

Freshwater Pearl Mussel

Second Draft

Owenea Sub-Basin Management Plan



Photo courtesy of Evelyn Moorkens

Produced by NS 2, funded by DEHLG

March 2010

TABLE OF CONTENTS

	GLOSSARY AND ABBREVIATIONS.....	I
	GUIDE TO PLAN	V
1	INTRODUCTION TO THE FRESHWATER PEARL MUSSEL <i>MARGARITIFERA</i>	
	<i>MARGARITIFERA</i>	1
1.1	BACKGROUND	1
1.2	LIFE HISTORY.....	1
1.3	REASONS FOR THE DECLINE OF PEARL MUSSELS.....	3
	1.3.1 Ecological reasons for decline.....	3
	1.3.2 History of decline.....	6
1.4	WHAT IS A SUSTAINABLE POPULATION OF PEARL MUSSELS?	6
1.5	HABITAT ATTRIBUTES FOR SUSTAINABLE POPULATIONS OF PEARL MUSSELS.....	7
1.6	LEGISLATION PROTECTING PEARL MUSSELS.....	8
	1.6.1 Legal protection and red listing	8
	1.6.2 How legal protection can be implemented	9
2	STATUS OF THE FRESHWATER PEARL MUSSEL <i>MARGARITIFERA MARGARITIFERA</i>	
	IN IRELAND	11
2.1	IRELAND IN CONTEXT WITHIN THE EU	11
2.2	STATUS OF POPULATIONS IN THE REPUBLIC OF IRELAND.....	11
3	IDENTIFICATION OF KEY PRESSURES AFFECTING THE STATUS OF THE	
	FRESHWATER PEARL MUSSEL <i>MARGARITIFERA MARGARITIFERA</i> IN THE OWENEA	
	CATCHMENT.....	15
4	STATUS OF THE FRESHWATER PEARL MUSSEL AND MONITORING IN THE OWENEA	
	CATCHMENT.....	39
4.1	CURRENT STATUS OF THE FRESHWATER PEARL MUSSEL... ERROR! BOOKMARK NOT DEFINED.	
4.2	CURRENT WATER QUALITY IN THE OWENEA CATCHMENT	45
5	MONITORING	62
6.0	SUMMARY OF MEASURES	64
7.0	OWENEA SUMMARY ACTION PROGRAMME	95
8	REFERENCES & BIBLIOGRAPHY.....	101

GLOSSARY AND ABBREVIATIONS

AA:	Appropriate Assessment for Natura 2000 sites.
Acidification (artificial):	The rough canopies of mature evergreen forests are efficient scavengers of particulate and gaseous contaminants in polluted air. This results in a more acidic deposition under the forest canopies than in open land. Chemical processes at the roots of trees, evergreens in particular, further acidify the soil and soil water in forest catchments. When the forests are located on poorly buffered soils, these processes can lead to a significant acidification of the run-off water and consequent damage to associated streams and lakes.
ACP:	Agricultural Catchment Programme
Animal poaching:	Ground trampled or puddled by livestock resulting in exposed bare soil. Poaching can be widespread (i.e. whole field level) and/or localised in sensitive settings (e.g. along river banks, adjacent to feeding and drinking troughs and in water logged soils). Poaching represents a significant source of sediment loss to watercourses.
Animal trampling:	Direct damage to pearl mussels by livestock and/or machinery entering streams and rivers
Artificial water body:	A body of surface water created by human activity.
Biodiversity:	Word commonly used for biological diversity and defined as assemblage of living organisms from all habitats including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part.
CFB:	The Central Fisheries Board
Coastal waters:	That area of surface water on the landward side of a line, every point of which is at a distance of one nautical mile on the seaward side from the nearest point of the baseline from which the breadth of territorial waters is measured, extending where appropriate up to the outer limit of transitional waters.
DAFF:	Department of Agriculture, Fisheries and Food.
DCENR:	Department of Communications, Energy and Natural Resources.
DEHLG:	Department of Environment, Heritage and Local Government.
DETE:	Department of Enterprise, Trade and Employment.
Diffuse sources (of pollution):	Non-point sources primarily associated with run-off and other discharges related to different land uses such as agriculture and forestry, from septic tanks associated with rural dwellings and from the land spreading of industrial, municipal and agricultural wastes.
EC:	European Commission
Ecological status:	An expression of the structure and functioning of aquatic ecosystems associated with surface waters. Such waters are classified as being of good ecological status when they meet the requirements of the Water Framework Directive.
Ecology:	The study of the relationships among organisms and between those organisms and their non-living environment.
Ecosystem:	A community of interdependent organisms together with the environment they inhabit and with which they interact; community and

	environment being distinct from adjacent communities and environments
EPA:	Environmental Protection Agency.
EU:	European Union
Eutrophic:	Having high primary productivity, the result of high nutrient content.
Eutrophication:	The process of enrichment of water by nutrients (principally phosphorus and nitrogen). The nutrients accelerate plant growth, disturbing the balance of aquatic plants and animals and affecting water quality.
Good status:	A collective term used to refer to the status achieved by a surface water body when both its ecological status and its chemical status are at least good or, for groundwater, when both its quantitative status and chemical status are at least good.
Groundwater:	All water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil. This zone is commonly referred to as an aquifer, which is a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow a significant flow of groundwater or the abstraction of significant quantities of groundwater.
GSI:	Geological Survey of Ireland.
Heavily modified water body:	A water body that has been changed substantially in character as a result of physical alterations by human activity.
HSE:	Health Service Executive
Hydromorphology:	A study of the quantity and dynamics of water flow within a water body that has variations in its width, depth, structure and substrate of bed and riparian zone.
Inland surface waters:	All standing or flowing water on the surface of the land (such as reservoirs, lakes, rivers) on the landward side of the baseline from which the breadth of territorial waters is measured.
Invasive alien species:	Invasive alien species are non-native plants or animals that successfully establish themselves in aquatic and fringing habitats and damage natural flora and fauna.
Leachate:	The liquid containing dissolved and suspended contaminants that is formed as percolating water passes through potentially polluting materials. The term is generally associated with landfills.
Mitigation measures:	Measures to avoid, prevent, minimise, reduce or, as fully as possible, offset or compensate for any significant adverse effects on the environment, as a result of implementing a plan or programme.
NAP:	National Action Programme
NRFB:	Northern Regional Fisheries Board
NPWS:	National Parks and Wildlife Service.
On-site system:	Septic tank or other system for treating wastewater from unsewered properties.
Oligotrophic:	Water bodies that are poorly nourished or unproductive.
OPW:	The Office of Public Works

PRP		Pollution reduction programme
Programme of measures:	of	Those actions, defined in detail, which are required to achieve the environmental objectives of the Directive within a river basin district.
Protected area		Water protected by European legislation including drinking waters, shellfish waters, bathing waters, urban wastewater nutrient sensitive areas or sites designated as Special areas of Conservation or Special Protected Areas
Quantitative status:		An expression of the degree to which a body of groundwater is affected by direct and indirect abstractions. If this complies with Directive requirements the status is good.
River Basin District (RBD) & International River Basin District (IRBD):		Administrative area for coordinated water management, composed of multiple river basins (or catchments), with cross-border basins (i.e. those covering the territory of more than one Member State) assigned to an international RBD.
River basin:		The area of land from which all surface water run-off flows, through a sequence of streams, rivers and lakes into the sea at a single river mouth, estuary or delta.
SEA:		Strategic Environmental Assessment
Sedimentation:		The deposition by settling of a suspended material.
ShRFB:		Shannon Regional Fisheries Board
SNIFFER:		Scotland Northern Ireland Forum for Environmental Research.
Special Area of Conservation (SAC):	of	Site designated according to the Habitats Directive (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora).
Special Protection Area (SPA):		Area designated under the European Directive on the Conservation of Wild Birds.
SRFB:		Southern Regional Fisheries Board
Statutory Instrument (SI):		Any order, regulation, rule, scheme or bye-law made in exercise of a power conferred by statute.
Surface water:		Inland waters on the land surface (such as reservoirs, lakes, rivers, transitional waters, coastal waters) within a river basin.
SWAN:		Sustainable Water Network
SWRFB:		South Western Regional Fisheries Board
TCC:		Technical Conservation Committee
Transitional waters:		Bodies of surface water in the vicinity of river mouths which are partly saline in character as a result of their vicinity to coastal waters, but which are substantially influenced by freshwater flows.
Water body:		A coherent sub-unit in the river basin (district) to which the environmental objectives of the directive must apply. Hence, the main purpose of identifying “water bodies” is to enable the status to be accurately described and compared to environmental objectives
Water Framework Directive (WFD):		The Water Framework Directive is European legislation that promotes a new approach to water management through river basin planning. It covers inland surface waters, estuarine waters, coastal waters and groundwater.

WRFB: Western Regional Fisheries Board

WMU: Water Management Unit – geographical sub unit of a river basin district

GUIDE TO PLAN

This sub-basin management plan has been produced to act alongside the wider River Basin Management Plans (RBMPs) to provide a programme of measures required to improve the habitat of the freshwater pearl mussel so that it can attain favourable conservation status.

In Chapter 1, a background to the freshwater pearl mussel is described, its life history, ecology and conservation requirements outlined and the legal basis for the implementation of the sub-basin plans. The status of the species in Ireland is presented in Chapter 2.

The pressures identified within the Owenea Catchment are given in Chapter 3, and the status of the Owenea pearl mussel population, together with the monitoring carried out in the catchment is presented in Chapter 4. Chapter 5 summarises the monitoring requirements in fulfilment of the *Margaritifera* regulations 2009 on an ongoing basis.

Chapter 6 provides a list of measures following the format of the RBMPs. The measures listed in Tables 6.1 list measures to be taken across the wider RBD and detailed information in relation to these measures can be obtained from the RBMPs. A toolbox of pearl mussel additional measures have also been developed (Table 6.2) which can be applied throughout the catchment. Finally, the summary action programme lists the site and catchment specific measures that are prioritised for the Owenea catchment over the timescale of this plan.

Chapter 7 is a summary action programme, and is presented as a succinct list of pressures and measures to be undertaken in the Owenea Catchment. This summary can be used on its own to gain a quick understanding of the key pressures and measures in the catchment, but the reader should refer back to the relevant chapter in the plan for greater detail.

1 INTRODUCTION TO THE FRESHWATER PEARL MUSSEL *MARGARITIFERA MARGARITIFERA*

1.1 BACKGROUND

The freshwater pearl mussel is a bivalve, which is a type of mollusc or snail with a body that is almost completely enclosed between a pair of shells. For most of its life it is a filter feeder, and large quantities of water are pumped through the animal's siphons and food particles are trapped and passed to the mussel's mouth. The adult pearl mussel burrows to two-thirds of its shell depth, and is almost sessile in nature, often not moving for 100 years.

There are two types of pearl mussels in Ireland, one called *Margaritifera margaritifera* and the other is the very rare *Margaritifera durrovensis*, which is only known from the Nore Catchment.

The pearl mussel *Margaritifera margaritifera* has attracted a lot of interest in recent years due to its interesting ecology, life cycle, ability to produce pearls and, most importantly, its decline which has left the species in danger of extinction.

As their name suggests, *Margaritifera* has the ability to occasionally produce pearls. However, there is currently no sustainable way to extract pearls (Moorkens 2004), and thus pearl fishing is illegal. This was not always the case, when pearl mussel populations were very abundant the pearl fishery was highly prized, and has been cited as the underlying reason for the invasion of Britain by the Romans (Johnston, 1850). When adult numbers were very high in certain rivers, pearls were an important cultural aspect of the river (Lucey 2005).

Populations of *Margaritifera margaritifera* are known from North America, northern, western and central Europe and Russia. The species is in very serious decline throughout its range and is listed in the IUCN red data book as endangered worldwide (Baillie & Groombridge 1996).

1.2 LIFE HISTORY

Pearl mussel ecology is complicated as individuals can grow to very large sizes for invertebrates (up to 145mm), building up thick calcareous shells, in most cases in rivers that have soft water with low levels of calcium. Their shell building is consequently very slow, and individuals live to over a hundred years of age (Comfort 1957).

Pearl mussels have separate male and female animals (Figure 1.1), which is unusual for molluscs, although there is no external difference between them. Reproduction occurs when sperm are released into the open water via the male's exhalant siphon, and are carried to the eggs via the female inhalant siphon (Figure 1.2) and fertilisation occurs in the brood chambers (Smith 1979; E. Ross 1988). These develop into the larval stage, called glochidia, which are temporarily brooded in the female gills from June each year, and are then released into the open water in high numbers in an event lasting one to two days between July and September, probably dictated by temperature in the river during development (Young & Williams 1984a; Bauer 1987, H. Ross 1992; Ziuganov *et al.* 1994; Moorkens 1996; Hastie & Young 2003). The numbers of glochidia being released have been found to vary between one individual and 28 million per individual female (Bauer, 1987; Young & Williams, 1984a; E. Ross, 1988).

A small percentage of the glochidia released to the river will be inhaled by passing salmonid fish (Bauer & Vogel, 1987), which act as the pearl mussels' temporary hosts. In a laboratory study, Young & Williams (1984b) found glochidia to be no longer viable after 24 hours. The same authors calculated that failure to find a host within 24 hours occurred 99.9996% of the time in the wild (Young & Williams, 1984a).

Glochidia are simple organisms with little more than a pair of shells, an adductor muscle to snap them shut, and a layer of cells which can absorb and digest nutrients (Ziuganov *et al.*, 1994). The valves close on a filament of the salmonid gills, and nourishment is taken from this fish host until the glochidia are large and mature enough to exist independently (Nezlin *et al.* 1994; Ziuganov *et al.* 1994). During this time they increase to about six times their original length. In a field study, Young & Williams

(1984a) found a 95% loss of glochidia while attached to fish. A laboratory study showed losses of 88 to 95% (Young & Williams, 1984b).

Those glochidia that survive on the fish develop into young mussels. They fall off in early summer (normally June) and bury into gravel, remaining buried for about five years, until large enough to withstand the flow of open water, moving stone, and perhaps trout predation (Cranbrook 1976; Wells *et al.* 1983; Moorkens 1996). Young & Williams (1984a) estimated from field studies that only about 5% of young mussels falling off fish survive to reach three to six years of age in rivers capable of supporting recruitment.

The retention of a glochidial stage is unusual for a creature living in fast flowing water. Most freshwater molluscs have developed means of depositing eggs safely in gelatinous masses or attached to aquatic vegetation, but pearl mussels release free glochidia downstream, and rely on the salmonid host to keep the glochidia from flowing to the sea. In addition, the host attachment stage may act as a mechanism for dispersal of populations to new rivers, or upstream within a river (Purser 1988; Oliver *et al.* 1993).

