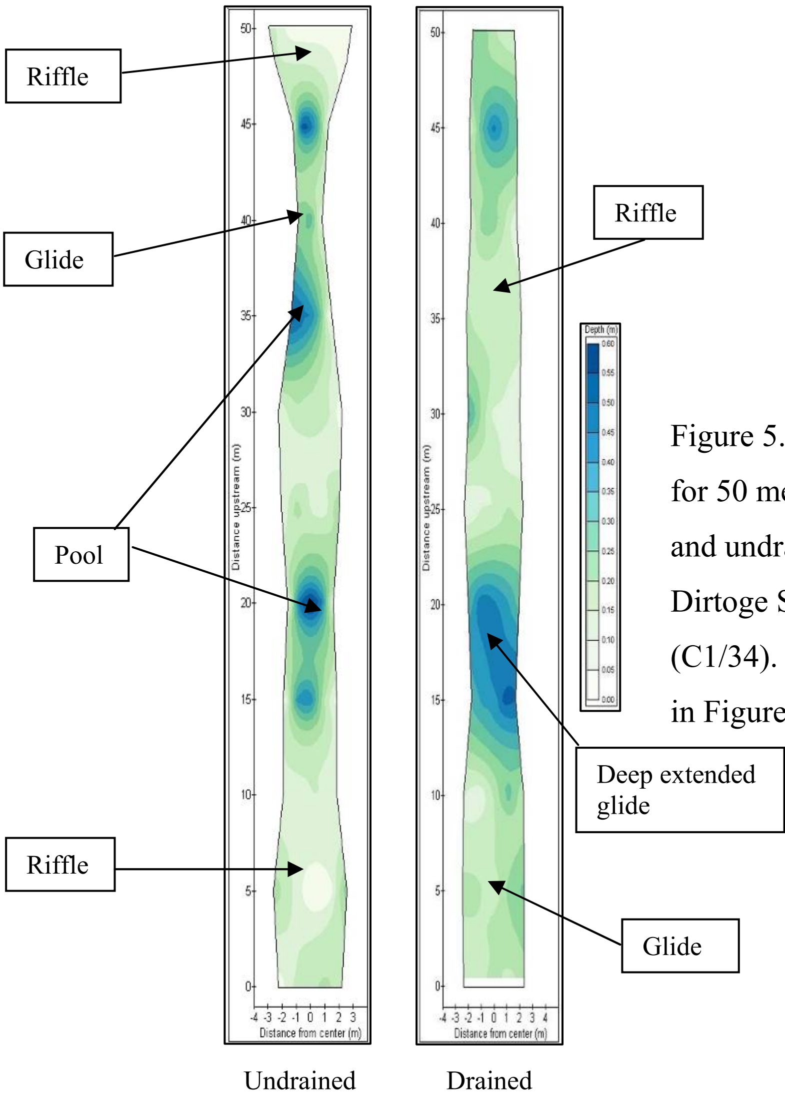


Figure 5.29 Depth contour plots for 50 meters from the drained and undrained sites on the Dirtoge Stream, Maine Trib. (C1/34). (0m corresponds to 30m in Figure 5.28)

A close examination of the depth data showed the undrained site to have a greater variation of depths, a median depth of 0.18m in the undrained site to 0.13m in the drained site. (The median is less sensitive to extreme scores than the mean and this makes it a better measure than the mean for highly skewed distributions). The undrained has greater variation in widths varying from 1.5 to 6.2m, the widths in the drained sites varied from 3.3 to 4.7m. Post drainage, the drained site has retained its trapezoidal shape, the channel remaining very uniform in width and depth. However the implementation of the enhanced drainage maintenance work plan within the proposed maintenance site will increase the instream habitat diversity by increasing pool areas and riffles throughout this section.

6. Other Scientific Studies

6.1. Lamprey Studies

6.1.1 Monitoring studies on the R. Stonyford:

A study of maintenance impacts on juvenile lamprey population structure and density was initiated on the R. Stonyford (Boyne CDS) in 2007. A series of 18 replicates were surveyed prior to maintenance and immediately following maintenance work in 2007. Comparison of the pre-and post data sets indicated a substantial loss of individual animals, with zero density recorded at some replicates. Those juvenile lamprey remaining spanned the same size range as that present prior to maintenance.

The survey in 2008 re-fished the set of 18 replicates. Density values remained low relative to the 2007 pre-maintenance condition. However, a larger overall number of individuals was recorded, compared to the immediate post-maintenance results of 2007 and the population structure indicated a definite trend of recolonisation by younger age groups or size-classes.

In 2009 the channel presented a substantially different aspect, compared to that both pre-and post maintenance in 2007. The overall water depth had increased substantially and the channel had a substantial and, frequently, continuous carpet of aquatic vegetation, predominantly of water celery. The depth regime precluded sampling via electric fishing in many of the enclosure replicate sites. In addition, it was apparent that many of the areas of siltation, previously available to juvenile lamprey, had extensive root masses of water celery ramifying through them. The same number of replicate enclosures were fished as in previous years. However, a number of new locations were used, all with areas of suitable sediment for juvenile lamprey. A total of 27 juveniles were collected, less than 50% of the total from 2008 and approximately 10% of the pre-maintenance total. Density values were low (Figure 6.1.1). The population structure indicated a range of age groups and was most comparable to that of 2008 (Figure 6.1.2).

The findings of 2009 introduce a new ‘twist’ into the post-maintenance situation. The growth of water celery is considered to be responsible for the elevated water depths and the infiltration of water celery root masses into the sediment may be a factor in reducing the suitability of the sediment for colonisation by lamprey juveniles. The celery growth may be a reflection of natural ecological succession occurring following the impact of maintenance. Thus, while the set of pre- and post- results of 2007 and those of 2008 may reflect a direct impact and of initial recovery, the findings of 2009 may point to a more subtle and less direct impact of maintenance on lamprey habitat in this channel.

At this stage it would be important to (a) continue to monitor the situation on the Stonyford study area and (b) source a new channel(s) where experimental monitoring of impact and recovery can be studied, ideally without the complication of plant succession impacts.