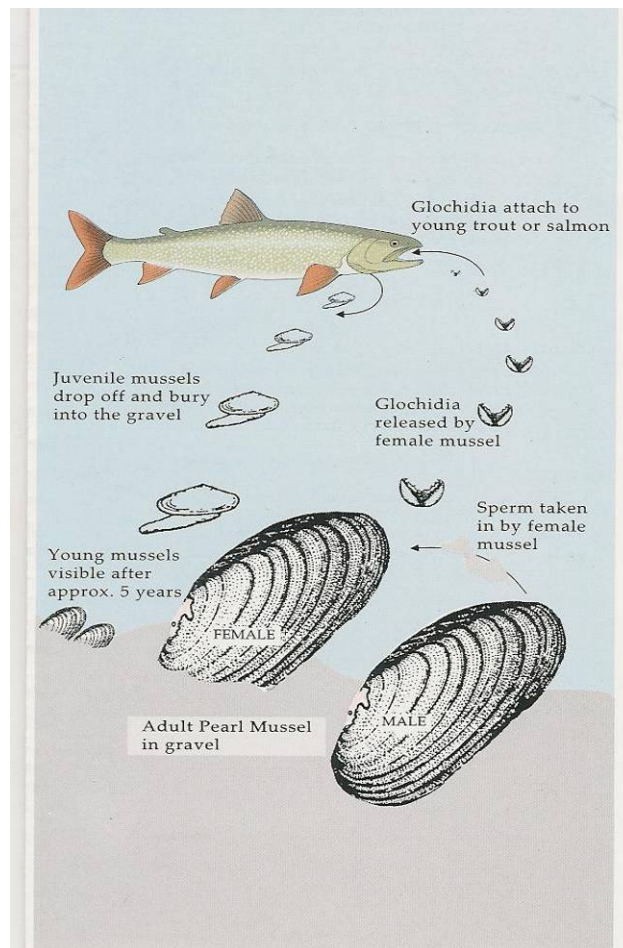


Figure 1.1: Life cycle of *Margaritifera* (from Moorkens, 1996)

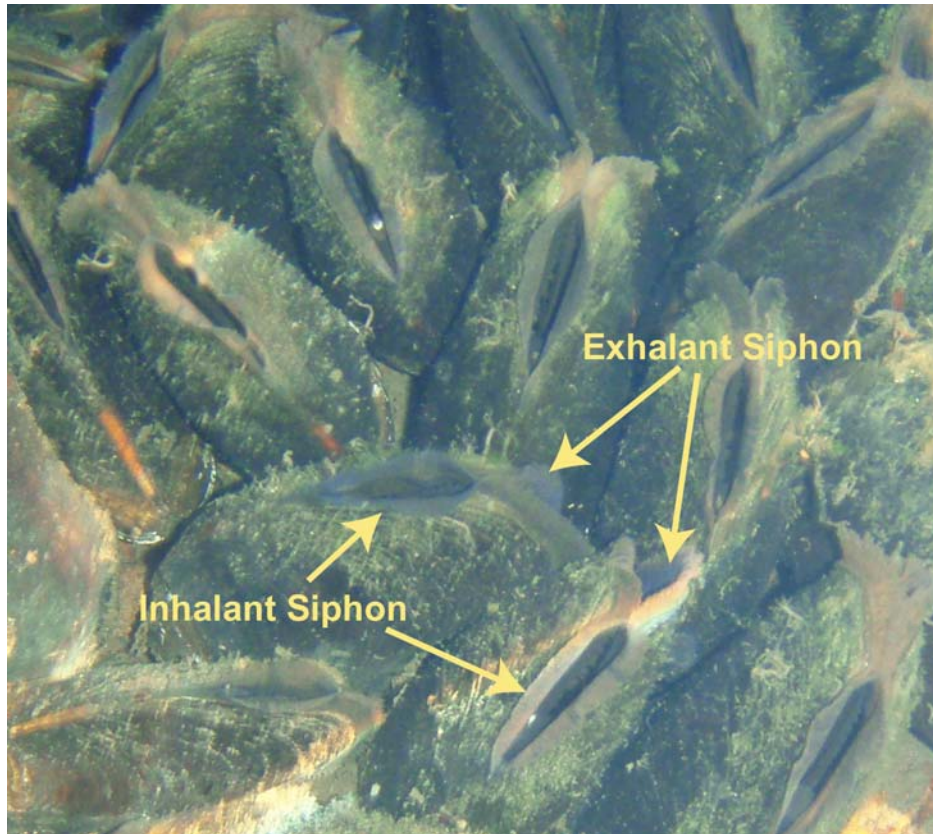


Figure 1.2: *Margaritifera* showing inhalant and exhalant siphons (Photo: Pete McCullough)

Fish hosts vary throughout the range of pearl mussels. In Europe, *M. margaritifera* has been shown to use native brown trout *S. trutta* L. and Atlantic salmon *Salmo salar* (Young & Williams, 1984a; Moorkens, 1996, 1999). Ziuganov & Nezlin (1988) have proposed that the relationship of pearl mussels and salmon is symbiotic. The fish provides the essential step in the mussels' life cycle, and mussels improve water quality by filtering water. Each mussel can filter up to 50 litres of water per day (Ziuganov & Nezlin 1988). In the Varzuga River in Russia, Ziuganov & Nezlin (1988) estimated that mussels filter 90% volume of the river in low water years.

Juvenile mussels spend their first five to ten years buried within the river bed substrate. Pearl mussels mature between seven and 15 years of age (Meyers & Milleman 1977; Smith 1978; Young & Williams 1984a), and can have a prolonged fertile period lasting into old age (Bauer 1987). Further details of the life cycle can be found in Moorkens (1999).

1.3 REASONS FOR THE DECLINE OF PEARL MUSSELS

1.3.1 Ecological reasons for decline

Some pearl mussel populations may have survived in parts of Ireland during glacial periods, but most probably established in Irish rivers shortly after the ice retreated. Large populations established where rivers were very clean and these are likely to have thrived for thousands of years. Early records of this species referred to very abundant populations, and it is only in the last 50 years that a major decline has been documented. It has been estimated that there was a decline of more than 90% in European populations during the 20th century (Bauer 1988), and the situation for the mussel continues to deteriorate (Araujo & Ramos, 2001).

The pearl mussel requires very high quality rivers with clean river beds and waters with very low levels of nutrients. In general, rivers and river bed habitat needs to be at "reference" level, i.e. near natural

conditions are required. Where river water quality has been depressed by inputs such as phosphates and nitrates, elevated BOD, or dangerous substances, such as metals or insecticides (particularly sheep dip), mussel numbers can rapidly decline.

The decline of pearl mussel populations in Ireland has mostly occurred from the continuous failure to produce new generations of mussels because of the loss of clean gravel beds, which have become infiltrated by fine sediment and/or over-grown by algae or macrophytes.

1.3.1.1 Decline in pearl mussel populations as a result of siltation and/or nutrient enrichment of juvenile habitat

Of particular importance in the decline of the pearl mussel has been the increase in sediment movement through rivers and its settlement onto the river bed. When this happens, formerly clean gravels become clogged with fine sediment. This prevents oxygen movement into the waters in the river bed (interstitial) that feed the juvenile mussels, and they quickly die. Each time siltation of gravels occurs, all juvenile mussels below five years of age are killed, and in rivers with chronic siltation problems, juvenile recruitment is rare and unsustainable. In these populations, lots of adult mussels may still be present, however when the older mussels die off they will not be replaced by a younger generation. If the habitat of the river bed is not restored, these populations will inevitably go extinct. The status of these populations is known as “functionally extinct”. The decline in interstitial water quality in silted gravels has been detailed by Buddensiek (1989) and by Buddensiek *et al.* (1993). Fine sediments in gravels were shown to increase mortality in juvenile mussels to 100% (Buddensiek, 2001). Fine sediment, once introduced to a pearl mussel river, can continue to cause very serious effects on a long term basis (Ellis 1936, Marking & Bills 1979, Naden *et al.* 2003, Araujo & Ramos 2001, Killeen *et al.* 1998).

As with siltation, nutrient enrichment can have serious and ongoing impacts on juvenile mussels. Increased inputs of dissolved nutrients to pearl mussel rivers tend to lead to filamentous algal growth, unless combined with siltation, where macrophyte growth can dominate. Macrophytes smother the juvenile habitat even further, and trap more sediment, exacerbating the problem in the long term. Filamentous algae can lead to the death of juvenile mussels, through blocking oxygen exchange with the sediment.

1.3.1.2 Adult pearl mussel deaths as a result of siltation and/or nutrient enrichment

Direct ingestion of silt by adult mussels can lead to rapid death. Turbidity, particularly from fine peat entering the water, causes adult mussels to clam up (they close their shells tightly and do not filter water through their siphons), a response that provides a protection against ingesting damaging fine particles. If the river water remains strongly turbid for a number of days, mussels can die from oxygen starvation, either from remaining clammed, or from ingesting contaminated water while stressed. During a time of year when water temperatures are high, oxygen depletion in the body occurs more rapidly, and mussels die more quickly. The evolutionarily primitive pearl mussel gills and the annual brooding of young in all four of the gills demand a continuous, high supply of oxygen. Even if the adult mussels survive an initial silt episode, food/oxygen deprivation from clamming will have caused them to become stressed, from which they will take a long time to recover. If during that recovery period, there are further incidents of mobilisation of silt, then the stressed mussels will be more susceptible to death than mussels in a cold river in unstressed conditions. Thus, they may continue to die over a period of several months. Higher temperatures throughout the summer further exacerbate this problem.

Silt also causes river changes, which in turn change the dynamics of the river into the future (Curran & Wilcock 2005, Colosimo & Wilcock 2005, Dietrich *et al.* 1989). Increases in fine material in the bed and suspended in the water column, and consequent changes in channel form, may affect mussels in many ways and at various stages in their life cycle. The fine sediment subsequently provides a medium for macrophyte growth, which makes the river bed habitat unsuitable for pearl mussels. One of the most essential requirements for pearl mussel conservation is the removal of the risk of any sediment reaching the river, as any one single incident has such long term ramifications.

Silt infiltration of river bed gravels can also have a negative effect on the essential species of fish that host the mussel glochidial stage (Levasseur *et al.* 2006).

Nutrient enrichment can also have serious and ongoing impacts on adult mussels. Filamentous algae can cause adults to become stressed, as a result of night time drops in oxygen. Even if filamentous algae are destroyed in a flood, adult mussels may not make a full recovery before the algae re-grow. Adult mussels may eventually die as a result of oxygen/food deprivation.

1.3.1.3 Declines in pearl mussel populations as a result of acidification

Acidification has been well documented as a threat to salmonid populations both internationally (e.g. Maitland *et al.* 1987, Henrikson *et al.* 1995, Lacroix, 1989) and in Ireland (Bowman & Bracken 1993, Allott *et al.* 1990, Kelly Quinn *et al.* 1997). Acidification has also been noted as a direct threat to pearl mussel from the first international IUCN red data book for invertebrates (Wells *et al.* 1983). Work carried out in Scandinavia has provided evidence for pearl mussel decline from acidification (Okland & Okland 1986, Eriksson *et al.* 1981, 1982, 1983; Henriksen *et al.* 1995, Raddum & Fjellheim 2004). A lowering of pH directly influences pearl mussels through a gradual destruction of their calcareous shell, and also their genital organs (causing infertility), and through problems with regulation of acid-base mantle fluid homeostasis (Vinogradov *et al.* 1987).

1.3.1.4 Declines in pearl mussel populations as a result of toxic pollution

Liming of land has a negative effect on pearl mussel populations, through direct toxic effects, and through increased growth rates leading to shortened life expectancy and, thus, loss of reproductive years (Bauer *et al.* 1991, Skinner *et al.* 2003). In some countries, however, acidification problems are so severe that liming is considered to have a more positive than negative effect (Henrikson *et al.* 1995). Water chemistry data from declining Irish pearl mussel rivers indicate high peaks of calcium and conductivity levels that are likely to have been caused by liming.

Other toxic products have resulted in deaths of pearl mussels. In one extreme case, a pearl mussel population became extinct as a result of toxic pollution. Pesticides such as sheep dip products are probably the most severe, but evidence from American surveys of glochidial stages of unionid mussels have demonstrated lethal effects from very low doses and environmentally relevant concentrations of chlorpyrifos and permethrin, the fungicides chlorothalonil, pyraclostrobin and propiconazole, and glyphosate. (Bringolf *et al.*, 2007a, b, c). Of particular concern are the severe deleterious effects of the latter substances in combination with surfactant blends, such as in commercial products like Monsanto Roundup. The end product including the surfactants can result in a much more toxic product than that of the individual ingredients

The Republic of Ireland is estimated to hold 46% of all the pearl mussels in the European Union, but only one of its populations is in favourable condition, none of the rest have sustainable juvenile recruitment. Recovery of a mussel population from unfavourable to favourable condition becomes more difficult when adult numbers are reduced, as the life history of the mussel relies on very large numbers of glochidia in the cleanest of waters to result in adequate juvenile survival. Thus, early detection of river management problems and fast remedial action is very important.

1.3.1.5 Issues that are unlikely to contribute to declines in pearl mussel populations

The essential interaction with salmonid fish hosts led to investigations into whether reductions in fish numbers contribute to pearl mussel decline (Geist *et al.* 2006). The research concluded declines in fish were not a contributory factor and that functional pearl mussel populations, i.e. those with high numbers of juveniles, had significantly lower densities and biomass of host fish than nonfunctional streams. Higher densities of host fish coincided with eutrophication, poor substratum quality and lack of pearl mussel recruitment.

Various studies have also investigated whether disease or parasite infestation may have contributed to the mussel's decline; these were reviewed with other factors affecting mortality by Bauer (2000). The conclusion drawn was that disease and parasite infection is a very rare occurrence in freshwater mussels, and an insignificant cause of mortality.

While climate change is noted as a possible future threat to the pearl mussel (Hastie *et al.*, 2003), due to the potential increase of flood events, there is no evidence that it has contributed to the local or worldwide decline of the species. In predictive modelling, the freshwater pearl mussel is expected to show neither gains nor losses of potentially suitable climate space and to occur almost all over Britain and Ireland into the next 80 years (Berry *et al.*, 2007).

1.3.2 History of decline

The pearl mussel was historically widespread in Ireland. There appear to have been three periods over the last 150 years during which the mussel has faced very serious problems:

The first was after the Drainage (Ireland) Act of 1842, when many river catchments were modified and the land adjacent the rivers changed radically. Ongoing drainage schemes began the deterioration of many of the lowland rivers that are now some of the centres of our most intensive agriculture. Following this land intensification, approximately about 130 rivers retained mussels.

The second period of decline coincided with Ireland's entry into the EEC in 1973, and was associated with intensification of agricultural practices, and a marked increase in phosphorus and nitrogen loading to river catchments. Increases in sheep numbers following the introduction of EU headage payments resulted in overgrazing of hillsides above pearl mussel rivers, leading to loss of soil into the rivers below. The number of cattle drinking directly from pearl mussel rivers increased, causing trampling of the river bed and fouling of the water, water and erosion of the river bank around entry areas. When EU-led intensification began, the campaign to plant state forestry was well underway, with peat and peaty soils targeted for planting and phosphorus, crucially, being used during establishment, and often at intervals along the route to tree maturity and cropping. Industrial drainage and exploitation of peat has also intensified over the last 40 years. Clearing, draining and/or ploughing land for agriculture, peat exploitation and forestry activities releases silt, as the soil or peat washes into the river, and this is joined by silt caused by the decay of the filamentous algae that grows when nitrogen and phosphorus levels rise. The majority of Ireland's pearl mussel rivers last bred successfully in the 1970s. Some of these still retain a small population of adult mussels, but they typically range in age from 60 to over 100 years old, although some individuals as young as 30 are sometimes found.

We have entered the third phase of pearl mussel population decline. A number of factors are combining to provide a very serious threat to the remaining breeding populations. Three are of particular concern. Firstly, agricultural land that was not intensively managed historically has been repeatedly fertilised and is becoming saturated with phosphorus. Secondly, forestry units are now reaching maturity and, particularly in upland peat areas, have the potential on felling to release large quantities of phosphate into these rivers. Thirdly, the recent intensification of development, with associated land clearance, pressure on sewerage schemes and inappropriate locating of on-site systems for once-off housing near the rivers, is adding to the nutrient and sediment load. The third phase of damage to the pearl mussel habitat in these rivers has manifested itself since the Habitats Directive came into force and serious declines have occurred in some rivers following their designation as SACs, although some of the causes of the decline were in place before their designation.

The pearl mussel rivers in Ireland that are known to have recruited young recently are generally in remote areas, with short rivers and small catchments that have not historically been subject to intensive fertiliser inputs. They are typically areas of low human population density, with few urban areas, any habitation being located low down in the catchments. They are mainly below lakes, which provide an even, buffered source of water through the river. Many of the SAC rivers for *Margaritifera margaritifera* fall into this category.

1.4 WHAT IS A SUSTAINABLE POPULATION OF PEARL MUSSELS?

The target for a sustainable population is one that it is where reproduction and survival of sufficient numbers of young mussels to adulthood to sustain the population at current levels or previous levels (if known). Table 1.1 shows the mussel demographic criteria for the assessment of the conservation

status of pearl mussel populations, as set out in the draft European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009.

Table 1.1 The targets for sustainable *Margaritifera margaritifera* population structure.

Criterion	Target to pass	Notes
Numbers of live adults	No recent decline	Based on comparative results from the most recent surveys
Numbers of dead shells	<1% of population and scattered distribution	1% considered to be indicative of natural losses.
Mussels shell length $\leq 65\text{mm}$	At least 20% of population $\leq 65\text{mm}$ in length	Field survey of 0.5 X 0.5 m quadrats must be carried out in suitable habitat areas for juveniles
Mussels shell length $\leq 30\text{mm}$	At least 5% of population $\leq 30\text{mm}$ in length	Field survey of 0.5 X 0.5m quadrats must be carried out in suitable habitat areas for juveniles

1.5 HABITAT ATTRIBUTES FOR SUSTAINABLE POPULATIONS OF PEARL MUSSELS

The habitat of *Margaritifera margaritifera* in Ireland is restricted to near natural, clean flowing waters, often downstream of ultra-oligotrophic lakes. A small number of records are from the lakes themselves.