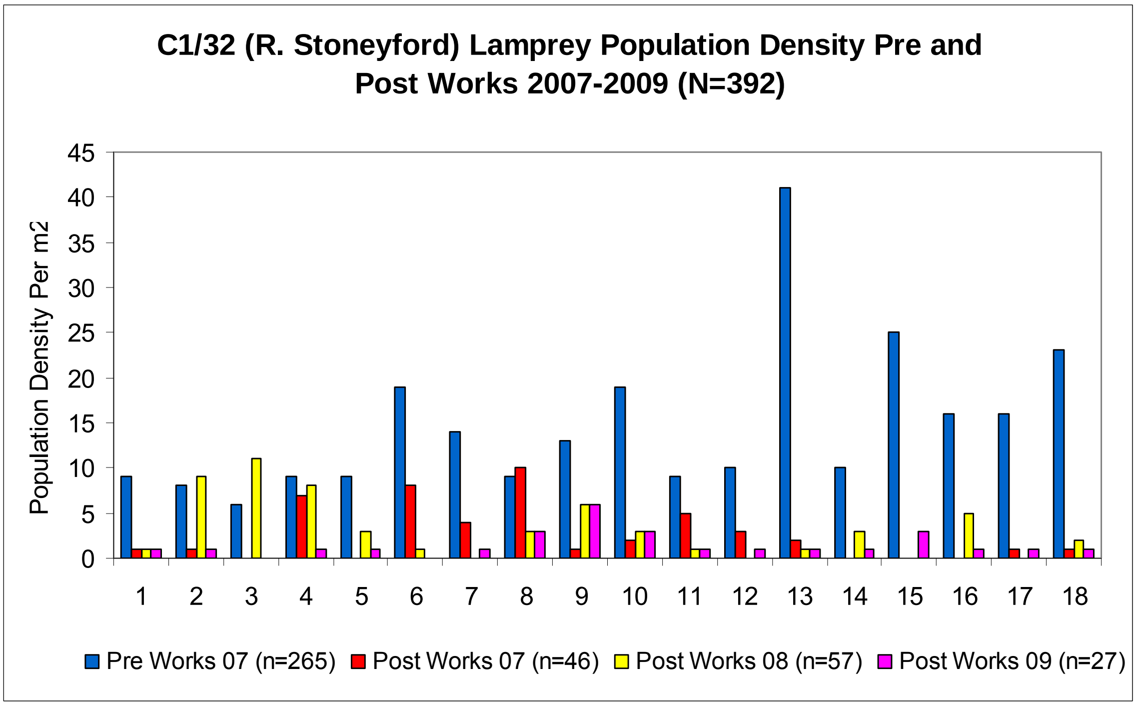
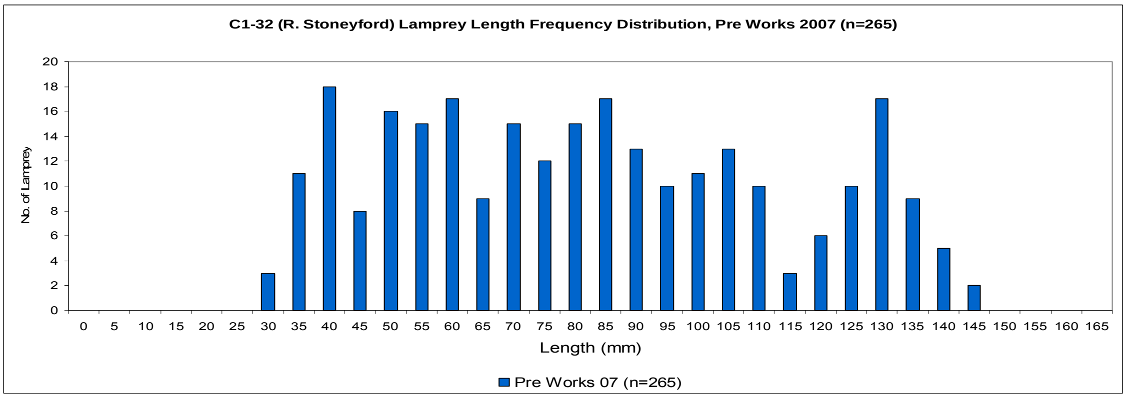
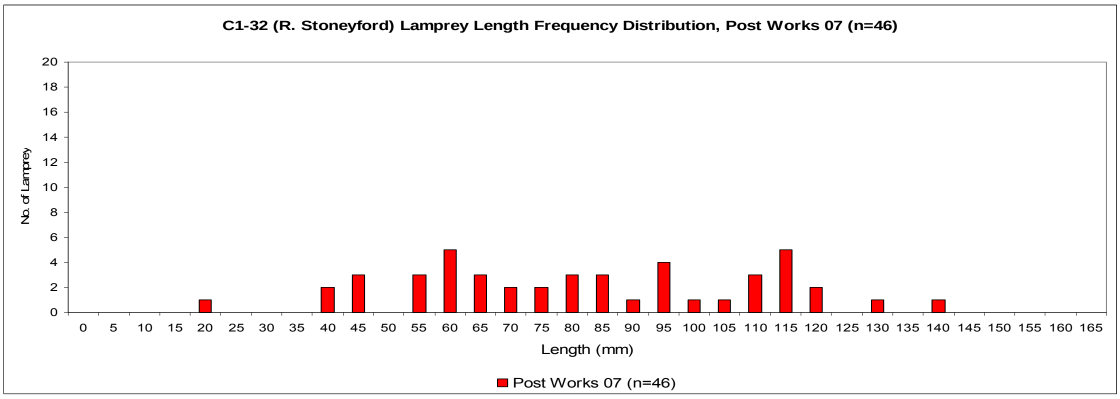
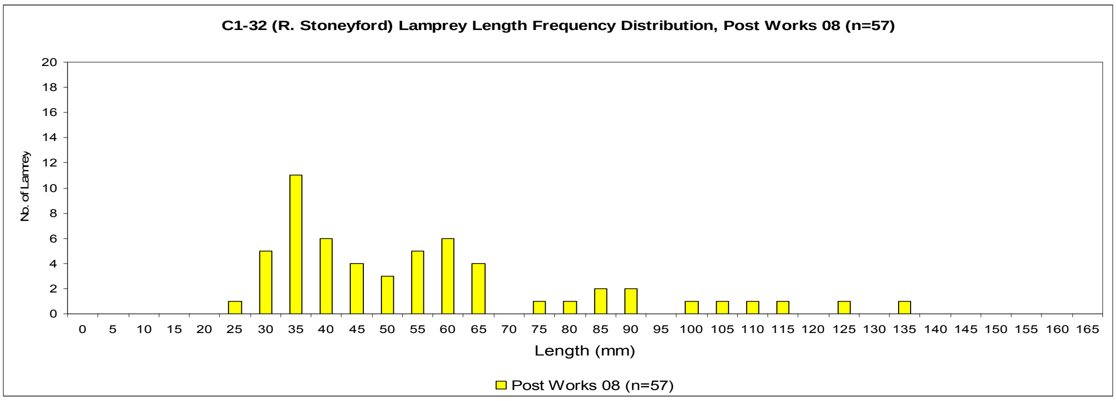


Figure 6.1.1. C1/32 (R. Stoneyford) Comparison of the lamprey population density per m^2, pre and post maintenance works, 2007-2009.







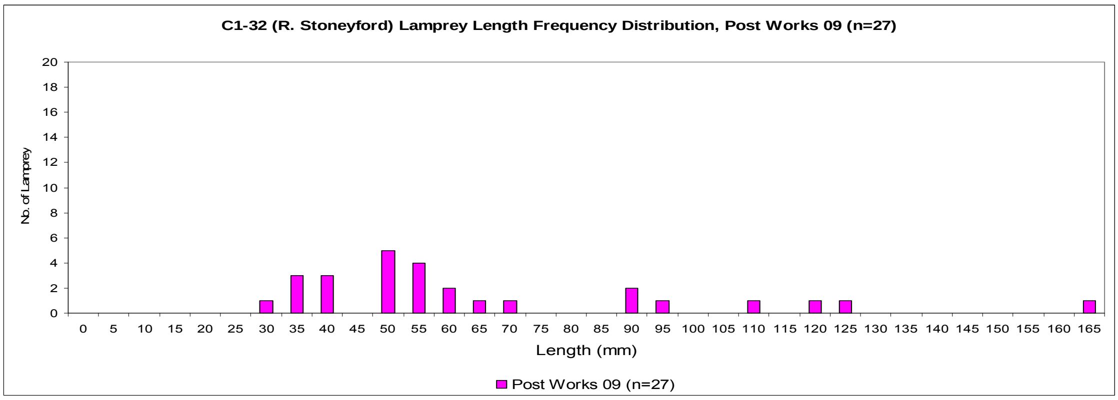
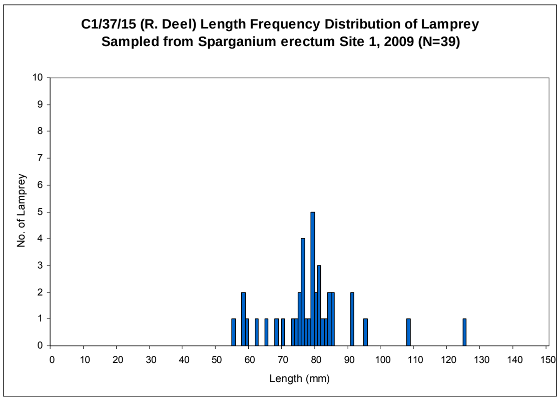


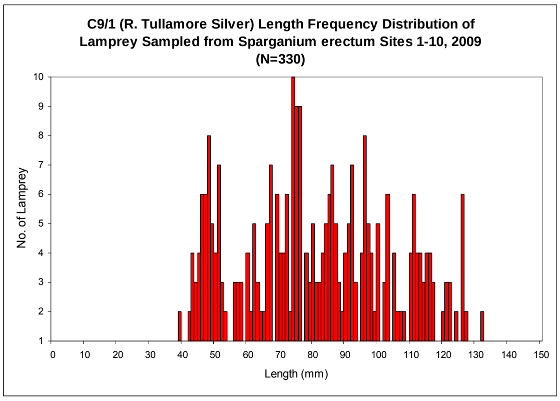
Figure 6.1.2. C1/32 (R. Stoneyford) Comparison of the lamprey population length frequency distribution, pre and post maintenance works, 2007-2009.

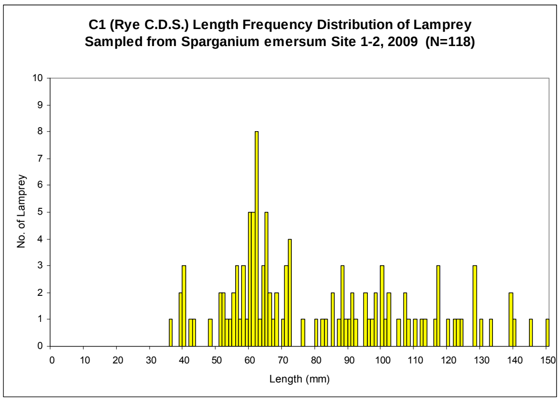
6.1.2 Lamprey populations and specific macrophytes:

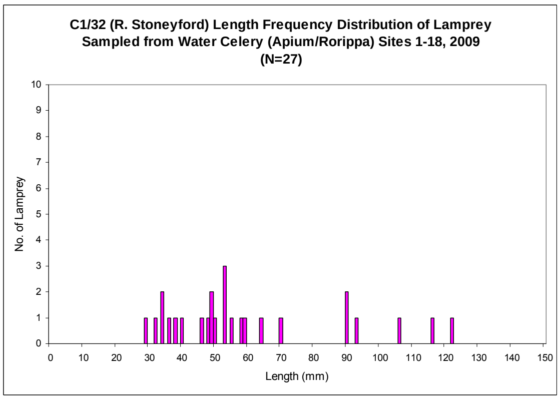
A convergence of observations from the R. Stonyford survey (see Section 6.1.1 above), from audit visits and from walkover surveys led to collection of a series of data sets on lamprey occurrence in relation to various plant species of relevance in OPW's channel maintenance. Data on juvenile lamprey population structure and density were available in relation to six plant species. Five of these were essentially open-water ones and one, the tall marginal grass *Phalaris*, was essentially terrestrial or of a water-side nature. The juvenile lamprey length frequency data indicated that a wide range of length or age groups could occur in association with all of the species (Figure 6.1.3).

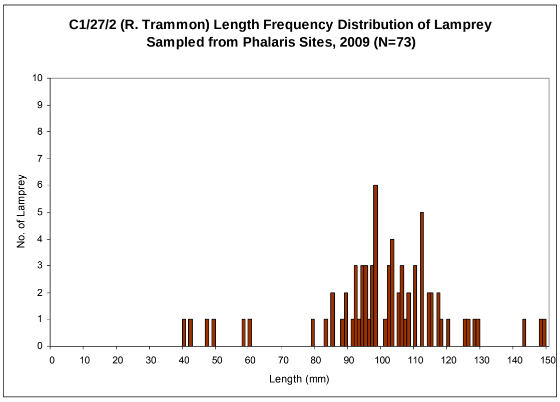
However, the density data did point to some of the vegetation types being substantially more important than others (Figure 6.1.4). Both the emergent and submerged forms of 'flaggers' or burr reed – *Sparganium erectum* and *S. emersum* – were found to be associated with large density values of juvenile lamprey. Sampling on the Cappa River (Cappa-Kilcrow CDS) was initially undertaken in respect of *Scirpus* beds, the dark green rush, and their management in enhanced maintenance operations. It was found that sediment adjacent to *Scirpus* might contain numbers of juvenile lamprey whereas the root mass of *Scirpus* was so fibrous and of such density as to virtually preclude lamprey use. Adjacent stands of the floating leaved lily, *Nuphar*, did have substantial numbers of lamprey, most likely due to the extent of soft sediment around the rooting tubers of the *Nuphar*.

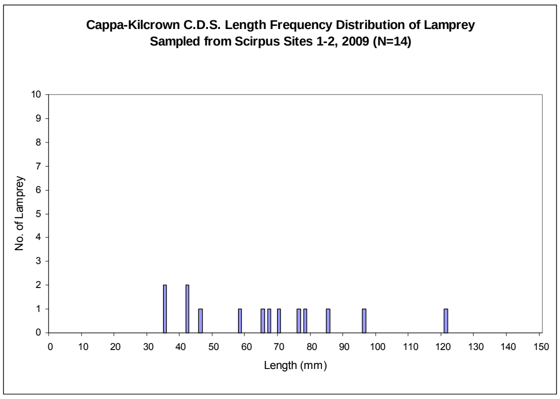












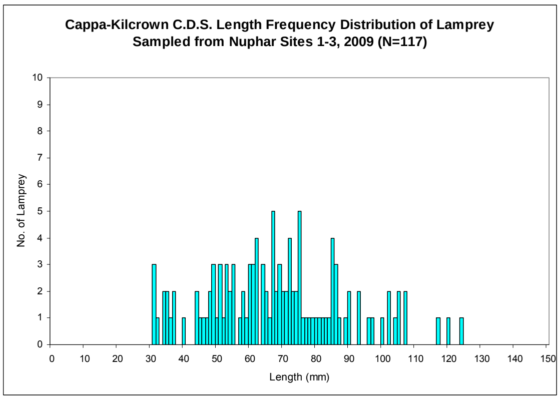


Figure 6.1.3. Length frequency distribution of lamprey sampled from specific aquatic and marginal vegetation types in 2009.

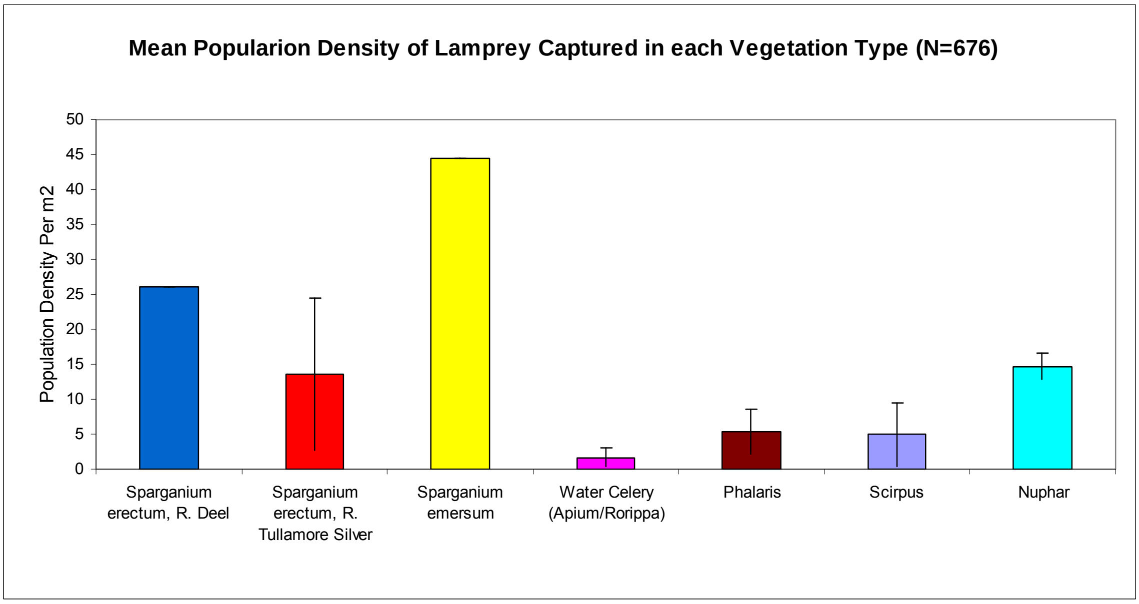


Figure 6.1.4. Comparison of the mean lamprey population density per m^2, sampled from seven different aquatic and marginal vegetation types, post maintenance, 2009.