The pearl mussel requires stable cobble and gravel substrate with very little fine material below pea-sized gravel. Adult mussels are two-thirds buried and juveniles up to five to ten years old are totally buried within the substrate. The lack of fine material in the river bed allows for free water exchange between the open river and the water within the substrate. The free exchange of water means that oxygen levels within the substrate do not fall below those of the open water. This is essential for juvenile recruitment, as this species requires continuous high oxygen levels.

The clean substrate must be free of inorganic silt, organic peat, and detritus, as these can all block oxygen exchange. Organic particles within the substrate can exacerbate the problem by consuming oxygen during the process of decomposition. The habitat must be free of filamentous algal growth and rooted macrophyte growth. Both block the free exchange of water between the river and the substrate and may also cause night time drops in oxygen at the water-sediment interface.

The open water must be of high quality with very low nutrient concentrations, in order to limit algal and macrophyte growth. Nutrient levels must be close to the reference levels for the river they inhabit. Phosphorus must never reach values that could allow for sustained, excessive filamentous algal growth.

The presence of sufficient salmonid fish to carry the larval glochidial stage of the pearl mussel life cycle is essential.

The conservation targets for sustainable mussel populations include maintenance of free water exchange between the river and the substrate and minimal coverage by algae and weed. The particular emphasis is on maintenance of recruitment i.e. the river bed structure required to breed the next generation.

Table 1.2 shows the sustainable pearl mussel habitat attributes, with ecological quality objectives for pearl mussel sites as set out in the draft European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009.

The targets set out in these Regulations are interim targets that may be revised in line with the results of the monitoring programmes. These targets may be too stringent or not stringent enough – and will be reviewed following analysis of pearl mussel recruitment data with data for nearby diatoms, macroinvertebrates and other monitored elements.

Table 1.2 Ecological Quality Objectives for Freshwater Pearl Mussel Sites

Element	Objective	Notes
Macroinvertebrates	EQR ≥ 0.90	High status
Filamentous algae (Macroalgae)	Trace or Present (<5%)	Any filamentous algae should be wispy and ephemeral and never form mats
Phytobenthos (Microalgae)	EQR ≥ 0.93	High status
Macrophytes - rooted higher plants	Trace or Present (<5%)	Rooted macrophytes should be absent or rare within the mussel habitat.
Siltation	No artificially elevated levels of siltation	No plumes of silt when substratum is disturbed

1.6 LEGISLATION PROTECTING PEARL MUSSELS

1.6.1 Legal protection and red listing

The pearl mussel *Margaritifera margaritifera* (L., 1758) is protected under several tiers of national and international legislation:

- The Wildlife Act, 1976 and Wildlife (Amendment) Act, 2000 (The pearl mussel was given protected faunal species status under The [Wildlife Act, 1976](#) (Protection of Wild Animals) Regulations, 1990, S.I. No. 112, 1990)
- The Habitats Directive (Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora) as transposed by the European Communities (Natural Habitats) Regulations, S.I. 94/1997, as amended by S.I. 233/1998 and S.I. 378/2005. The pearl mussel is listed on Annex II and Annex V to the Directive,
- Bern Convention Appendix 3

The freshwater pearl mussel *Margaritifera margaritifera* (L., 1758) is also on the following red data lists:

- IUCN Red Data List as Endangered (IUCN, 1996)
- Red Data (Ireland) as Critically Endangered (Moorkens, 2006; Byrne *et al.*, 2009)

The Republic of Ireland currently has stretches of 19 SACs designated for the pearl mussel covering 27 sub-basins. 26 of these sub-basins hold *Margaritifera margaritifera* and one, the River Nore, contains *M. durrovensis*.

Article 1 of the Habitats Directive states:

For the purpose of this Directive:

(a) *conservation means a series of measures required to maintain or restore the natural habitats and the populations of species of wild fauna and flora at a favourable status as defined in (e) and (i);*

(i) *conservation status of a species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within the territory referred to in Article 2;*

The conservation status will be taken as "favourable" when:

- population dynamics data on the species concerned indicate that it is maintaining itself on a long-term basis as a viable component of its natural habitats, and*
- the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and*
- there is, and will probably continue to be, a sufficiently large habitat to maintain its populations on a long-term basis;*

Article 6.1 of the Habitats Directive states:

For special areas of conservation, Member States shall establish the necessary conservation measures involving, if need be, appropriate management plans specifically designed for the sites or integrated into other development plans, and appropriate statutory, administrative or contractual measures which correspond to the ecological requirements of the natural habitat types in Annex I and the species in Annex II present on the sites.

Article 6.2 of the Habitats Directive states:

Member States shall take appropriate steps to avoid, in the special areas of conservation, the deterioration of natural habitats and the habitats of species as well as disturbance of the species for which the areas have been designated, in so far as such disturbance could be significant in relation to the objectives of this Directive.

1.6.2 How legal protection can be implemented

Under Article 6 of the Habitats Directive as mentioned above Member States must show the steps taken to achieve the Directives objectives as well as avoiding deterioration in those natural habitats and habitats of species. To achieve these requirements, in Ireland the European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 (S.I. No. 296) have been established and require:

- a) Specific objectives and targets, in accordance with Regulation 2 and the Fourth Schedule, and deadlines for their achievement;
- b) The investigation of sources of pressures leading to the unfavourable conservation status of the pearl mussel;
- c) The establishment of a programme, including a timeframe, for the reduction of pressures giving rise to unfavourable conservation status. The programme shall include pressure reduction targets and deadlines, either in relation to individual pollutants or to particular sectors or activities or both, to be implemented within the sub-basin, or parts of the sub-basin as appropriate;
- d) A detailed programme of monitoring to be implemented within the sub-basin, or parts of the sub-basin as appropriate, in order to evaluate the effectiveness of measures and progress made towards restoring favourable conservation status.

In addition to this, the Water Framework Directive (WFD) requires that a programme of measures (POMs) is established in order to achieve its environmental objectives. The EU WFD (2000/60/EC), which came into force on 22 December 2000, is the most important piece of European water legislation. It aims to promote common approaches, standards and measures for water management on a systematic and comparable basis throughout the European Union. It establishes a new,

integrated approach to the protection, improvement and sustainable use of Europe's rivers, lakes, transitional waters (estuaries), coastal waters and groundwaters.

The WFD POMs include "basic measures" which include those measures required to implement Community legislation for the protection of water including measures specified under 11 named Directives, one of which is the Habitats Directive. The programme of measures will be established by the 22 of March 2010 and must be made operational by 22 December 2012 at the latest.

Consequently, the sub-basin plans and environmental objectives established for those pearl mussel populations designated under the Habitats Directive are also afforded protection under the Water Framework Directive's river basin programme of measures. They form part of the basic measures and the objectives for these protected areas must be achieved.

2 STATUS OF THE FRESHWATER PEARL MUSSEL *MARGARITIFERA MARGARITIFERA* IN IRELAND

2.1 IRELAND IN CONTEXT WITHIN THE EU

In the EU, most countries' pearl mussel populations are considered to be completely extinct (e.g. Poland), almost extinct (e.g. DenmarkLuxembourg) or have small senescent populations which, in the absence of major river habitat recovery, will become extinct by the end of the lives of the current generation (e.g. Austria, Latvia, Luxembourg, Belgium) (Araujo & Ramos, 2001; Geist, 2005). A few countries have populations with some juvenile recruitment (Scotland, Finland, Sweden), but recruitment in most cases is found to be inadequate to replace existing adults. The 2007 Habitats Directive Article 17 reports classified the pearl mussel as in unfavourable-bad conservation status in all EU regions (<http://biodiversity.eionet.europa.eu/article17/>).

2.2 STATUS OF POPULATIONS IN THE REPUBLIC OF IRELAND

Pearl mussels are widespread in Ireland, particularly in the South West, West and North West of the country. Populations range from very small relict examples with a few remaining elderly mussels that have not successfully recruited for 50 years, to some of the largest populations of pearl mussels in the world. There are 96 populations of pearl mussels in the Republic of Ireland, some of which include two or more rivers in close enough proximity to make them one single population (Moorkens *et al.* 2007). A total of 27 populations have been designated within 19 SAC areas for *Margaritifera margaritifera* (Figure 2.1, Table 2.1).

Only one of the 96 populations in the country is considered to be in favourable conservation status, as in the other populations reproduction and juvenile survival is not matching adult mortality rates and numbers are declining annually.

Many of the non-designated rivers contain very small populations of 5,000 or less, and although some of these are still internationally important compared with the remaining populations of other countries, the most important Irish populations, and the ones of most international concern are those with populations between 500,000 and 3,000,000. These are populations within catchments that were near pristine up until very recent times, but have declined within the lifetime of their designation as SACs, although much of the decline may have been the result of activities occurring before designation.

Recent declines have been due to a number of issues, which have combined to lower the quality of the river water and river bed habitat. The purpose of this sub-basin management plan is to address the catchment-wide issues that are contributing to this decline and to develop a strategy for implementing measures that will bring the catchment and thus the population back to favourable condition.

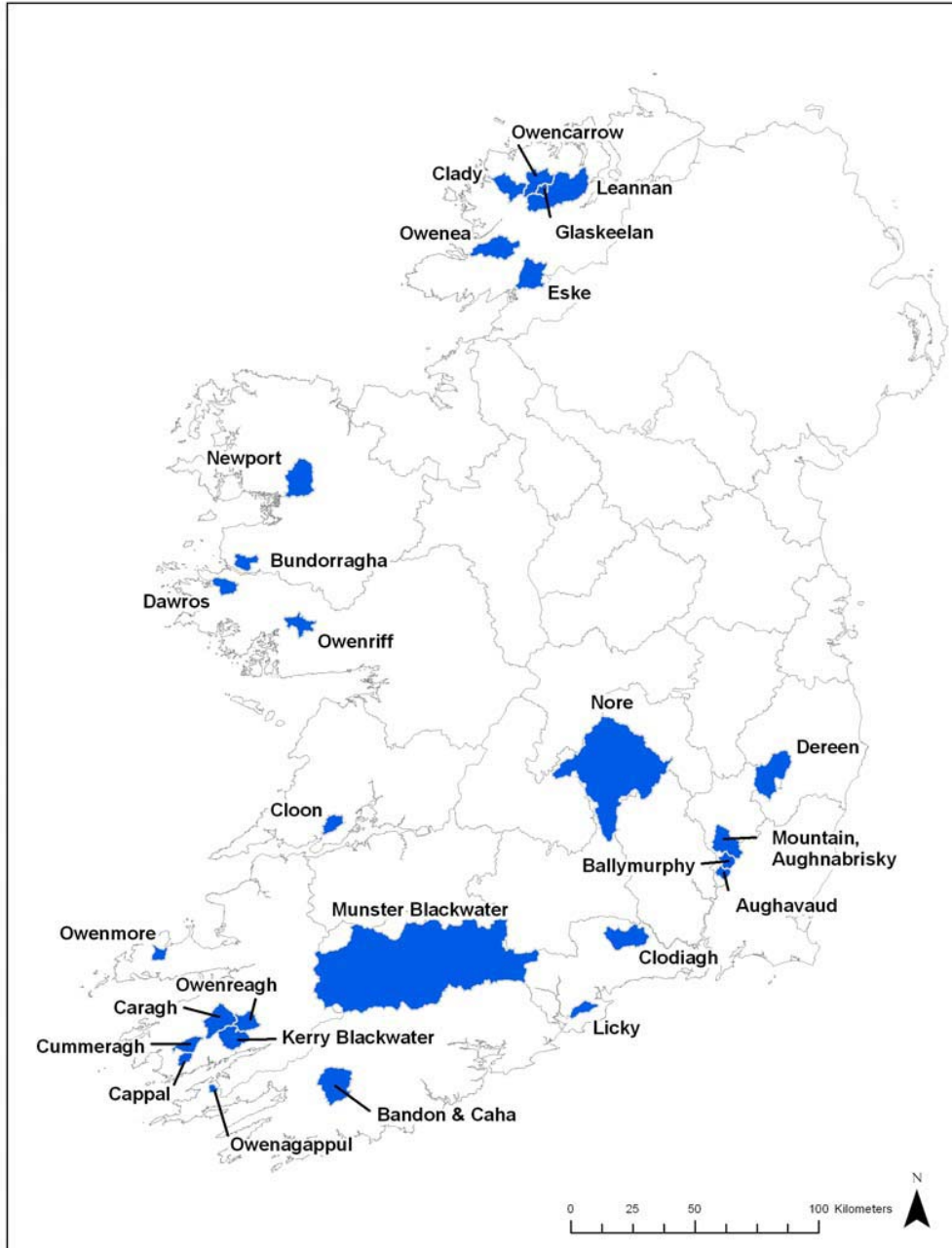


Figure 2.1 Map of the catchments of the specified pearl mussel populations.

Table 2.1 List of the 27 sub-basin catchments designated as SACs for freshwater pearl mussel populations.

	Freshwater pearl mussel population¹	SAC Site Code	SAC Site Name	Rivers and lakes containing <i>Margaritifera</i> (list not exhaustive)	Associated RBD
1	Bandon	002171	Bandon River cSAC	Bandon & Caha	South Western RBD
2	Aughavaud (Barrow)	002162	River Barrow and River Nore cSAC	Aughavaud	South Eastern RBD
3	Ballymurphy (Barrow)	002162	River Barrow and River Nore cSAC	Ballymurphy	South Eastern RBD
4	Mountain (Barrow)	002162	River Barrow and River Nore cSAC	Mountain, Aughnabriskey	South Eastern RBD
5	Bundorragha	001932	Mweelrea/ Shreefry/ Erriff Complex cSAC	Bundorragha	Western RBD
6	Caragh	000365	Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment cSAC	Caragh, Owenroe, Meelagh, Caraghbeg, Glashawee, Lough Beg Stream, Lough Acoose, Cloon Lough	South Western RBD
7	Clady	000140	Fawnboy Bog/ Lough Nacung cSAC	Clady	North Western IRBD
8	Owenriff (Corrib)	000297	Lough Corrib cSAC	Owenriff, Glengawbeg	Western RBD
9	Currane	000365	Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment cSAC	Capall, Cumberagh	South Western RBD
10	Dawros	002031	The Twelve Bens/ Garraun Complex cSAC	Dawros	Western RBD
11	Eske	000163	Lough Eske and Ardnamona Wood cSAC	Eske	North Western IRBD
12	Kerry Blackwater	002173 & 000365	Blackwater River (Kerry) cSAC & Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment cSAC	Blackwater, Kealduff, Derreendarragh	South Western RBD
13	Gearhameen (Laune)	000365	Killarney National Park, Macgillycuddy's Reeks and Caragh River Catchment cSAC	Gearhameen Owenreagh &	South Western RBD
14	Gliskeelan (Leannan)	002047	Cloghernagore Bog and Glenveagh National Park cSAC	Gliskeelan	North Western IRBD
15	Leannan	002176	Leannan River cSAC	Leannan	North Western IRBD

¹ Population named after river of highest stream-order that contains mussels

	Freshwater pearl mussel population¹	SAC Site Code	SAC Site Name	Rivers and lakes containing <i>Margaritifera</i> (list not exhaustive)	Associated RBD
16	Allow (Munster Blackwater)	002170	Blackwater River (Cork/Waterford) cSAC	Allow	South Western IRBD
17	Licky	002170	Blackwater River (Cork/Waterford) cSAC	Licky	South Western RBD
18	Munster Blackwater	002170	Blackwater River (Cork/Waterford) cSAC	Munster Blackwater (main channel)	South Western RBD
19	Newport	002144	Newport River cSAC	Newport	Western RBD
20	Nore	002162	River Barrow and River Nore cSAC	Nore	South Eastern RBD
21	Owencarrow	002047	Cloghernagore Bog and Glenveagh National Park cSAC	Owencarrow	North Western IRBD
22	Owenea	000197	West of Ardara/Maas Road cSAC	Owenea	North Western IRBD
23	Owenmore	000375	Mount Brandon cSAC	Owenmore	South Western RBD
24	Owagappul	001879	Glanmore Bog cSAC	Owagappul & Barrees	South Western RBD
25	Cloon (Shannon Estuary)	002165	Lower River Shannon cSAC	Cloon	Shannon IRBD
26	Derreen (Slaney)	000781	Slaney River Valley cSAC	Derreen	South Eastern RBD
27	Clodiagh (Suir)	002137	Lower River Suir cSAC	Clodiagh	South Eastern RBD

3 IDENTIFICATION OF KEY PRESSURES AFFECTING THE STATUS OF THE FRESHWATER PEARL MUSSEL *MARGARITIFERA MARGARITIFERA* IN THE OWENEA CATCHMENT

3.1 Introduction

The Owenea catchment lies in West Donegal and runs from the Blue Stack Mountains in the east to the sea at Ardara (**Figure 3.1**). It encompasses the Owenea, Shallogan and Owengaarve rivers. The Owenea River itself runs for some 13 miles, draining Lough Ea in the west of the Croaghs, into Loughrosmore Bay at Ardara. It also encompasses the West of Ardara/Mass Road SAC to the west and the Lough Nillan Bog SAC to the south. The catchment also contains a number of lakes including Anna Lough and Drummalough. The town of Glenties lies at the centre of the catchment with Ardara and Mass just outside the catchment boundary.

The catchment is 126.08 km² and is within the North Western IRBD.

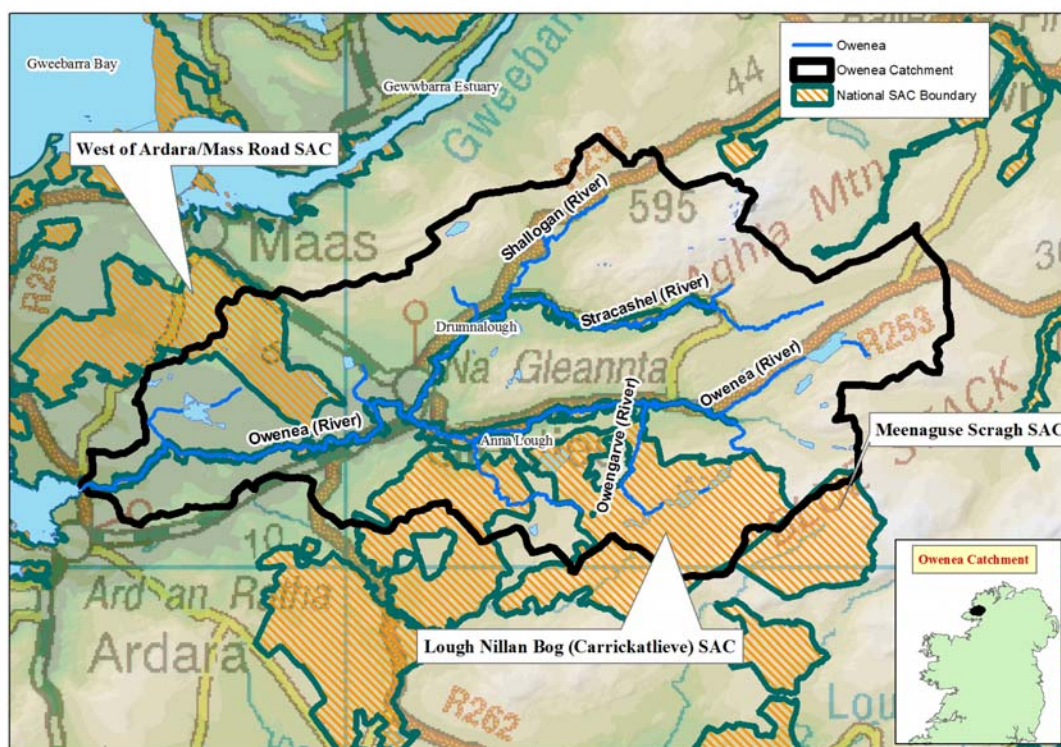


Figure 3.1 Overview of Owenea Catchment indicating the extent covered by the SAC Boundary

Based on the Corine land cover data, which are obtained from aerial imagery <http://www.eea.europa.eu/publications/COR0-landcover>, the most common Corine land use type within the Owenea catchment is “peat bogs” (37.37%) followed by “moors and heathland” (22.82%). Inland peat bogs form a further 37.37% of the land cover with coniferous forests accounting for 9.35% within the Owenea catchment. From an agricultural point of view, 12.95% consists of areas of pasture.

CORINE level 6 data were utilized in the sub-basin management plans. Due to the coarseness of the data and the age of the data however, they were used with caution. As a result, aerial photography was also used where available, and catchment walkovers and pressure assessments have been carried out as part of the field work which was undertaken through the NS2 project in 2009. Both the aerial photography and the catchment walkovers will provide more accurate information on land cover and pressures. Higher resolution maps of

agricultural land-use, including livestock density, fertiliser use, slurry spread grounds and application rates are required in order to assist the prioritisation and accurate identification of measures.

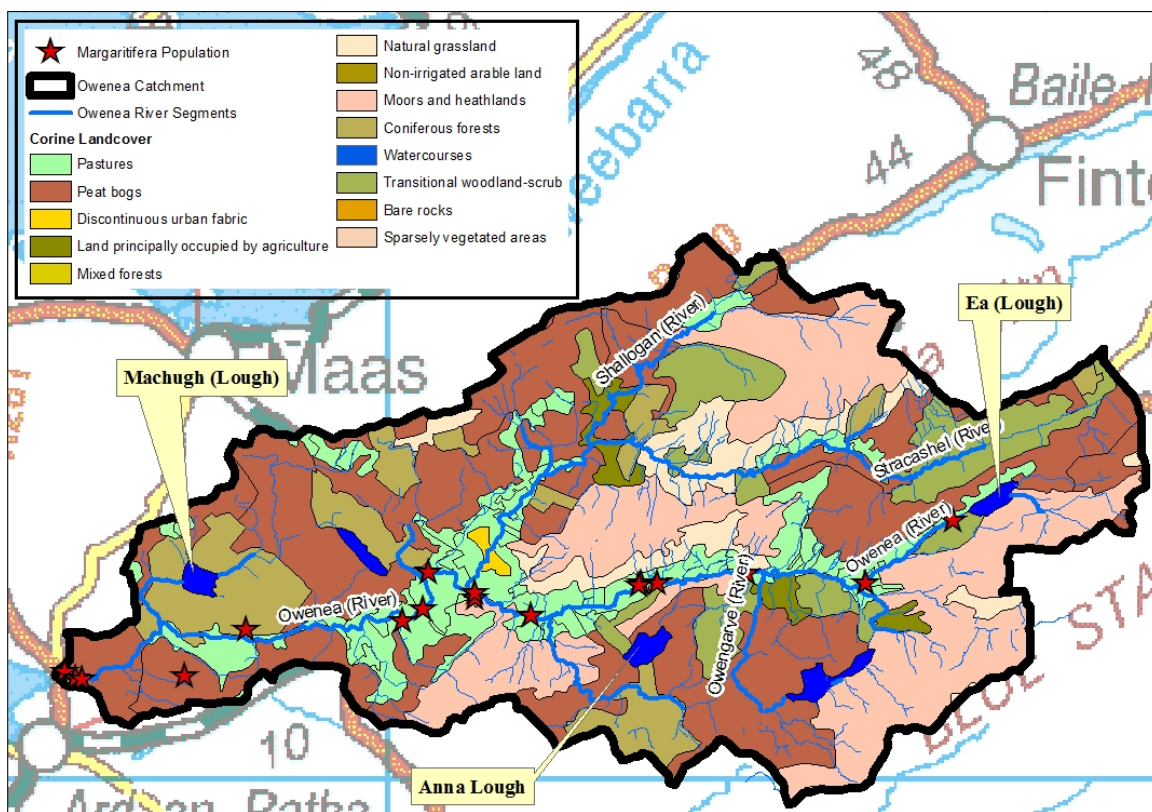


Figure 3.2 Corine Landcover within the Owenea Catchment

The main causes of the current unfavourable conservation status of the Owenea pearl mussel population are described below. The key improvements needed for the Owenea Catchment are to restore juvenile habitats to appropriate condition by simultaneously reducing nutrient and silt inputs to the river.

The order with which the pressures are described does not reflect their magnitude or their significance for the decline in pearl mussel populations in the Owenea catchment. Instead the order follows the River Basin Management Plan format as the Freshwater Pearl Mussel Sub-Basin Plans are background documents to this.

Table 6.2 contains a toolbox of measures, a selection of which will be implemented at those sites where investigations and risk assessment have shown that specific pressures need to be remediated to restore pearl mussel to favourable conservation status. Chapter 6 contains a summary of the measures which will require implementation within the catchment by the statutory authority. The Summary Action Programme contains the site specific measures which will be implemented on a prioritized basis as indicated by the overview map. Throughout 2008 and 2009, a series of field investigations and risk assessments were conducted in order to verify the pressures identified in the Draft Freshwater Pearl Mussel Plans together with locating further pressures within the Owenea catchment. Field investigations covering biological surveys (pearl mussels, fish, invertebrates and plants), as well as physico-chemical, morphological and siltation surveys were carried out. Further details in relation to the results of these field surveys can be obtained from Chapter 4 and the monitoring methods report can also be downloaded from

(http://www.wfdireland.ie/docs/5_FreshwaterPearlMusselPlans/Monitoring%20Manual/).

Prior to implementation, all measures will be assessed for their effectiveness and potential negative impacts on mussels or other species or habitats of high conservation value. The measures will also be subject to a cost benefit analysis to ensure that the most cost-effective measures are used to solve particular problems.

Every six years, under Article 17 of the Habitat's Directive, each member state must report to the EU on the status of each habitat and species protected under Annex I and Annex II of the Habitat's Directive. The Owenea population of the freshwater pearl mussel was reported in 2007 to be in unfavourable conservation status. In 2013, the next set of Article 17 reports will be sent to the EU. This will need to include an update on the size and status of the Owenea population, the measures that are in place and the improvements or deteriorations (as applicable) to the river bed at mussel habitat (such as silt, filamentous green algae and macrophytes). It is therefore urgent that measures are undertaken as soon as possible, and data on their implementation returned in a timely manner to NPWS to assist Article 17 reporting.

3.2 Hydrological and Morphological Pressures

Morphological and Hydrological (termed hydromorphological) pressures within catchments generally have the key impact of increasing sediment load to the river, and erosion and deposition processes within the river itself. This has a critical effect on pearl mussel survival.

3.2.1 Morphological Pressures

Desk based investigations using national GIS pressure datasets, such as the OPW drainage schemes and the National over-grazing GIS layers developed by the Central Fisheries Board (CFB), helped us to initially identify, locate and target the areas where pressures exist. By using detailed aerial imagery we were further able to refine these assessments and identify more localised issues. Through identification of these pressures using the desk-based approach we were then able to focus our field-work element within these areas. This enabled us to verify and ground-truth the pressures and to focus the application of measures.

Where impact is confirmed, the Code of Practice for Morphology Pressures which is included in River Basin Management Plans shall be referred to (Shannon IRBD Freshwater Morphology Programmes of Measures and Standards Study, Review of Best Practice Measures, 2008), as well as any relevant future guidance produced by DEHLG. These measures encompass the concepts of reducing the pressure itself, and remediation where necessary.

Desk Based Assessments

Table 3.1 shows the national GIS pressure datasets that were used in the assessment of pearl mussel catchments from a morphological perspective.

Table 3.1 National GIS Based Pressure Datasets for Morphology

Pressure	National GIS Pressure Dataset	Present in Owenea Catchment
Channelisation	OPW Drainage Scheme	No
	OPW Drainage District (pre 1945 Arterial Drainage Act), maintained by Drainage Boards, Local Authorities, or OPW	No
Barriers To Migration	Barriers to Migration (located using expert judgement by CFB but not yet qualified using fish data)	Possibly

Over-grazing	National dataset developed by CFB using expert judgement	No
	Damaged areas depicted by Commonage Framework Plans through the Rural Environmental Schemes and Programmes (REPS 3) in 1999	Negligible

Barriers to Fish Migration

Barriers to fish migration can cause a significant threat to the efficient reproduction of pearl mussels. This is due to their complex life-cycle which requires the inhalation of the glochidial stage of the pearl mussel by juvenile Atlantic salmon, brown trout or sea trout in order to progress to the next life-stage. Glochidia attach to the gills of juvenile fish in autumn, growing in this hyper-oxygenated environment until the following spring. If barriers pose a threat to the safe passage of these young fish then the reproductive cycle of the pearl mussel can be severely hindered.

The Central Fisheries Board (CFB) has identified possible barriers to migration in Ireland; however, these have not yet been supported by fish data. Therefore it is not yet certain if these structures are causing a problem. The River Basin Management Plans have identified this as a key data gap which must be addressed.

National datasets indicate that Barriers to Fish migration may be a pressure in the catchment. However, this requires further investigation.

A survey to determine the location of barriers is required, and also to determine the type of structure (e.g. weir, bridge apron, culvert) and the risk of impassability. This shall be combined with fish data to confirm if it is a problem or not. The methodology for undertaking this risk assessment is outlined in the *Assessment of the Risks of Barriers in the Nore Catchment* report, which was completed by CFB through the Shannon River Basin District Project (Freshwater Morphology Programmes of Measures and Standards Study) www.wfdireland.ie

While no barriers to migration were identified during the catchment pressures assessment please refer to Chapter 4 for details in relation to the catchment specific fish surveys.

3.2.2 Agriculture

Agricultural practices that contribute to increases in nutrient or silt to the river can be damaging to pearl mussels. Any practice that leads to exposure of bare ground can increase the fine sediment and nutrient load to the river. The cumulative effects of such practices can have very severe impacts on mussels.

Liming of land has a negative effect on pearl mussel populations, through direct toxic effects, and through increased growth rates leading to shortened life expectancy and, thus, loss of reproductive years (Bauer *et al.* 1991, Skinner *et al.* 2003). In some countries, acidification problems are so severe that liming is considered to have a more positive than negative effect (Henrikson *et al.* 1995). However, water chemistry data from declining Irish pearl mussel rivers indicate high peaks of calcium and conductivity levels that are likely to have been caused by liming.

Pearl mussels continued to thrive until recent years in catchments with very extensive agricultural practices. The intensification of agriculture, particularly with slurry and artificial fertilisers has led to cumulative effects that have had very severe consequences for pearl mussel reproductive success.

Toxic products have also resulted in the deaths of adult and juvenile mussel losses and, in one extreme case, the loss of an entire pearl mussel population. Pesticides such as sheep dip products are probably the most severe, but evidence from American surveys of glochidial

stages of Unionid mussels have demonstrated lethal effects from very low doses and environmentally relevant concentrations of chlorpyrifos and permethrin, the fungicides chlorothalonil, pyraclostrobin and propiconazole, and glyphosate (Bringolf *et al.*, 2007a, b, c). Of particular concern are the severe deleterious effects of the latter substances in combination with surfactant blends, such as in commercial products like Monsanto Roundup. The end product including the surfactants can result in a much more toxic product than that of the individual ingredients.

Figure 3.3 and **3.4** indicate the soil types and livestock densities within the Owenea Catchment.

The Owenea catchment is dominated primarily by peaty soils, primarily peat, peaty podsol and peaty gley soils, with some gley soils along the main river stem (**Figure 3.3**). Soils have been grouped in accordance with their organic matter content based on the Irish Forest Service soils map (commonly referred to as the Teagasc/EPA soil map layer). Soils which are high in organic matter have low phosphorus retention properties (Daly *et al.*, 2002). The dominant agricultural land use associated with these soils is pasture. Livestock unit density is low, as indicated by the national livestock unit density data provided by Teagasc (**Figure 3.5**), with densities ranging up to 0.56 lu/hectare suggesting that nutrient loss from agricultural soils is not generally a significant land use pressure in the catchment. Measures considered will include investigation of agricultural sources of nutrients and silt, relevant measures in REPS and GAP Regulations, future agricultural data needs and sharing, soil P tests, wetlands for farmyard runoff and prioritisation of GAP Regulations farm inspections.