The findings have implications for weed management in the context of lamprey presence and should be incorporated into driver training protocols going forward. The initial driver training programme of 2002-03 proposed full removal of *Scirpus*, water celery and of 'flaggers'. This continues to hold true for both *Scirpus* and celery, in respect of lamprey. It is evident that whole-channel removal of 'flagger' vegetation may have serious adverse impact on juvenile lamprey numbers, should they be present in the channel containing the 'flaggers'. Where juvenile lamprey are shown to be present in channels with a 'flagger' maintenance issue, a new protocol will be required that will permit retention of some 'flagger' vegetation and the fine sediment accumulated by the plants in order to facilitate ongoing lamprey colonisation and occupancy.

6.2. Crayfish Studies

OPW-funded studies to examine the impacts of channel maintenance on the white-clawed crayfish (*Austropotamobius pallipes*) have been on-going since 2006. In all cases, sampling was undertaken pre-maintenance and at annual intervals, at same time of year, subsequently. In addition, post-maintenance sampling was undertaken in the Brosna and Glore sites within weeks of the initial maintenance, as well as the annual post-works sampling.

The response of crayfish populations, over time, has differed in the different waters surveyed (Figure 6.2.1). In all cases, a population decline was recorded in the year following maintenance. However, an untreated control site, the CM4/43 – a tributary of the R. Robe, itself a major reservoir of crayfish – also showed a similar decline. The population in that channel subsequently showed a degree of stability in the (September) 2007–09 period.

Both the R. Rath and the Loobagh tributary (C1/34/12) showed a continuing decline in numbers of crayfish over the three years of post-maintenance monitoring whereas the R. Tullamore and the L. Ennell tributary (C38/1) showed a substantial increase in numbers in the third year after maintenance with total numbers increasing to a level above that recorded prior to maintenance. This is particularly notable in the R. Tullamore, given that additional channel cleaning work was undertaken in the survey areas during the winter-spring of 2008-09, prior to survey in 2009.

The R. Brosna and R. Glore have been studied over a two year post-maintenance period. Both showed a substantial decline in total crayfish numbers following maintenance. This decline continued in the R. Glore to the extent that zero crayfish were recorded in 2009, two years after maintenance. In contrast, the R. Brosna total numbers stabilised in the second year after maintenance (Plate 6.2.1).

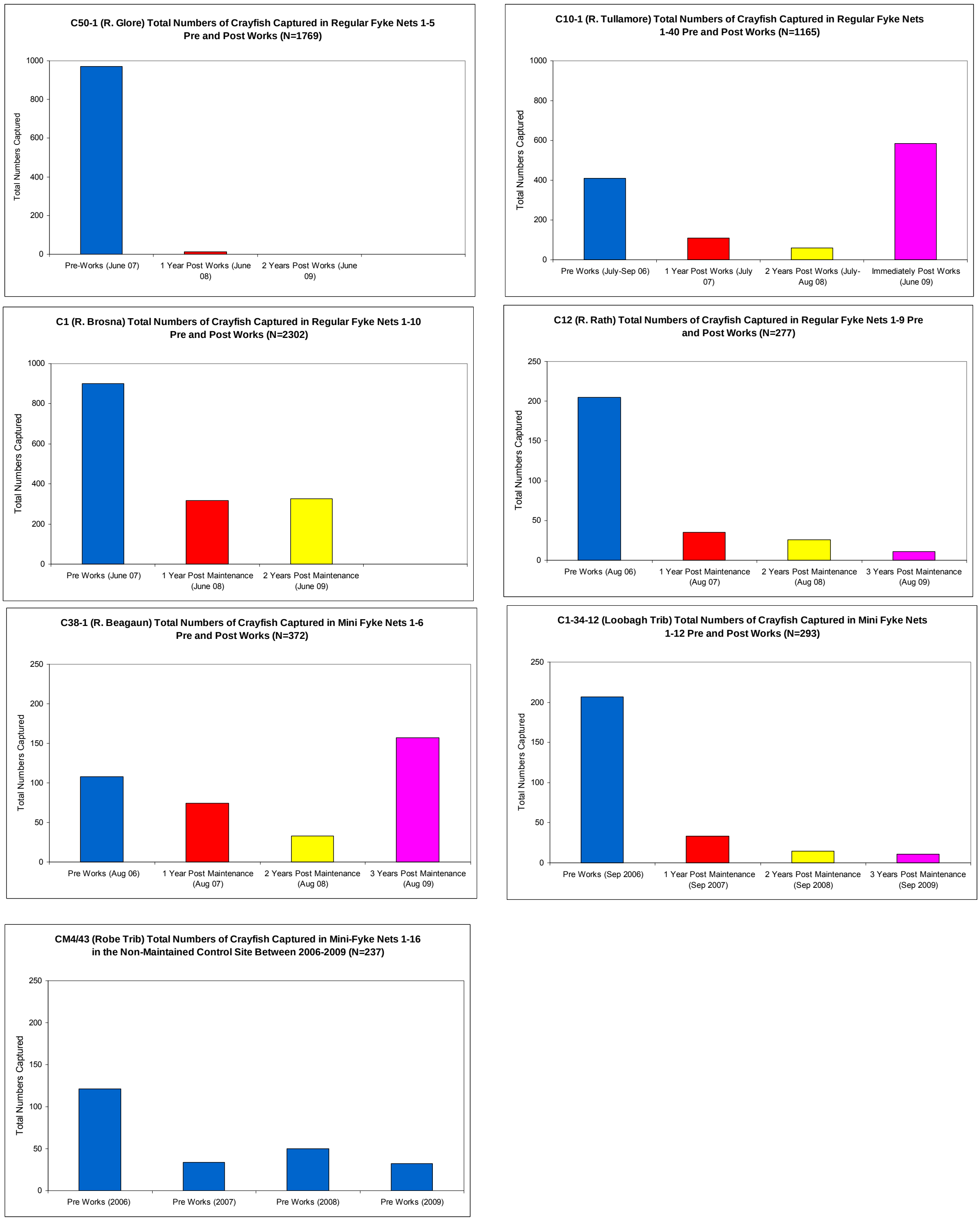


Figure 6.2.1 Total numbers of crayfish captured in annual sampling of individual channels, 2006-2009.

It is evident that this study is yielding important management results and continued monitoring at the suite of study sites should continue in 2010. It would be desirable if an additional study could be initiated in a channel containing significant numbers of crayfish and in which only the lower reaches of the channel were to be maintained. This would facilitate sampling in 'Control' as well as 'Experimental' reaches within the same channel. This facility was not available in the channels examined to date. As with the lamprey studies (see Fig. 6.1.2) above, it is clear that increased knowledge will lead to altered approaches to weed management in OPW channels. While *Scirpus* and water celery are not shown to be conducive to good juvenile lamprey habitat, the opposite is the case for crayfish. *Scirpus* is a major vegetation element in the R. Robe, where very large crayfish numbers occur. Equally, the EREP report for 2008 indicated large numbers of crayfish associated with water celery in a channel being maintained while few crayfish were associated with the substratum underlying the celery.

Plate 6.2.1 R. Brosna Site comparison photographs taken immediately post works, June 2007 and 2 years post maintenance, June 2009.