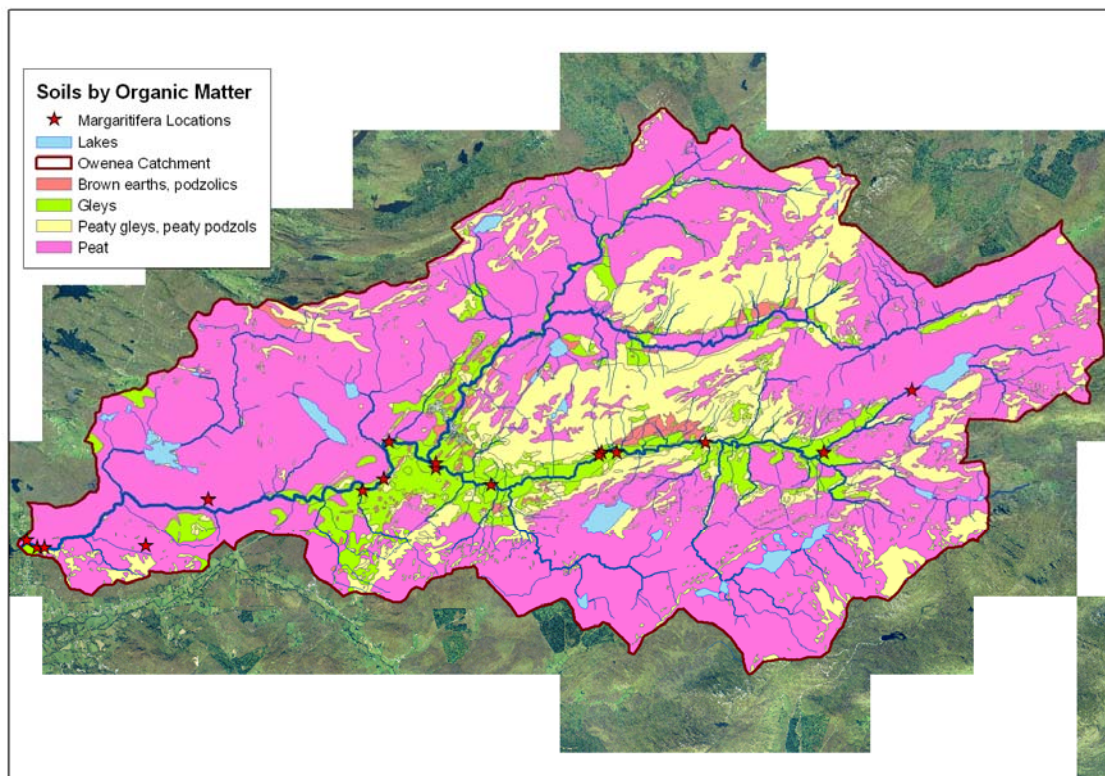


Figure 3.3 Owenea soil organic matter content

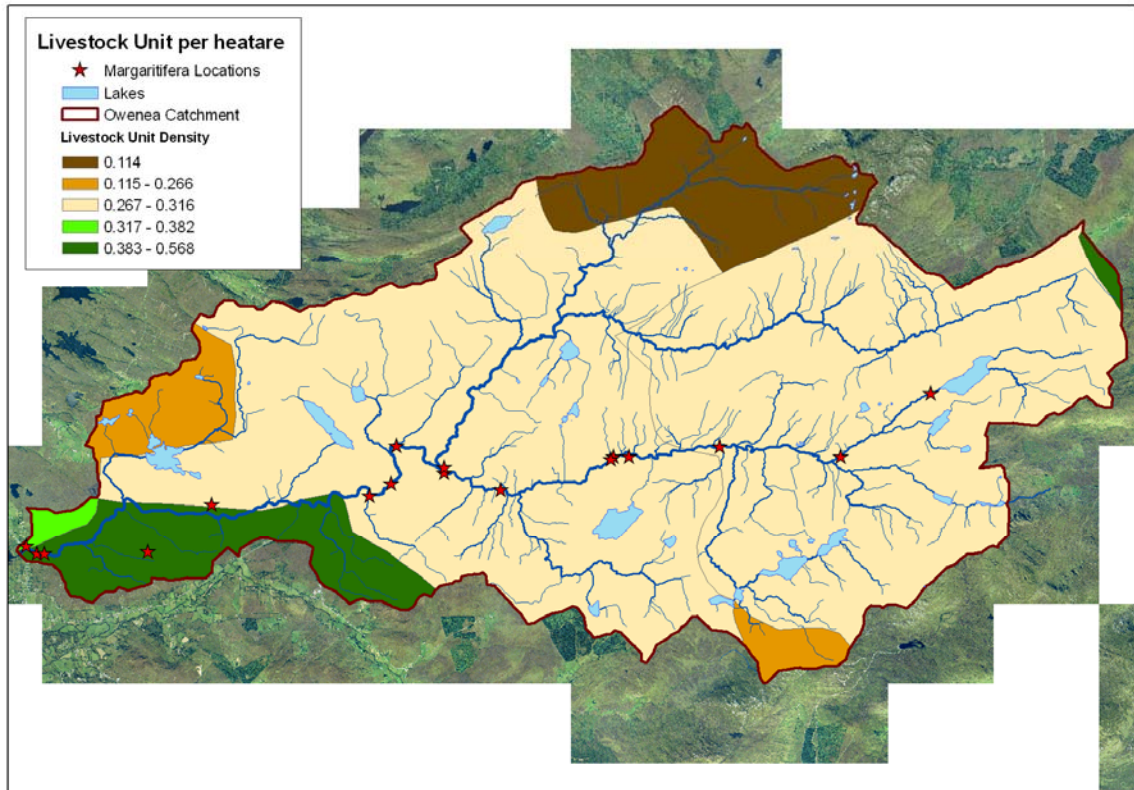


Figure 3.4 Owenea livestock unit density map

The livestock unit density map was provided by the Department of Agriculture to the River Basin District Projects to facilitate preparation of the RBD characterisation reports. It is based on the CSO data from 2002 and provides the average LU densities averaged on a DED basis. Whilst this data set is eight years old it provides a general guide to the level of livestock unit density in each sub basin catchment rather than absolute values on a field by field basis.

3.2.3 Catchment Walkover Risk Assessments

As outlined above, the best use was made of all available datasets such as the pressure source data collated by the River Basin District Projects for the Article V Characterisation and Programme of Measures Studies to allow the NS2 project team to assess the catchment through the combined availability of aerial imagery and digitised pressure information. Where gaps in this data existed together with areas that required ground truthing such as physical barriers to migration, catchment walkover risk assessments were focussed throughout the 2009 field survey season.

The catchment walkover risk assessment covers eight main categories or pressures which are subsequently sub-divided into the various sources as outlined below:

Source of Erosion	Bank erosion	Barriers to Migration	Culverts
	Land clearance		Bridge aprons
Diffuse Nutrient	In river clearance	Field Drainage	Weirs
	Arable ploughing		Stone weirs
	Animal trampling		Other sources
	Fords		Ditch managed
	Channel manipulation		Ditch unmanaged
	Hard bank protection measures		Drainage on high slope
	Other sources		Drainage on low slope
			Land drainage (perforated pipes)
	Other sources		
		Outfalls	Industrial discharges
			Storm drains
			Culvert outfalls
			Other sources
		Abstractions	Small
			Large
Diffuse Silt	Arable	Current Riparian Zone	Fencing
	Grazing		Buffer
	Over-grazing		Tree line at bank
	Improved grassland (Re-seeding)		Tree line buffer
	Forest		Plantation with no buffer
	Silage		Urbanisation
	Industry		Flood protection
	Construction stages		Marshy land
	Housing		Landuse at bank
	Infilling		Other sources
	Peat cutting		
	Quarries		
	Other sources		

Each source is identified if present and an overall risk assessment for each pressure assigned from high to medium to low over the survey length. All eight pressures are combined to give an overall risk assessment to the catchment based on the “one out all out principle”.

A total of nineteen sites were surveyed in the Owenea sub-basin catchment, with a risk assessment carried out at sixteen of these sites (three stopping points). **Figure 3.5** outlines the stopping point locations in addition to the High to Low Risk Assessment from the Catchment Walkover Risk Assessments. Thirteen high risk sites were recorded out of the sixteen that were assessed. The remaining three sites were recorded as medium risk, meaning no low risk sites were recorded within this catchment. **Figure 3.6** outlines the percentage of sites classified at high and medium risk together with the number of stopping points throughout the catchment. The most common high risk categories identified were:

- Erosion – evident at 77% of high risk sites,
- Current riparian zone – 38% of high risk sites.

The Current Riparian Zone category of the Catchment Walkover Risk Assessment slightly varies from the seven other categories or pressures. The Current Riparian Zone is not a pressure in itself; however the aspects listed in this category are the interceptors to the pressure and convey the extent or lack of buffer provided by the riparian zone. A high risk riparian zone indicates that the pressures acting on the river are more likely to have significant impact. For example the lack of fencing along a river stretch can lead to excessive trampling and/or poaching which in turn may lead to siltation within a pearl mussel habitat.

The various categories and pressures listed in the Catchment Walkover Risk Assessment sheet were designed to assist the project in focusing the measures which will be needed to combat the pressure along its pathway, rather than removing a source which may not always be possible such as intensive agriculture. Recording the Riparian Zone in terms of its current performance as a buffer is important in this regard.

Current Riparian Zone has ten aspects as follows:

- Fencing
- Buffer
- Tree line at bank
- Tree line buffer
- Plantation with no buffer
- Urbanisation
- Flood Protection
- Marshy Land
- Landuse at bank
- Other Sources

Where one or any of these aspects is found to be the cause of significant impact to the riparian zone, or the channel along the stretch then this category may be assigned a high risk score.

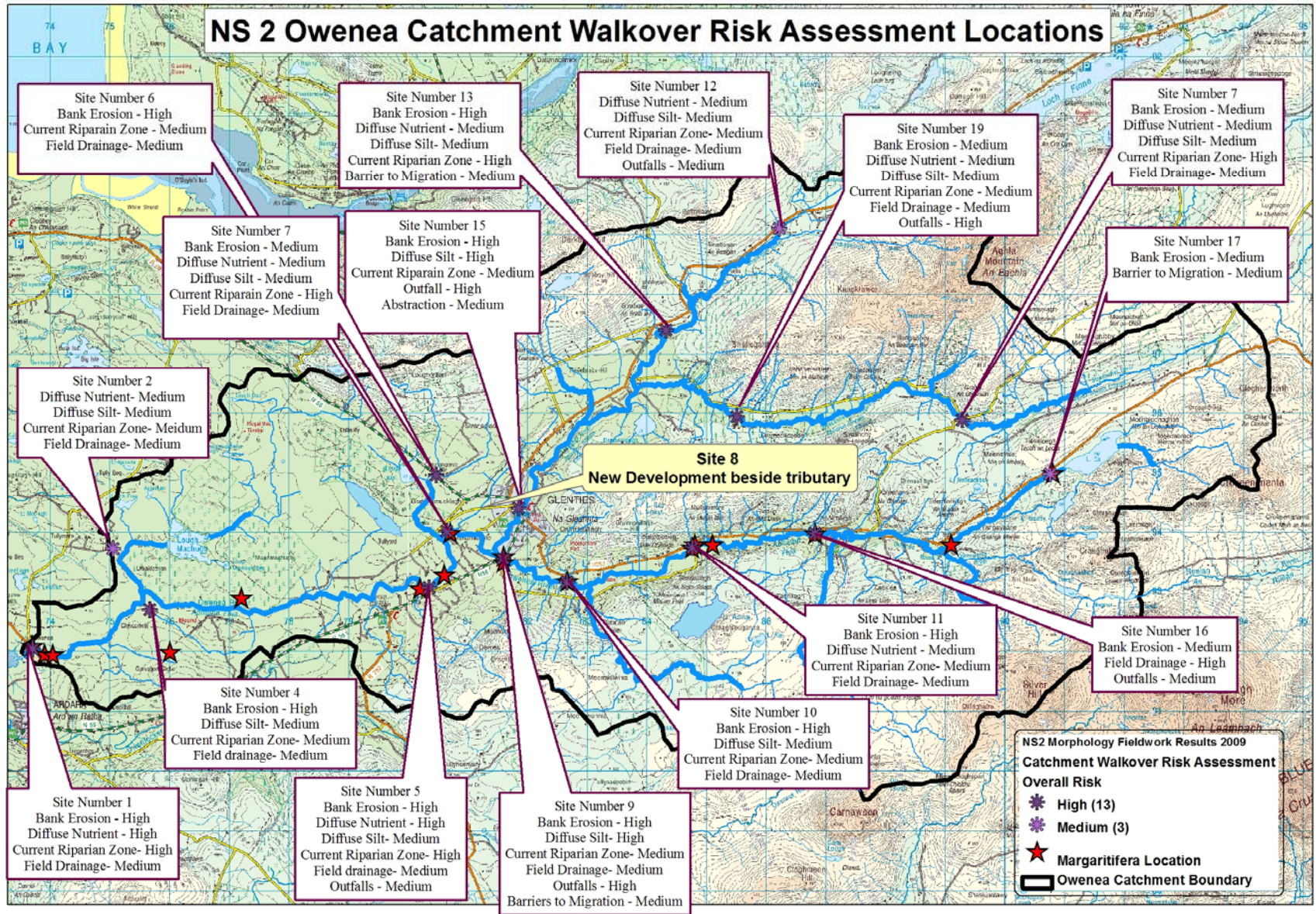
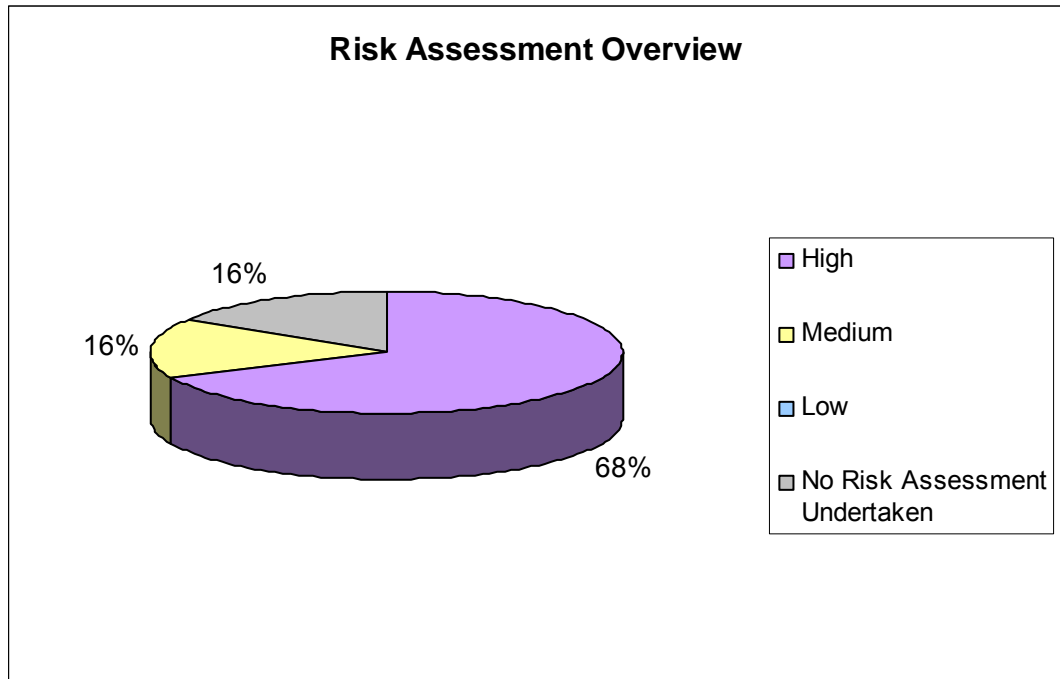


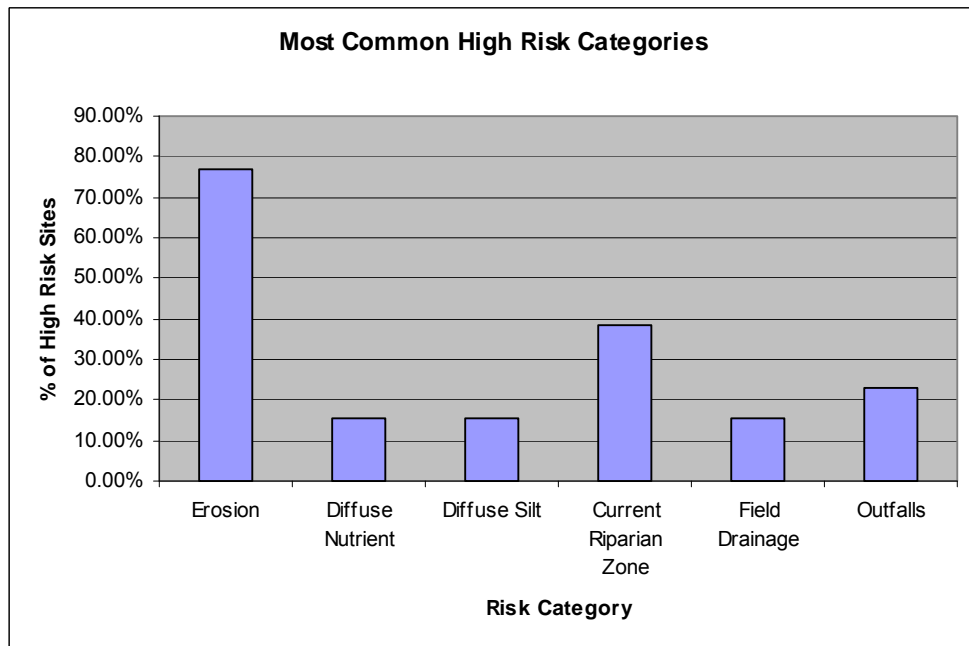
Figure 3.5 Location of Stopping points and Catchment Walkover Risk Assessment