7. River Hydromorphology Assessment Technique (RHAT)

The Water Framework Directive (WFD) requires information on three elements in order to determine the ecological status of a water body, these include biological quality, physico-chemical conditions and hydromorphological conditions. A classification of High Ecological Status cannot be assigned to a water body unless the hydromorphological conditions are high also. If the hydromorphological conditions of a water body has not been determined and the system has been impacted by drainage then that catchment is deemed to be “probably at risk”. It has also been stated by the WFD that if the overall status of a water body has been impacted by morphology then measures must be taken to restore good status to that system.

The majority of channels, across the country, that are impacted by drainage are under the remit of OPW. As such the OPW have an obligation, under WFD, to put measures in place in their channels that are under pressure due to channel morphology and thus potentially unlikely to achieve high ecological status.

Information on channel morphological status is required when reporting back to WFD. No system was in place, in this country upto this year, that was capturing the required data. There was a need therefore to develop a field method, with a scoring system attached, that the EPA (the statutory body responsible for implementing WFD) could use within their WFD monitoring programmes which would provide an assessment of the morphological conditions of a channel. The River Hydromorphology Assessment Technique (RHAT) monitoring system was approved as the appropriate method and is being used by the EPA and the NIEA (Northern Ireland Environment Agency) to assess hydromorphological condition at those sites identified for WFD monitoring.

EREP will also collect information on hydromorphological conditions of OPW drained channels using the RHAT system. The data collected will feed back to the EPA and contribute to the overall assessments made nationally on channel morphology. In particular it is viewed as an assessment tool that will help identify why a water body might be failing to achieve good ecological status. Channels identified for work under EREP are those that have hydromorphological problems that can be addressed through capital works and enhanced maintenance programmes. Therefore it is important to show that the changes in channel morphology, post works, will have a positive effect on the RHAT score for the section enhanced. It would be expected that post enhancement a RHAT score will increase as the works described for these channels all aim to put back many of the natural features these rivers had pre drainage. A RHAT score will be assigned to all channels pre enhancement works and then again 1 year post enhancement.

The CFB and OPW have attended two fieldtrips/workshops on the application of the RHAT system given by the NIEA. However before RHAT scores would be accepted by the EPA and NIEA, staff from other agencies (CFB / OPW) would have to undergo training in order to become accredited RHAT assessors. It is hoped that this training will be delivered early in 2010 by the NIEA and the EPA. Following on from this, the EREP team will carry out RHAT assessments on all channels identified for both Capital Works and Enhanced Maintenance.

Figure 7.1. Example of a low RHAT score: uniform channels no diversity instream or on banks, evidence of channelisation.

Figure 7.2. Example of a high RHAT score channel.

Figure 7.3. Example of a high RHAT score channel.

8. OPW Training Programme

One of the required deliverables to the EREP study is the development and roll-out of a training programme to OPW's field staff, involved in arterial drainage maintenance work, dealing with environmental issues in the river corridor.

The first such environmental training had been developed in the EDM study (2002 – 2006). At that time the training consisted of two classroom modules presented over a half-day period. A total of fourteen sessions were held around the country and were attended by in excess of 200 OPW staff, of all grades, involved with channel maintenance.

Since that period, a number of the maintenance strategies espoused in the initial training have become routine practice in many areas. However, new challenges continue to emerge and the training to be developed must be cognisant of the Water Framework Directive. It is considered that a robust implementation of maintenance strategies in relation to overdigging the channel bed and re-profiling cross-sections would make a substantial contribution to improving the hydromorphology of arterially-drained channels. Such improvement would be consistent with the requirements of the directive. On-going investigations on the Annex II species, lamprey and crayfish, in regard to channel maintenance impacts have thrown up much new information. Large crayfish populations have been found in some low-gradient main channels within arterially-drained catchments in the midlands. Such results require a re-appraisal of maintenance strategies advocated in the previous training. In addition, these investigations have reinforced the reservations in regard to maintenance impacts in some channels and have contributed to roll-out of Standard Operating Procedures (SOPs) in regard to encountering either crayfish or lamprey in channel maintenance. A particular feature of the EREP study is the Capital Works provision, whereby material can be imported by OPW into specific salmonid channels with a view to undertaking diggings or placing structures that will radically alter the physical form of the channel to bring about positive hydromorphological and biodiversity change. It is essential that OPW field staff be made familiar with the background behind the Capital Works and with the types of structures involved and how these function in the channel.

High levels of implementation were recorded in driver visits following training in the 2003 – 05 period. However, it was clear from audit visits to driver crews in 2009 that a degree of slippage was occurring in regard to the 10-point environmental strategy advocated in the EDM training. Some of this may be due to a shortfall in continuous coaching and it is envisaged that the new training programme will generate renewed interest and a return to high levels of implementation.

The training programme in EREP is envisaged as a 1-day course. Modules will be provided in river corridor biology and ecology, in strategies drivers can employ in 'Enhanced Maintenance' and in the structures and strategies involved in the Capital Works element. An important part of the ecology element will cover the series of Annex II species that drivers are likely to encounter on a regular basis and what to do when these are encountered. This group includes

- Atlantic salmon
- Lamprey – with particular emphasis on juvenile life stages
- White-clawed crayfish
- Freshwater pearl mussel
- Otter

Given the day-long timing, the course will endeavour to be as visual as possible, with examples drawn from OPW channels, and will provide scope for open-floor discussion and for written responses to tasks set.

While the training outlined above covers the formal approach to the training programme this will be complimented by on-site training provided during the year. This will be particularly important when implementing Capital Works structures.

The EREP team has drawn up a series of presentations for the training programme. This was to have been examined with OPW's engineers and technicians in late autumn. However, the prolonged rainfall and flooding prevented the OPW staff from convening, being drawn to reviewing and assessing a number of major flooding events. Roll-out of the new training was scheduled for spring 2010. It is evident that there will be some slippage on this timeline and new schedules will be developed in line with pressures on OPW teams, arising from the recent flooding and from scaling–up of maintenance work in late spring-early summer.

9. Auditing Programme

As a follow up to the training provided to all OPW field staff under an earlier programme (EDM) and the implementation of the resultant "10 Steps" approach to environmentally friendly maintenance, EREP will carry out machine works assessments (audits) on approximately 1/3 of all OPW machines annually across the three OPW regions. OPW are also conducting a number of internal machine works audits annually. Both the CFB and the Environment Unit of the OPW have agreed a common auditing form.

Procedures for such audits require that the relevant foreman, and when possible the engineer, be present during the audit. All feedback on-site in relation to the audit is provided directly to the foreman and not the driver. The audit visit provides an opportunity for a detailed review of compliance with the "10 steps" process on site with the foreman. Opportunities may present themselves whereby alternative maintenance methods can be demonstrated and explained to a driver while on-site. There will be substantially greater emphasis on this element in 2010 and thereafter in the light of the new environmental training programme roll-out for OPW maintenance staff. The outcomes of the audit visit are compiled on the appropriate form and this is reviewed with the foreman at the end of the visit. A copy of the form is forwarded to the relevant resident engineer.

In 2009 the CFB carried out 18 audit visits to driver teams. This involved direct inspection and drew in 10 of OPW's civil foremen across all Maintenance Regions. Information gained from these is used to examine which elements of the "10 Steps" are being readily applied by drivers, across all OPW regions, and will identify any areas that drivers are not implementing, where that option was available.

In general the approach to environmentally sensitive maintenance by drivers, as recorded by EREP in 2009, was very mixed (Figure 9.1). Scoring for compliance was ONLY carried out in respect of relevant issues. Thus, if no berms were present at a site there was no scoring for this topic. In addition, the two items listed as 'to be implemented with Fisheries' – pool excavation and loosening of gravels – were not scored as OPW requested these be omitted until after the new round of training in early 2010. As a consequence, some site visits scored on as few as three or four items. The audit process is still in development and it is envisaged that further modification to the recording sheet, to better capture the inputs of the driver staff on-site, will occur during 2010. To date, no categorizing of effort or 'banding' of scoring has been developed – what would constitute a high score, what a poor one. If a cut-off score of 75% were used on the 2009 findings (Figure 9.1) it is clear that the majority of the 18 crews visited would be considered to be performing well. However, it is also clear that 16% of the visits registered a score of less than 60%.

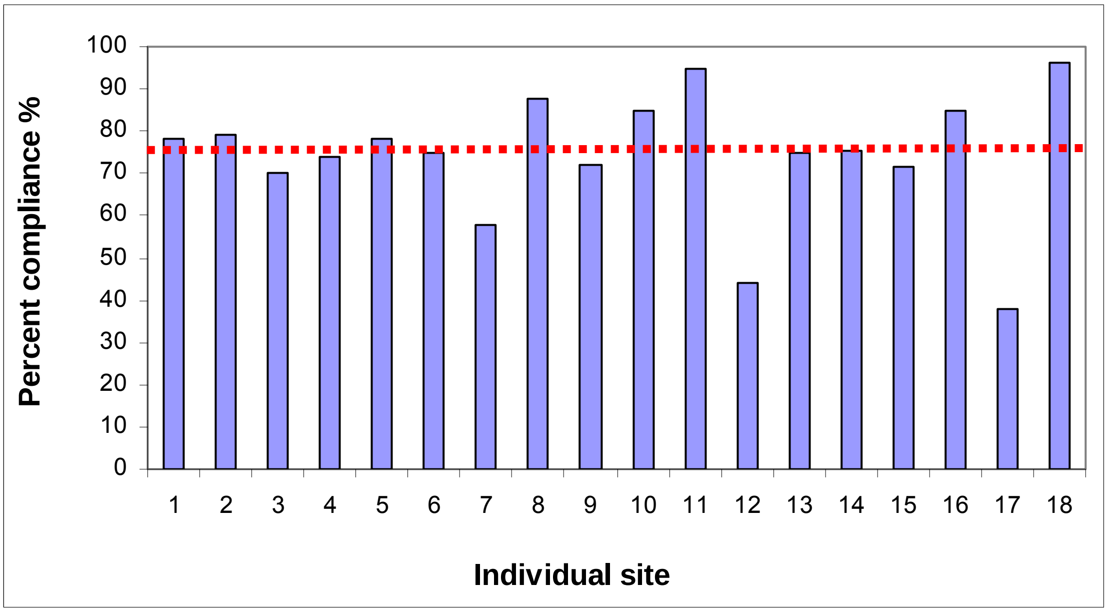


Figure 9.1. Compliance scores from individual visits to sites where channel maintenance was being undertaken in 2009.

On occasions compliance was very good (Plate 9.1), while the opposite end of the scale was also evident (Plate 9.2). This alone suggests that the "10 Steps" are achievable but many of the options listed are often not being applied. This would seem to be by choice, in some cases, or due to lack of support and direction from line management. When examined on a topic-by-topic basis, within the 10 individual steps, it was evident that a degree of slippage was occurring in a number of aspects. Of particular concern was the encroachment onto the non-working bank, in many cases, with impact to this bank slope and marginal area (Plate 9.3). The leaving intact of the non-working bank was a fundamental tenet of the initial environmental training and the degree of slippage away from this is a major concern (Option No 0 in Figure 9.2). This issue arose frequently in channels of very small base width and was often a consequence of the bucket being too large for the size of the drain. The ‘placement’ or digging component of the bucket’s arc could often not be achieved without impacting onto the non-working bank slope.

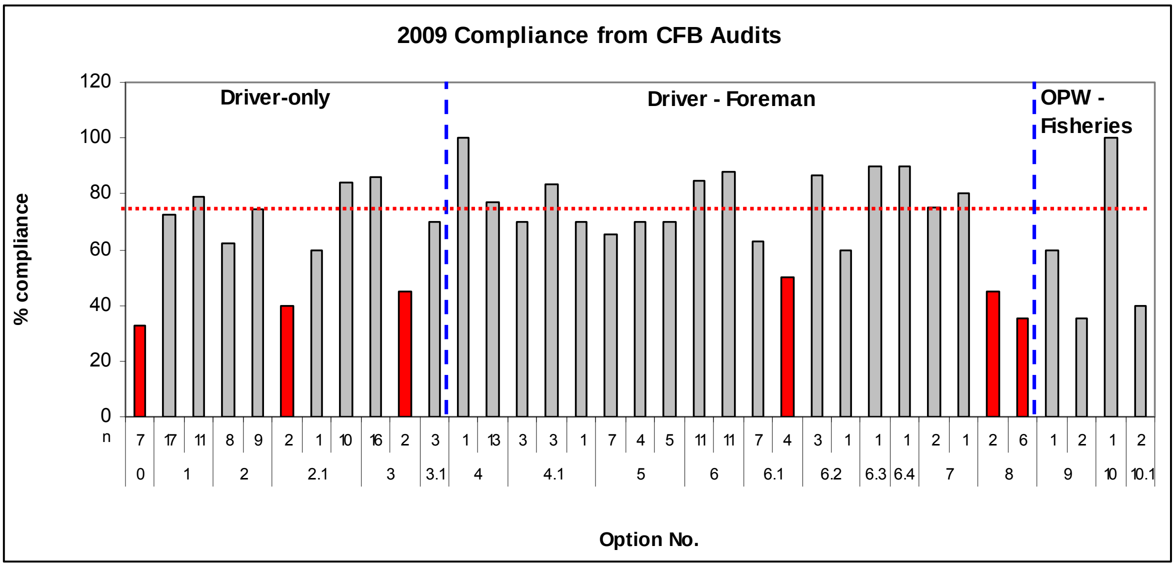


Figure 9.2. Overview of implementation of specific topics within the 10-point suite (Items 0 – 10.1 are individual audit items, based on the 10-point environmental training; N values refer to number of cases within each item)

The findings also showed a high degree of deviation from the original environmental training in regard to restriction of maintenance to the open channel (Option No 2 – 2.1 in Figure 9.2), with an emphasis on no new diggings, and in regard to the handling of spoil (Option No 3 – 3.1 in Figure 9.2). In some case, spoil handling involved placement of material wherever possible within the cross-section. This clearly was not consistent with leaving the non-working bank alone. Clearly, there is an increasing degree of issue occurring with land-owners, many of whom are not prepared to permit spoil to be placed on their land immediately on the top of the bank full line. This obliges drivers to place the material in whatever locations they can manage to find. Many of the bank slopes observed are extremely steep and are not capable of retaining spoil material placed on them. It is becoming increasingly evident that total removal off-site will arise as an issue and possible solution to the spoil management situation, where landowners will not permit spoil placement on bank full lines.

Items 6.1 and 6.2 related to subsets within the 'Tree Management' suite of issues. There was a shortfall in compliance within both – the former relating to management of understorey scrub, which remains an outstanding issue to be resolved, and the latter relating to use of chain saws for cutting trees and branches. In 2009 observations were made on more than one channel where trees were still being 'handled' directly by use of the machine bucket and jib. This was identified as totally unsatisfactory practice at the environmental training in 2003. In one of the recent cases observed, chain saw use was also in evidence by the same crew – off setting any excuse for use of the machine bucket.

Plate 9.1. Good compliance of the "10 Steps" with instream fishery enhancement works also achieved.

Plate 9.2. Excessive removal of bed material. Deposition of spoil on both bank slope and bank full line. Damage to non-working bank evident.

Plate 9.3. Excessive removal of instream and marginal vegetation and damage to non-working bank.

Acknowledgments

The assistance and support of OPW staff, of all grades, from each of the three maintenance regions is gratefully appreciated. The support provided by Regional Fisheries Board officers, in respect of site inspections and follow up visits and assistance with electrofishing surveys is also acknowledged. Overland access was kindly provided by landowners in a range of channels and across a range of OPW drainage schemes.