Figure 3.6 Risk Assessment Overview



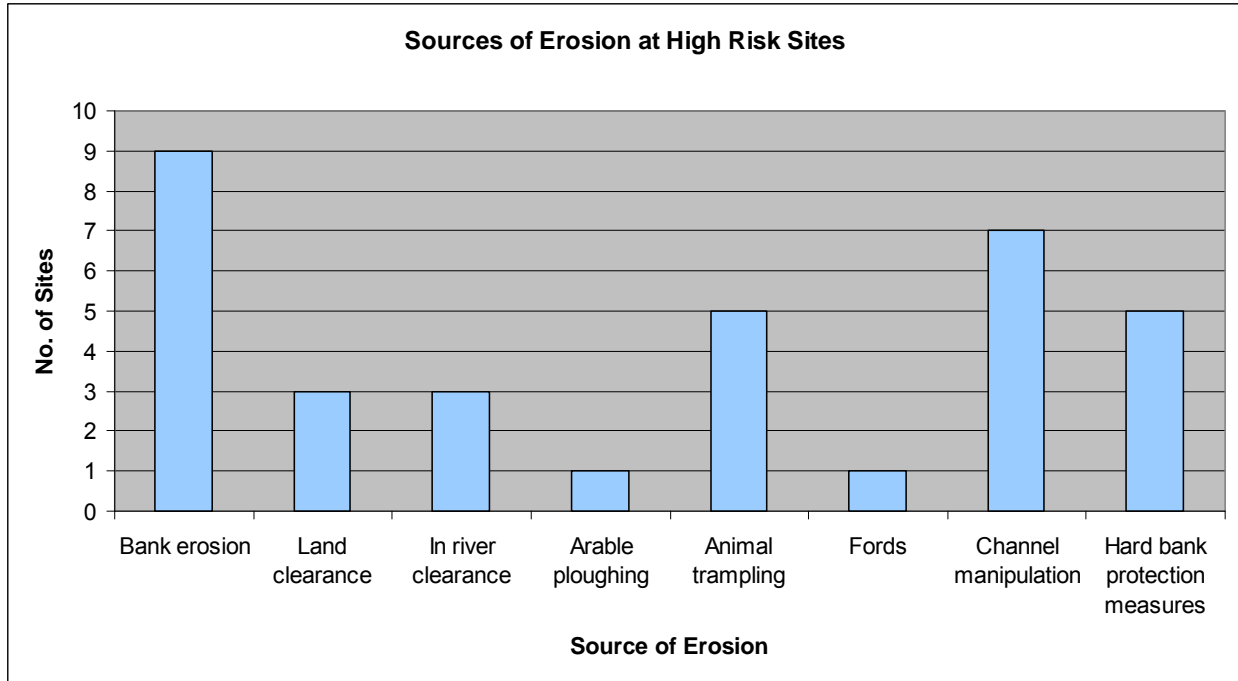
The break-down of pressure categories identified as high risk are outlined in **Figure 3.7**

Figure 3.7 Break-down of High Risk categories



The most frequent source of erosion is bank erosion which is apparent at nine of the thirteen high risk sites. Channel manipulation and bank protection are significant erosion pressures. Outlined below are the sources of erosion leading to a high risk site:

Figure 3.8 Sources of Erosion at High Risk Sites



The current riparian zone is another considerable pressure within this catchment, however generally this pressure relates to how a poor riparian buffer can intensify other pressures e.g. animal trampling caused by a lack of fencing or increased pressure from diffuse nutrient as a result of a poor buffer zone. Within the Owenea catchment the main cause of a high risk from riparian zone is:

- Inappropriate or lack of adequate fencing which prevents animal trampling on grazing land – this increased the impact of erosion which has already been identified as a major pressure as well as from diffuse nutrient and silt.
- Ineffective buffer on agricultural land and forestry – increasing potential impact of diffuse nutrient and diffuse silt particularly during tree-felling.

3.2.4 Direct Morphological Pressures

Aerial Imagery is currently available for the Owenea Catchment. This imagery enables closer inspection of the catchment and the identification of more direct morphology pressures, which are not detected by national datasets.

The following sections describe the morphology pressures observed using the Aerial Imagery and verified by field investigations.

Peat Exploitation

The initial drainage of bog lands and subsequent peat extraction activities result in an increase in the amount of water emanating from sites as both baseflow and storm water, potentially leading to large quantities of peat silt being discharged to the receiving waters. The potential for run-off of peat silt is greater during extreme rainfall events (Shannon IRBD Freshwater Morphology Programmes of Measures and Standards Study, Review of Best Practice Measures, 2008).

In addition to the impacts on adult and juvenile pearl mussels, the run-off of peat silt from peat cutting operations can seriously impact on receiving rivers through:

- Settlement on key substrates e.g. salmonid spawning and nursery areas
- Formation of secondary banks and islands which vegetate, stabilise and may alter stream morphology and hydrology
- Prevention of erosion of gravel and cobble materials from banks back into channel
- Elimination of flora and fauna

Major settlement of peat silt is more likely in low gradient reaches of rivers, as this material consists of very fine particles.

Figure 3.9 indicates the areas of peat cutting observed using aerial imagery.

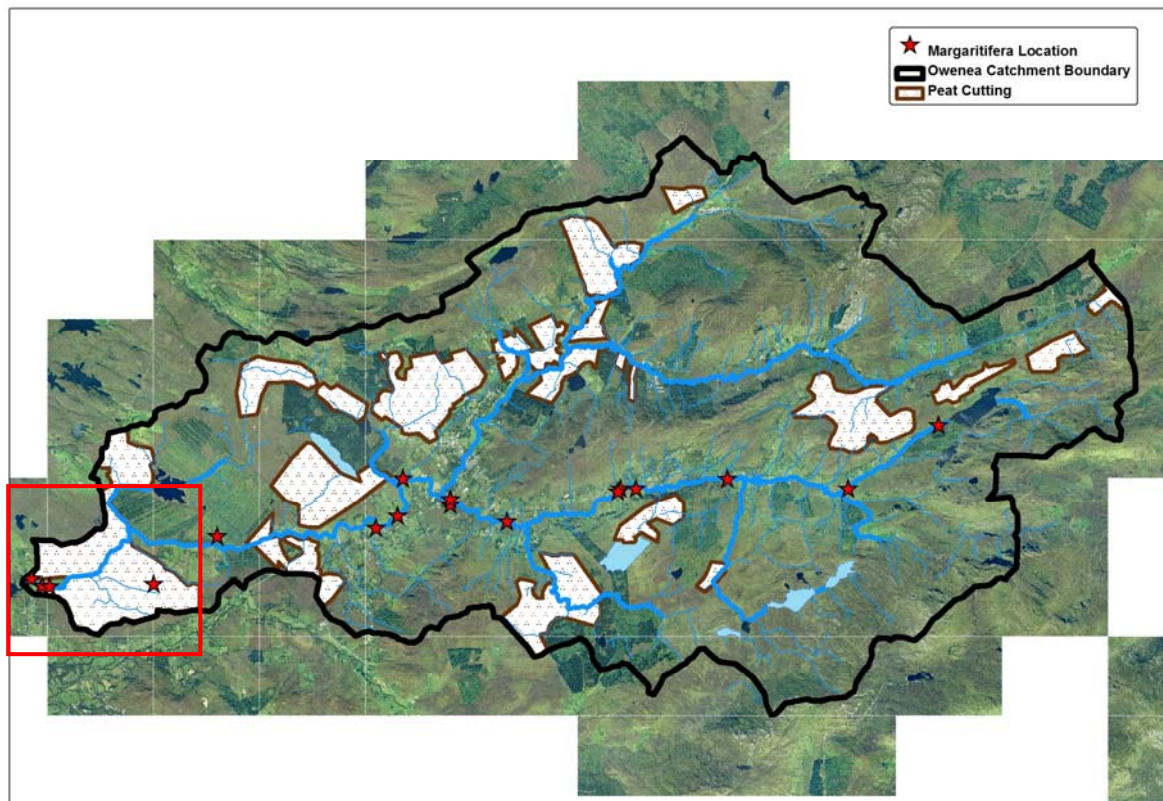


Figure 3.9 Areas of Peat Cutting within the Owenea Catchment

Peat cutting is evident throughout the catchment, but most significantly, it occurs within the vicinity of the pearl mussel populations at the downstream end. These areas of peat cutting are of key concern in terms of potential impact to the pearl mussels.

Figure 3.10 focuses on an example of specific area where peat cutting adjacent to pearl mussel stretches is evident. The lack of riparian zone increases the probability of excessive sediment run-off to the river.

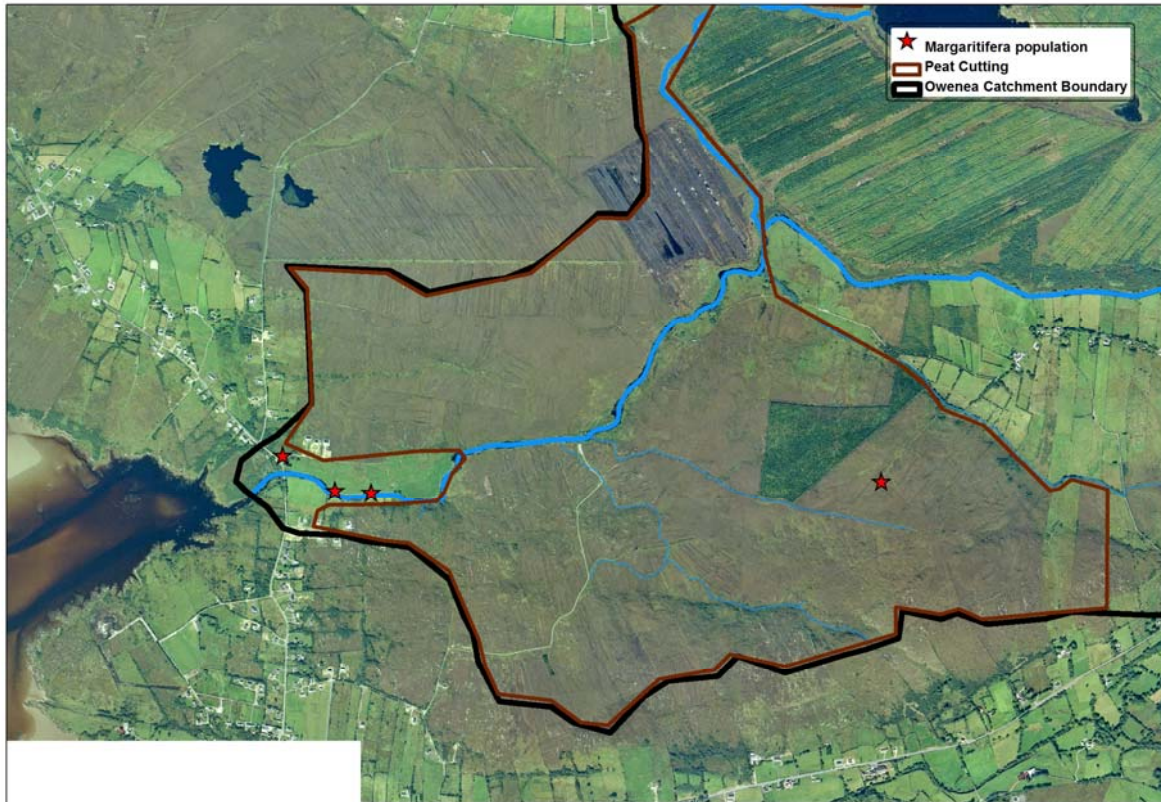


Figure 3.10 Peat Cutting adjacent to the river channel

Road and Bridge Construction Adjacent to River

Bridges can be very destructive and result in damage unless the river is clear-spanned with enough sustainable natural banks on either side not to interfere with the natural hydrological processes in place (Richardson & Lagasse, 1999; Briaud, 2004). There is evidence of loss of pearl mussels where both bridges with in-stream piers and clear-span bridges with abutments that interfere with natural banks (Moorkens, in prep.).

A new bridge (**Plate 3.1**) has recently been built in the vicinity of Fishery Beat 7, between Glenties and Ardara along a pearl mussel stretch within the SAC boundary. To the south of the bridge is a gravelled, hardcore roadway or track (**Plate 3.2**).

The bridge is not clear span and has a large central pier embedded in concrete (**Plate 3.3**), with end piers at each side also encroaching into the natural bank area. Rock armouring upstream and downstream of the bridge has also been placed in front of the river banks (**Plate 3.4**).



Plate 3.2 Gravelled,hardcore roadway / track to south of bridge



Plate 3.3 Large central pier embedded in concrete



Plate 3.1 New Bridge



Plate 3.4 Rock armouring upstream and downstream of the bridge

Regulation of Future Engineering Activities

The River Basin Management Plans outline all of the required (or basic) measures currently in place in Ireland (Table 6.1 of this report). These measures are required by law and apply to all waters. Many required measures are under existing EU Directives, but the WFD stipulates extra required measures which must also be implemented. '*Control on physical modifications to surface waters*' is one of these extra required measures. The RBMP Programmes of Measures for Morphology recognised the need for a prior authorisation or registration based system to manage future engineering activities near rivers and lakes (Shannon IRBD 2008, Freshwater Morphology POMS Study, Final Report).

National technical studies on the impact of physical modifications on fresh and marine waters (www.wfdireland.ie/docs) identified apparent gaps in existing authorisation systems. A Ministerial decision on the need for new regulations creating a registration and authorisation system is required.

These controls will account for the assessment requirements of the Habitats Directive within the decision making process. If permission is granted, stringent binding rules or conditions will be attached to the license, in accordance with the Freshwater Morphology Code of Practice and Protected Areas requirements. The potential for impeding fish migration will also be a key factor in impact assessment.

A Freshwater Morphology Web Based tool has been developed which is driven by a Morphology Database. This tool supports decision making in authorisation systems by assessing pressure extent and risk to water body status. Damage to mussel populations, in combination with other impacts both during construction and operation will be considered in the assessment. Currently this web based tool is held and operated by the EPA. If an authorisation process is rolled out Local Authorities should be given access to this tool. Therefore structures within rivers may be subject to controls in future.

3.3 Abstractions

Water abstraction from rivers can cause low flows, which can be directly damaging through drying out of existing or potential mussel habitat, or through temperature increases, silt deposition or nutrient concentration. Water abstraction from managed lakes can cause low flows in the river downstream.

The River Basin Management Plans state that where abstraction pressures are identified within a water body as posing a risk, this risk must be confirmed by a process of investigation. This involves determination of instream flow needs for rivers through computer modelling, which will enable review or setting of compensation flow requirements and selection of the appropriate measures on a site-specific basis.

In the context of pearl mussel catchments, this enables a focussed application of measures where abstraction pressures are specifically problematic to the pearl mussel populations.

A national register of abstractions has been compiled and up-dated in March 2009 to identify areas at risk by the Eastern River Basin District Project (ERBD). The up-dated register is improved over versions used to perform the Article V Initial Characterisation in 2005. Most public and group water schemes have been identified and included, but it is unlikely that all industrial, miscellaneous small private abstraction schemes (e.g. schools, hospitals or farms) are captured in the updated register. It also does not include domestic wells

As far as possible the NS2 project undertook a programme of investigation through their catchment walkover risk assessments to locate and identify any of these small scale abstractions which may pose a threat to the pearl mussel or its habitat.