Project Personnel

Members of the EREP team include:
Dr. Martin O'Grady
Dr. James King
Karen Delanty
Rossa O Briain
Brian Coghlan
Michelle O'Regan
Fiona Bracken

Scientific support and expertise to the plant studies was provided by Dr. Thomas Harrington (University of Limerick). Field investigations were also supported by members of the Botanical Society of the British Isles (BSBI), in particular Ms Margaret Norton, vice-county recorder for Meath, who provided mentoring and field support in channels of the Boyne catchment. Staff at the National Botanic Gardens, Glasnevin, were also very helpful in the identification of field samples. In respect to bird survey work training and scientific support in the areas of survey techniques and identification was provided by Dr. Tom Hayden (University College Dublin) and Dr. Fintan Bracken (WYG, Ireland).

REFERENCES

Botantical Society of the British Isles (BSBI), (2009). www.bsbi.org.uk/

Conlan, K.E. (1994). Amphipod crustaceans and environmental disturbance: a review. Journal of Natural History 28, 519±554.

D'Amico, F. & Hémery, G. (2007). Time–activity budgets and energetics of Dipper *Cinclus cinclus* are dictated by temporal variability of river flow. Comparative Biochemistry and Physiology - Part A: Molecular & Integrative Physiology Volume 148, Issue 4, Pages 811-820

Duffy, J. E. & Hay, M. E. (1991). Amphipods are not all created equal: a reply to Bell. *Ecology* 72, 354±358.

Duffy, J. E. & Hay, M. E. (1994). Herbivore resistance to seaweed chemical defence: the roles of mobility and predation risk. *Ecology* 75(5), 1304±1319.

Fossitt, J.A. (2000). A guide to the habitats of Ireland. The Heritage Council.

Friberg, N. & Jacobsen, D. (1994). Feeding plasticity of two detritivore-shredders. *Freshwater Biology* 32.

Grimble, A. (1903). The Salmon Rivers of Ireland, Volume: 2: Publisher: K. Paul, Trench, Trübner& Co., ltd.

Information leaflet on fens. http://www.enfo.ie.

MacNeil, C., Dick, J.T.A. & Elwood, R.W. (1997).The trophic ecology of freshwater *Gammarus* (*Crustacea*: *Amphipoda*); problems and perspectives concerning the functional feeding group concept. Biol. Rev., 72, pp. 349±364 Printed in the United Kingdom .

Suggested Reading List

OPW Series of Ecological Impact Assessments:

Screening Report No. 1 - Screening of Natura 2000 Sites for Impacts of Arterial Drainage Maintenance Operation

EcIA No. 3 Salmon

EcIA No. 6 Birds Dependent on Riparian Habitats

EcIA No. 9 Lamprey

EcIA No. 10 Crayfish

APPENDIX 1

List of Scientific Publications in relation to River Enhancement Works

Gargan, P., O'Grady, M.F., Delanty, K., Igoe, F. and Byrne, C. (2002) The Effectiveness of Habitat Enhancement on Salmon and Trout Stocks in Streams in the Corrib Catchment. Dublin, Ireland, Central Fisheries Board.

Igoe, F. (1999). The Implications of Dense Riparian Vegetation for Juvenile Salmonid Populations in Nursery Streams in Ireland. An Analysis Based on Five Nursery Streams. Ph.D. Thesis, National University of Ireland.

Kelly. F.L. (1996). Fisheries Enhancement of the Rye Water, a Tributary of the River Liffey. Ph.D. Thesis, National University of Ireland.

King, J.J. (1996). Channel Maintenance in Drained Irish Catchments: Experimental Strategies, Ecological Impacts and Management Implications. Ph. D. Thesis, National University of Ireland.

King, J.J., Joyce, T., Collins, M., O' Donaill, C. and Rhatigan, V. (2007). Mitigating for Fish and Habitat: Fisheries – Engineering Interactions in Flood Relief Schemes in Ireland, 1996-2002.

King, J.J., O'Grady, M.F. and Curtin, J. (2002). The experimental drainage maintenance (EDM) programme: engineering and fisheries management interactions in drained Irish salmonid channels. Verh. Internat. Verein. Limnol. 27, 1532-1535.

Lynch, J.M. and Murray, D.A. (1992). Fishery rehabilitation and habitat enhancement following arterial drainage in Ireland. XXV S.I.L. Conference, Barcelona.

McCarthy, D.T. (1977). The effects of drainage on the Trimblestown River. 1 Benthic invertebrates and flora. Irish Fisheries Investigations Series A, 16 16pp.

McCarthy, D.T. (1983). The impact of arterial drainage on fish stocks in the Trimblestown River – in Moriarty, C. – Ed: Advances in Fish Biology in Ireland. Irish Fisheries Investigations Series, A, 23, p16-19.

McCreesh, P.A. (2000). Effects of a Fisheries Restoration Scheme on the Biological Communities of the Rye Water, an Irish Lowland River. Ph.D. Thesis, University College Dublin, Dublin, Ireland.

O'Grady, M.F. (1991). Ecological changes over 21 years caused by drainage of a salmonid stream, the Trimblestown. Irish Fisheries Investigation Series A, 33, 16pp.

O'Grady, M.F. (1991). Rehabilitation of salmonid habitats in a drained Irish river system, in Steer, M.W. Irish Rivers: Biology and Management, Royal Irish Academy, Dublin, 187-204.

O'Grady, M.F. (1993). Initial observations on the effects of varying levels of deciduous bankside vegetation on salmonid stocks in Irish waters. Aquaculture and Fisheries Management, 24: 563-574.

O'Grady, M.F. (1998). The Boyne. In: C. Moriarty Ed: Studies of Irish Rivers and Lakes. Essays on the occasion of the XXVII Congress of Societas Internationalis Limnologiae (SIL) Dublin. Marine Institute.

O'Grady, M.F. (2002). Salmonid Riverine Enhancement in Ireland – Past, Present and Future. Went Memorial Lecture, 2002. Royal Dublin Society. Occasional Papers in Irish Science and Technology, No. 26. 24pp.

O'Grady, M.F. and Curtin, J. (1993). The enhancement of drained Salmonid Rivers in Ireland – A Bioengineering Perspective. Hydroecol. Appl., Tom 5, Vol. 2, p. 7-26.

O'Grady, M.F., Delanty, K. and Igoe, F. (2002) (a). Enhancement of Brown Trout Spawning and Nursery Habitat, in the Lough Ennel Catchment, Co. Westmeath, Ireland. In: O'Grady, M.F. (ed.) Proceedings of the 13th International Salmonid Habitat Enhancement Workshop, Westport, Ireland, Sept., 2002, pp78-92.

O'Grady, M.F., Gargan, P., Delanty, K., Igoe, F. and Byrne, C. (2002) (b). Observations in Relation to Changes in Some Physical and Biological Features of the Glenglosh River Following Bank Stabilisation. In: O'Grady, M.F. (ed.) Proceedings of the 13th International Salmonid Habitat Enhancement Workshop, Westport, Ireland. pp. 61-77