The ERBD used this register to assign a risk classification to each river water body which contains the abstractions as follows:

Risk Category	Risk Classification	Net-abstraction-to-Q95 Flow*
2b	Not at risk	<5%
2a	Probably not at risk	5-10%
1b	Probably at risk	10-40%
1a	At risk	>40%

* In a few cases, the compensation flow may be substituted or added to the Q95 flow

Within the Owenea Catchment one water body was classified as “1b” and fourteen as “2b”. No further small scale abstractions were identified as problematic through the NS2 catchment walkover risk assessments. Further information in relation to ERBD Programme of Measures study together with a detailed report on the methodologies used is available to download from www.wfdireland.ie

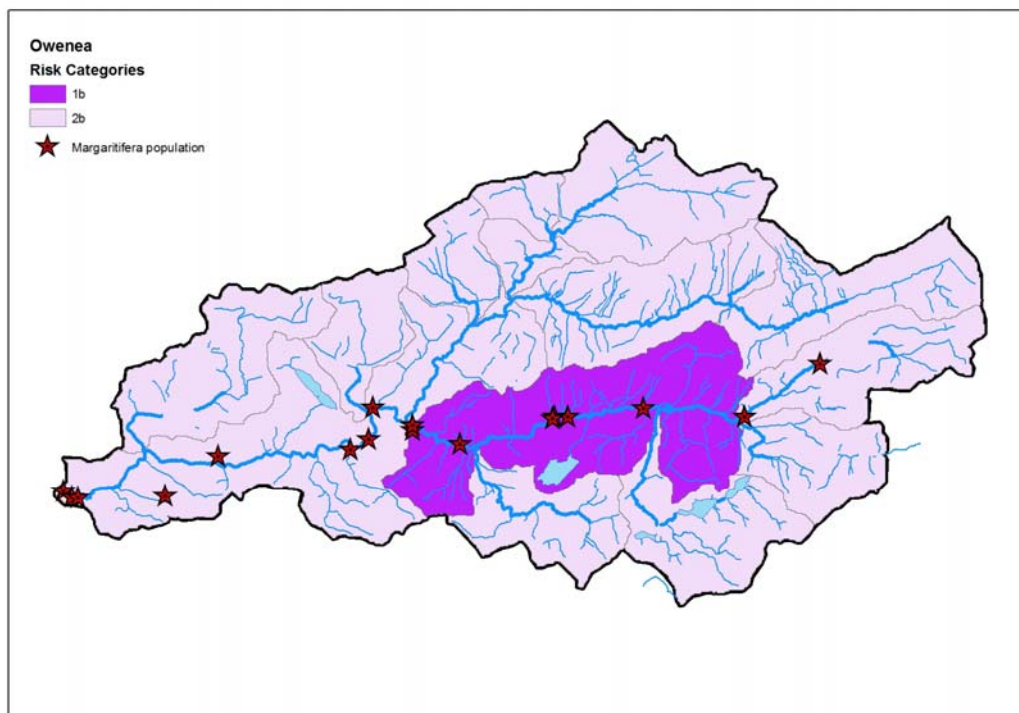


Figure 3.11 Water body NW_38_3822 which is probably at risk from abstraction according to the ERBD PoMs

3.4 Diffuse Pressures

3.4.1 Forestry

Forestry establishment (including drainage and ground preparation), thinning, roading, harvesting, replanting and all associated management practices are a major potential source of both silt and nutrients in pearl mussel catchments. Establishment of forests (afforestation) generally involves site preparation including drainage, which can give rise to erosion and release of silt into rivers or lakes. Afforestation occasionally involves the use of herbicide. Fertilisation of forestry at establishment stage and subsequently (often aerial fertilisation) can lead to release of nutrients into the watercourse. Fertilisation is generally a requirement for nutrient poor soils such as peat soils (raised bog, blanket bog, fen peat and cutaway peat). Brash left on site during and following harvesting operations can

also release nutrients through decomposition, a process which can continue for a significant number of years. A further significant contributing factor is the extent of the drainage network in the forested areas. Prior to 1990, forests were established with extensive drainage networks draining directly to surface water courses and lakes, and without the benefit of buffer strips. Recent research related to forestry operations, such as harvesting, indicates these forest stands, where planted on peat type soils, pose the greatest threat in terms of sedimentation and nutrient loss.

Recent research in Ireland carried out by the Western RBD in relation to forestry and acidification (www.wfdireland.ie) has linked coniferous forest cover on peat soils overlying igneous/metamorphic rock (Granites) and sedimentary rock (Old Red Sandstones) to acidification impacts. Impacts are also observed with coniferous forest stands on podsollic/lithosolic soils on granite and to a lesser extent on sedimentary rocks. The main known impacts from coniferous forestry to date have been the result of increased sedimentation and nutrient pollution rather than acidification.

The National Summary Characterisation Report identified forestry as a one of the main pressures which should be addressed in the Water Framework Directive River Basin Management Plans and Programme of Measures (www.wfdireland.ie). The National Forestry Inventory indicates that the total forest area in Ireland now stands at 10% of the total land area, of which 57% is in public ownership and 43% in private ownership. Conifers comprise 74% of the total stock. An estimated 43% of the total stocked forest estate is on peat soils. A typical forest lifecycle for conifer plantations is 40 years and longer in the case of broadleaves.

The threat from forestry operations in pearl mussel catchments is significant. Appropriate mitigation measures must be put in place to ensure the restoration and future protection of the pearl mussel populations. Such measures may include initiatives to remove or restructure forestry in pearl mussel catchments. Even given such a commitment, major mitigation works will be necessary during the removal or restructuring process to protect pearl populations.

Forest stands in the Owenea catchment are located throughout the catchment along the length of the Owenea River and on its major tributaries (Shallogan and Stracashel) and also around the main lakes in the catchment (Machugh, Ea, Anamina and Anna). 17% of the Owenea catchment is covered by coniferous plantations. Forestry is mainly state owned with some private forestry (**Figure 3.12**).

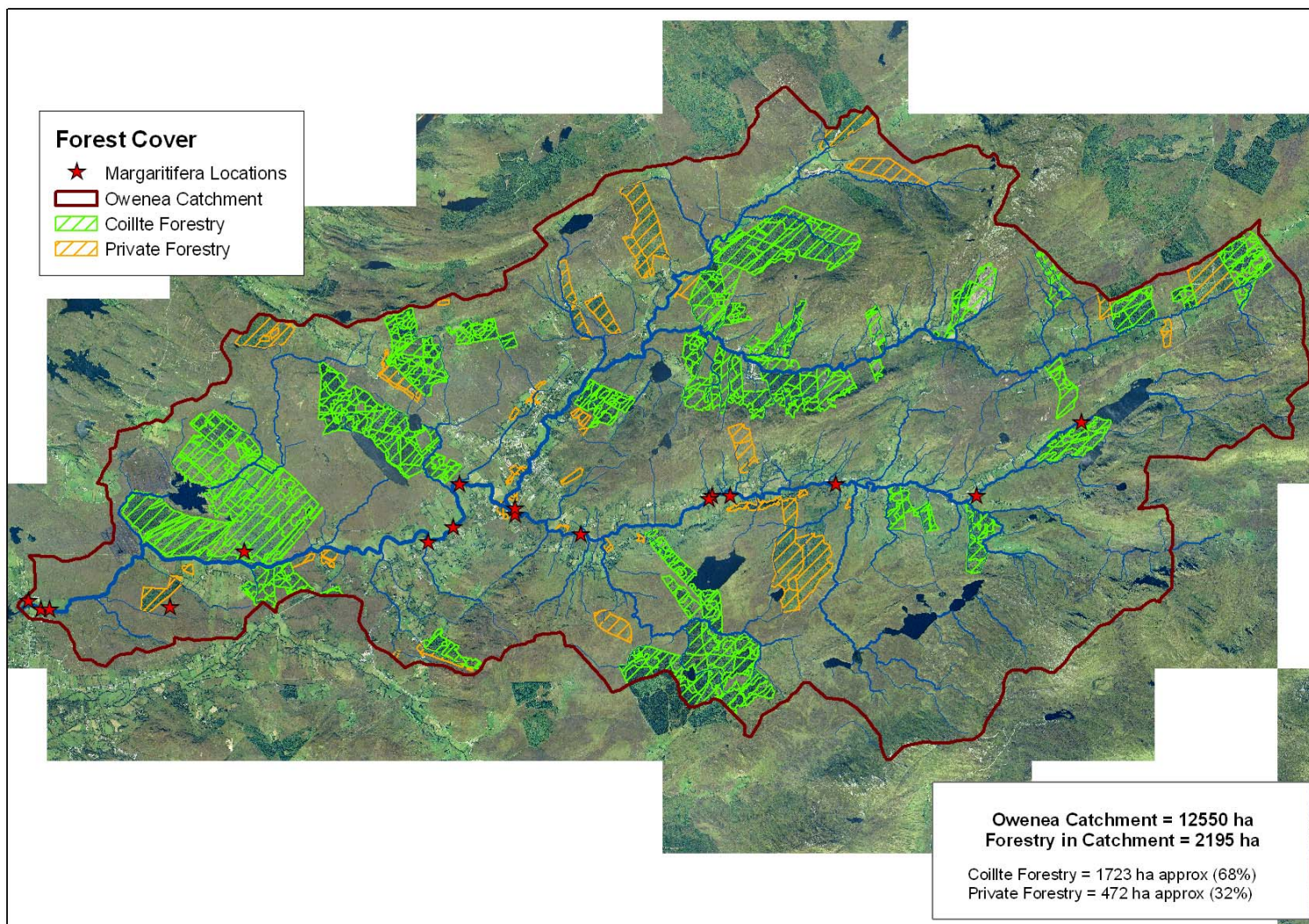


Figure 3.12 Owenea forestry by ownership

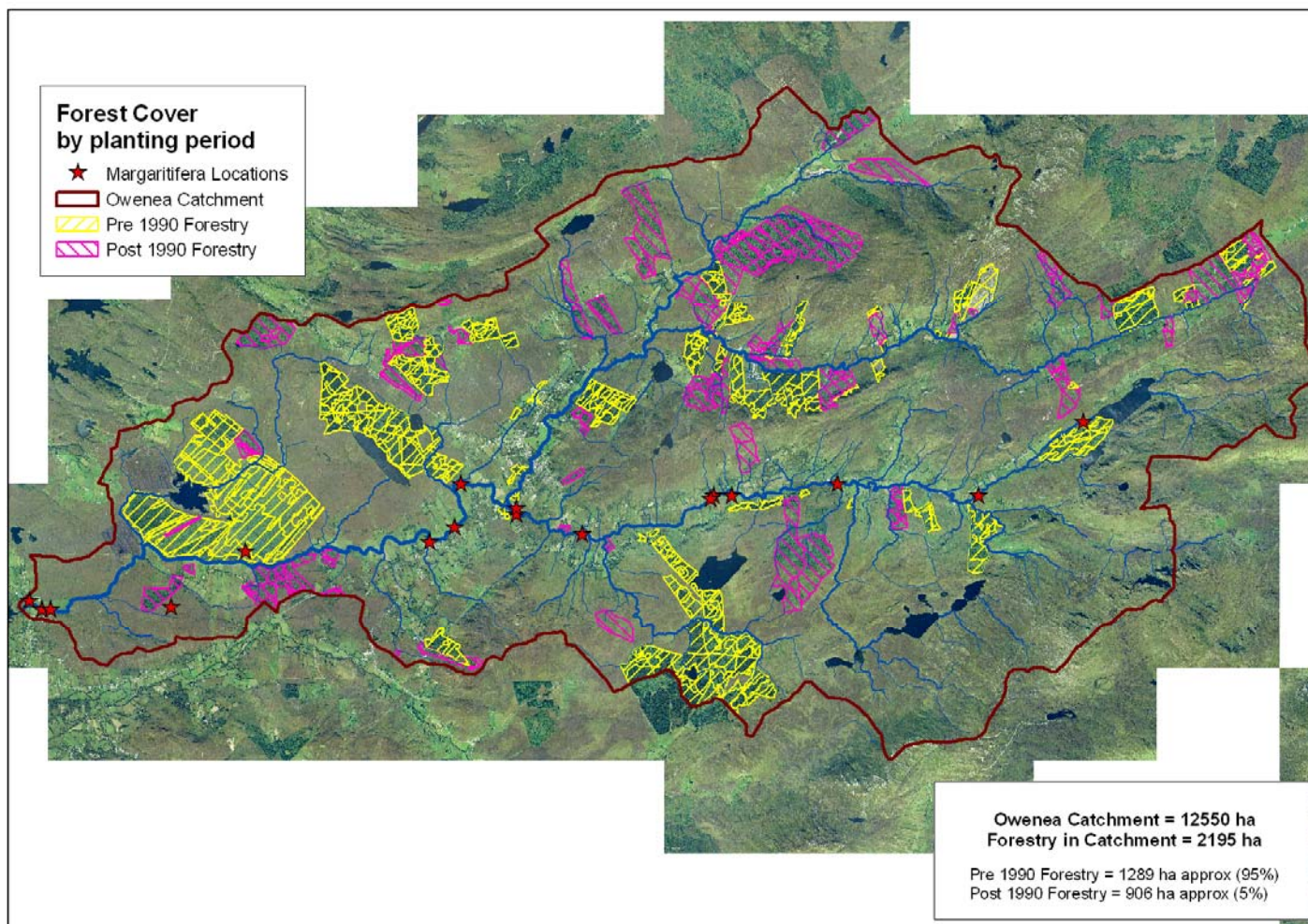


Figure 3.13 Owenea forestry by planting period

Forest species are mainly of the coniferous type, largely Sitka Spruce, Lodgepole Pine and Japanese Larch. An analysis of the age structure of the forest stands indicates that about 58% of the coniferous forestry was planted prior to 1990 (Figure 3.13). This is significant as forests planted prior to this date were largely planted without the benefit of the Forest Service guidance documents and codes of practice. In addition the national Irish Forest Service soils map indicates that this forestry was largely planted on peat type soils. The afforestation technique used generally resulted in significant drainage of the area, direct connectivity of the drainage network to the main watercourses and planting right down to stream or lake edge. No buffer zones would have been provided.

Main pressures from forestry in the Owenea catchment

The main pressures from forest stands identified in the Owenea catchment are

- Nutrient enrichment from ground and aerial fertilisation: Conifer forest growing on nutrient poor soils like peat may require an application of phosphorous fertiliser to achieve the required yield class. Peat soils have poor P retention properties and hence fertilisation poses a risk of nutrient loss to the receiving waters.
- Nutrient enrichment from brash decay post felling: Brash decay post clearfelling can potentially release nutrient, both N and P.
- Sediment loss: Forestry operations associated with harvesting, such as roading and clearfelling can give rise to significant loss of sediment particularly on highly erodible soil types.
- Further investigation is required into the potential impacts of increased dissolved organic carbon (DOC) on pearl mussel habitats. DOC may support biofilms of heterotrophs that, similar to the impact of macroalgae, could prevent the free exchange of oxygenated water between the water column and the substratum and result in the deposition of significant quantities of detritus on the river bed. Increases in DOC concentrations in surface waters have been reported across eastern North America and northern and central Europe in recent times (Evans et al., 2005; Monteith et al., 2007). The global increases in DOC have been linked to climate change, deposition chemistry (particularly acid deposition) and changes in land use. It has also been suggested that extensive conifer afforestation may exert some influence on DOC generation through increased litter production and mineralisation; and that this effect may be more significant following felling (Evans et al., 2005). It is considered that one of the most likely mechanisms for increased DOC in Irish surface waters is increased decomposition of peat as a result of drainage. Draining peat also increases water movement through the soil and, thereby, may increase the rate of DOC loss to surface water. The effect of peat drainage on DOC concentrations in surface waters warrants significant further research.
- Pesticide use. Both insecticides and herbicides are used at afforestation and replanting stages for coniferous forestry. Insecticides, such as cypermethrin, are used at re establishment stage (replanting) on post-clearfelled sites to limit attack of the pine weevil (*Hylobius abietus*) a devastating pest of young conifer stands. Potential exists for losses of insecticide to the aquatic environment.

The above pressures have the potential to impact significantly on the pearl mussel population in the Owenea catchment. The risk is increased due to the direct connectivity of the forest drainage network to the receiving water course, lack of vegetated buffer strips, and high potential for P and N loss from harvesting operations due to the poor retention capacity of the peat type soils. The Minister for Agriculture, Fisheries and Food is responsible for ensuring that any forestry activity, operation, plan or project (either individually or in combination) likely to have a significant effect on a European Site within the catchment designated for the protection of the freshwater pearl mussel species and/or its habitat, and that requires his concurrence, consent or approval, is subject to the An Appropriate Assessment for Natura 2000 sites (HDA) process. This assessment process will take account of the Forestry and Freshwater Pearl Mussel Requirements together with any revisions and further information provided by appropriate authorities.

3.4.2 On-Site Wastewater Treatment Systems

On-site wastewater treatment systems and other small effluent systems can be significant sources of nutrients to rivers. Losses from such systems typically behave as diffuse nutrient sources, however, more serious leaks and inappropriate systems can cause point source pollution damage.