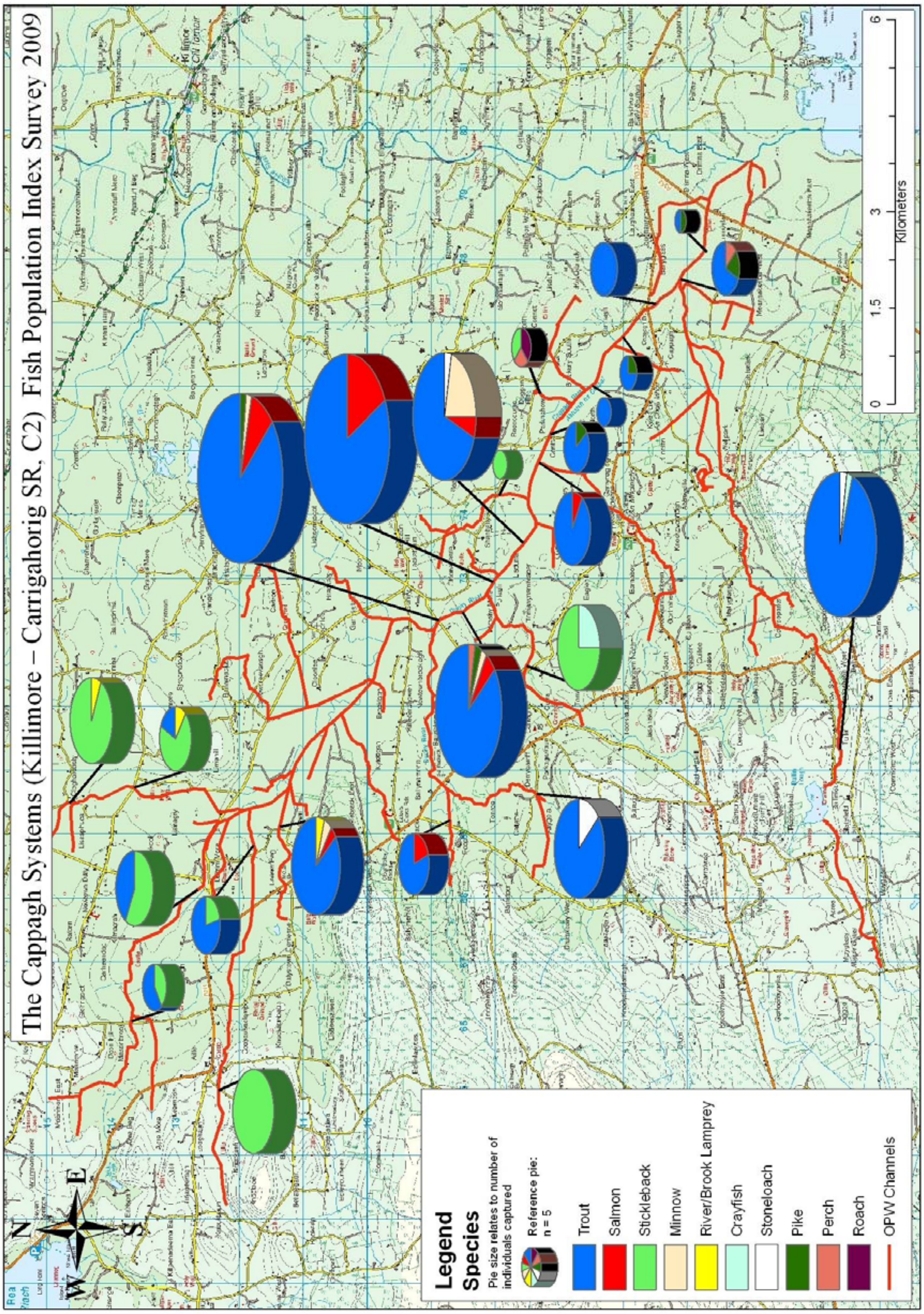
O'Grady, M.F. and King, J.J. (1992). Ecological changes over 30 years caused by drainage of a salmonid stream, the Bunree River. Irish Fisheries Investigation Series A, 34, 16pp.

O'Grady, M.F., King, J.J. and Curtin, J. (1991). The effectiveness of a physical instream works programme in enhancing salmonid stocks in a drained Irish lowland river. In: Mills, D. (ed.) Strategies for the rehabilitation of salmon rivers. Linnaean Society, London.

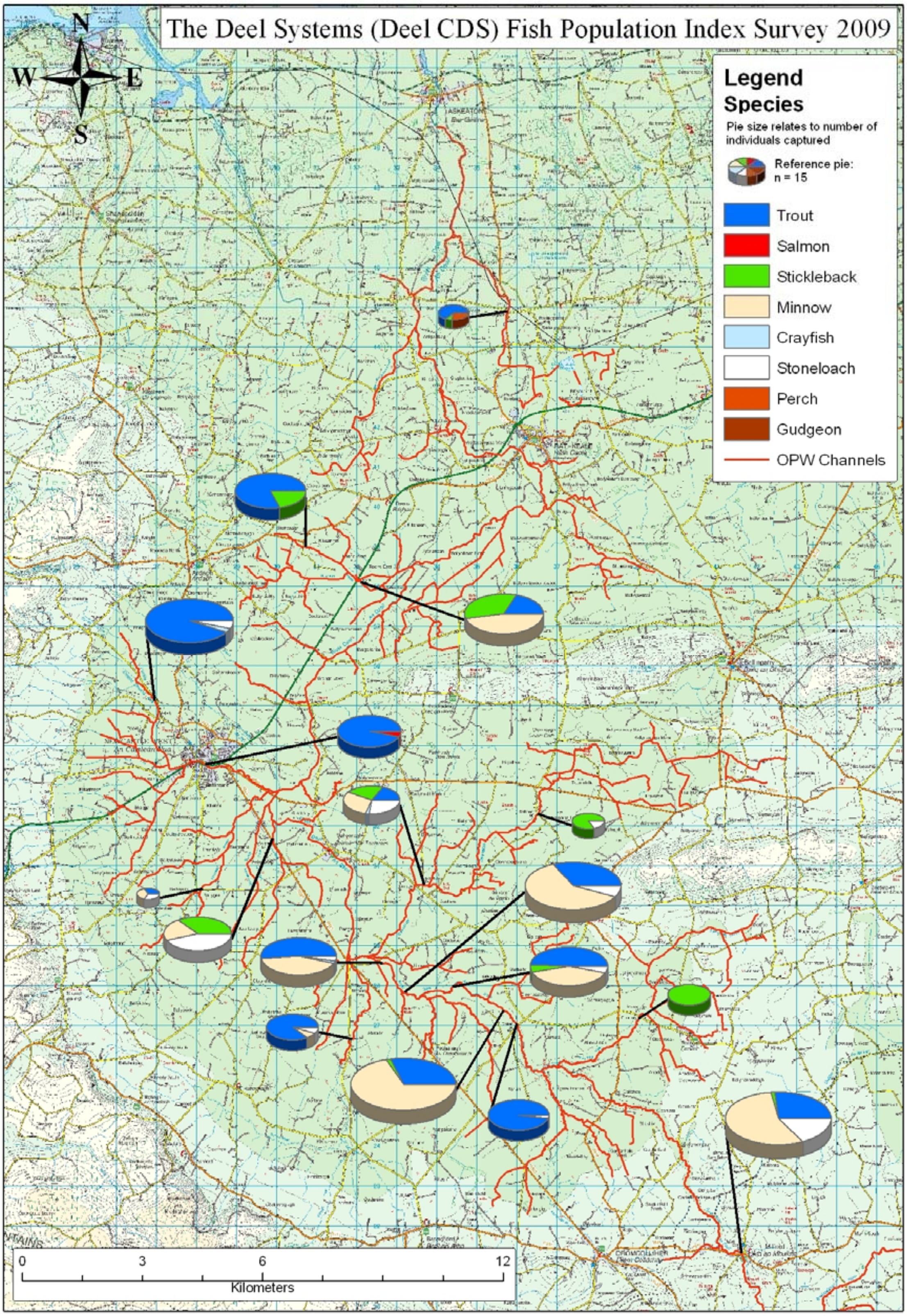
O'Grady, M.F. and O' Leary, C. (2007). Programmes of Measures and Standards – Freshwater Morphology. Irish Fisheries Recovery Dataset Provisions May 2007. Dublin, Ireland, Central Fisheries Board.

APPENDIX 2

Fish Population Index Data



Appendix 2a. FPI Survey Results: Percentage abundance of each species recorded, from the Cappagh R. System (Cappa – Kilcrow).



Appendix 2b. FPI Survey Results: Percentage abundance of each species recorded, from the R. Deel System, Deel CDS.