Two fundamental questions need to be considered for effective treatment of single house effluent discharged through on-site wastewater treatment systems, such as septic tanks with percolation areas and proprietary systems.

- Will the effluent be afforded adequate treatment by the system?
- Will the final effluent be able to get away?

A simplified pathway risk map (**Figure 3.14**) of the Owenea catchment has been prepared to assess the potential impact from On-site wastewater treatment systems. These are based on the WFD National Programmes of Measures and Standards study on on-site Wastewater Treatment Systems. The risk maps take into consideration the aquifer type, vulnerability and subsoil permeability in assessing the pathway risk. Locations of on-site wastewater treatment systems have been derived from the most up to date An Post GeoDirectory. The locations of the on-site systems indicate that there will be very high to extreme risk in terms of pathogens and phosphorous load to surface waters. This is also borne out by the risk mapping of areas of likelihood of inadequate percolation. It should be borne in mind that these are generalised maps providing an overall indication of likely risk and specific localised conditions need to be taken into account in assessing each on-site system. However, it highlights the need to undertake surveys of on-site systems in the catchment where there is a high likelihood of risk to surface waters, particularly from phosphorus.

The European Court of Justice has ruled against Ireland in relation to on-site wastewater treatment systems (ref. Case C-188/08). The Court found that by failing to adopt the necessary legislation to comply with Articles 4 and 8 of Council Directive 75/442/EEC as regards domestic waste waters disposed of in the countryside through septic tanks and other individual waste water treatment systems, Ireland has failed to fulfil its obligations under that directive. To address the ruling, the Department of the Environment, Heritage and Local Government will be bringing forward legislation in the first half of 2010. It is intended that the legislation will provide for the setting of standards for the performance and operation of all septic tanks and similar on-site wastewater treatment systems. The legislation will also provide for the monitoring and inspection of the performance of such treatment systems and will set out the responsibilities of households served by those systems (including requirements to carry out remedial actions where necessary). In order to ensure prompt compliance with the Court ruling, it is intended that this legislation will be in place by Q3 2010.

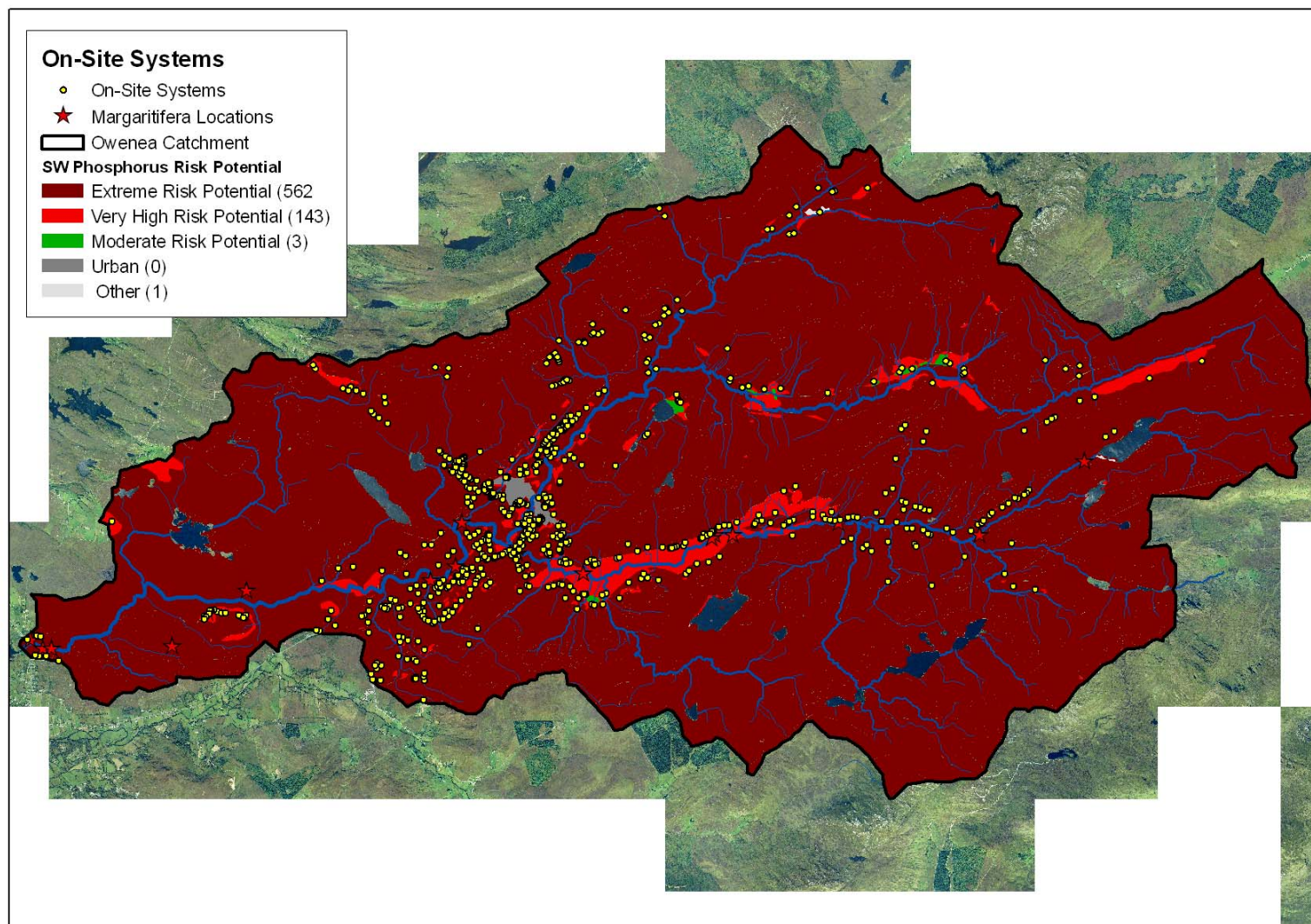


Figure 3.14 Surface water phosphorous pathway risk map showing location of onsite wastewater treatment systems.

3.5 Point Source Pressures

Point Discharges

Point sources discharging nutrients, such as wastewater treatment plants, can contribute very significant nutrient and organic loads to rivers. Quarry dust and effluent can cause problems with silt pollution and, in some cases, lime pollution. Landfills and landfill leachate can be sources of surface and groundwater contamination that can find pathways to the river. Storm water drainage can be a source of silt and pollutants.

Waste Water Treatment Plants

A review was undertaken of the available information on municipal and industrial discharges by the South Western River Basin District Project (SWRBD) and an assessment carried out as to whether any river water bodies were considered to be at risk from point sources under a number of circumstances. Within the Owenea catchment we then assessed all monitoring information together with pearl mussel status above and below any WWTP and prioritised those which we deemed to have a significant adverse effect on the pearl mussel population or its habitat. Following this prioritisation process Glenties WWTPs within the Owenea catchment were deemed to have a significant adverse effect on the pearl mussel or its habitat. It is found to be a significant factor leading to the loss of this mussel population. Waste Water Treatment improvements within this catchment are pivotal to the recovery of Freshwater Pearl Mussel population to favourable conservation status. Investigation is also required into the connection of all developments in the village and its environs to the WWTP. Glenties WWTP has now been included on the Water Services Investment Programme 2010-2012.

The pressures outlined above all have the ability to negatively affect the status of the freshwater pearl mussel. In some cases, a single pressure alone may be enough to cause a kill or ongoing chronic effects, but in most cases it is the combination of the negative effects of a number of pressures that are acting together to leave the freshwater pearl mussel habitat in unfavourable condition. It is unlikely that the effect of every diffuse source of pollution can be totally removed. Therefore, it is not possible to choose a subset of pressures to act on; steps must be taken to reduce every pressure, until the cumulative effect of all the reductions is a sustainable habitat for the freshwater pearl mussel and all the other species that it protects thanks to its umbrella and keystone status in its habitat. This is the essence of the precautionary principle under which the Habitats Directive must be implemented.

4 STATUS OF THE FRESHWATER PEARL MUSSEL AND MONITORING IN THE OWENEA CATCHMENT

4.1 INTRODUCTION TO THE OWENEA CATCHMENT

H. Ross (1988, 1992) carried out a detailed study of the Owenea pearl mussel population which also included work on life history strategy. Mussels were found to be widely distributed from the bridge near the estuary, north of Adara, to a location near Lough Ea, covering a distance of around 21km. The population was estimated to be in the region of 200,000 individuals with the last 0.5km supporting 32,000 individuals. The ages ranged from 7 to 98 years with a significant portion in the 10-20 year old age class. However, the numbers of mussels under 10 years old was found to be very low. Pearl fishing was cited as being a major threat at the time but it would not have caused the low juvenile numbers.

E. Ross (1988) also surveyed a number of sites on the Owenea. He found mussels to be abundant in the vicinity of Glenties.

Beasley (1996) carried out a further survey and showed that whilst the distribution was generally similar to that found by Ross (1988) there had been some local disappearances and that overall density had declined considerably over the 12 year period. Beasley also cited pearl fishing incidents into the mid 1990s.

A survey was carried out by Moorkens (2005) in a 500m long section downstream of Glenties on behalf of Donegal County Council. Only 76 live mussels were located – all were very large and old. All of the substrate in the survey section was covered in a layer of silt, and filamentous algae were also present throughout.

A rapid assessment was undertaken of the Owenea Population by Moorkens (2007) for NPWS. It demonstrated that the population has continued to decline both in terms of numbers and geographical extent.

Mussels were not found upstream of the bridge at Mully (G86818 93992), where only 4 large adults (c. 130mm) were seen (**Figure 4.1**). Small numbers of very large, scattered adults were found at other locations downstream as far as Glenties. Several hundred large mussels were found along the North bank from G73901 91964 to G74040 91957. All were in the size range from 80mm to over 130mm, showing that there had been a lack of significant recruitment for at least 20 years and probably longer.

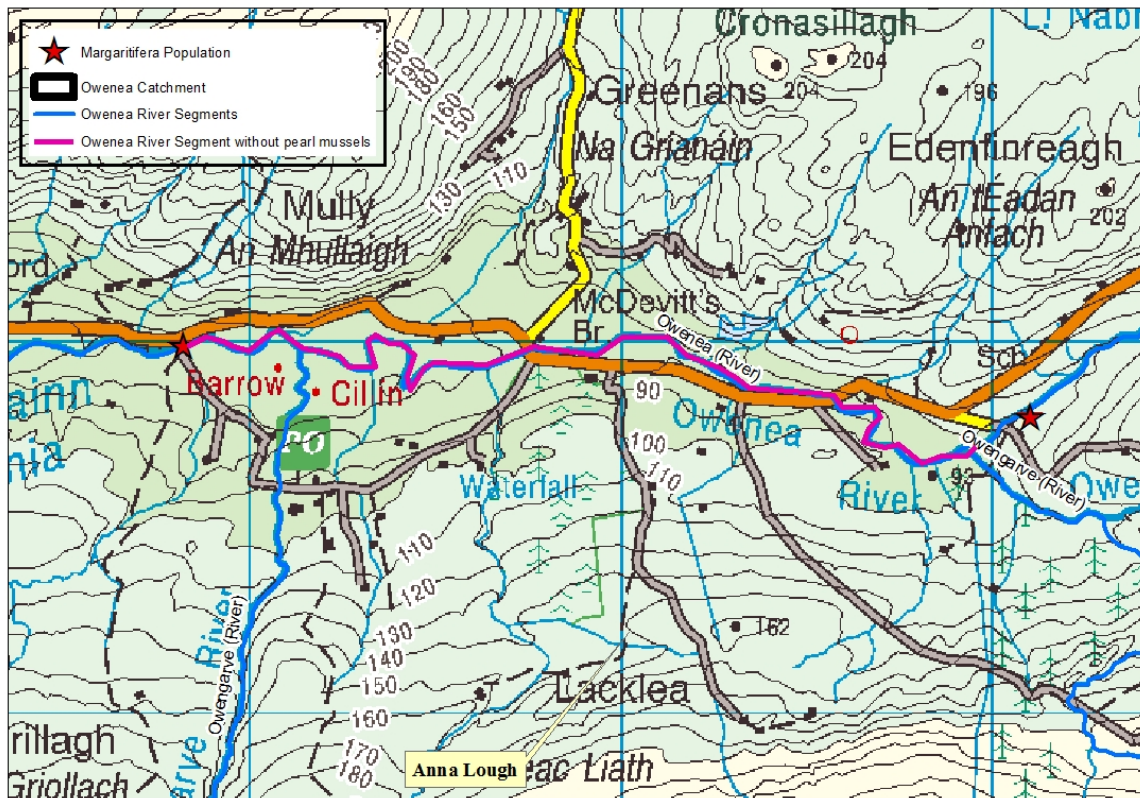


Figure 4.1 River stretch upstream of Mullin and downstream of Overgarve river.

4.2 CURRENT STATUS OF THE OWENEA CATCHMENT

Work carried out for the current study by Moorkens & Killeen (2009) consisted of:

- 1) Survey of numbers of mussels in selected sections to assess likely population numbers
- 2) Redox potential measurements to determine habitat quality.

- 1) Survey of numbers of mussels

Three stretches were surveyed to count total mussel numbers. All stretches were areas of prior mussel records, and the results are given in **Table 4.1**.

Table 4.1 Results of mussel surveys

Section	No of mussels	Habitat comments
1	21	<ul style="list-style-type: none"> • Single mussel along south bank at downstream end • 20 large adult mussels in riffle run along north bank as far as fence post (on S bank) at G80266 93085 • Good potential mussel habitat in poor condition in this section with sand, gravel and occasional larger boulders • Revetment continues to G80459 93124 • Mussels occasional in section for c.100m from start of revetment
2	0	<ul style="list-style-type: none"> • Mostly glide and short riffle section • Substrate in poor condition with silt veneer over cobble and gravel • Substrate compacted in places • <i>Callitriche</i> present • This section should support mussels if the habitat if it was clean
3	0	<ul style="list-style-type: none"> • Downstream part with relatively swift flow but rather unstable substrate • Substrate ranged from bedrock to scored cobble and exposed shoals • Middle section deep on outside of bend • Large rounded cobble substrate with large quantities of silt on bend most of which was covered with filamentous algae • Some <i>Fontinalis</i> covered cobble in riffle d/s bend but virtually no interstitial gravels • River upstream of bend the river is shallow and braided around an island • Upstream section with no stable mussel habitat

The results show that potential habitat is present in very poor condition but with no mussels present, and where mussels are present in correct habitat they are very sparse and in fast shallow riffles.

The live mussels were all in excess of 120mm, and juvenile searches were undertaken in the gravels but no young mussels of any size were found. The Section 1 delimited search area had 25 mussels present in 2005 (Moorkens, 2005), thus there was a 16% loss in 4 years.

2) Redox potential measurements to determine habitat quality.

Redox potential measurements were undertaken at Sections 1, at the fastest run where the mussels are present, and towards the opposite bank closer to the revetment area. The results are shown in **Figures 4.2** and **4.3**. Geist & Auerswald (2007) found that a loss of redox potential of less than 20% was needed in order for juvenile mussels to survive.

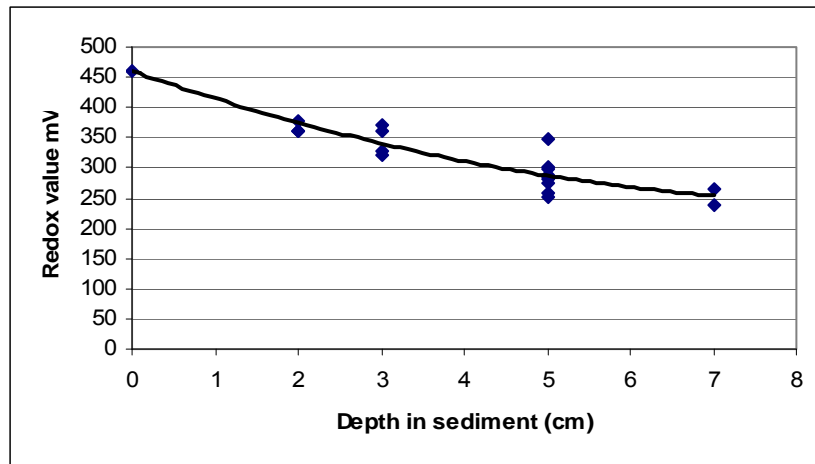


Figure 4.3 Section 1, in run inhabited by mussels, Loss at 5cm depth = 37.4%

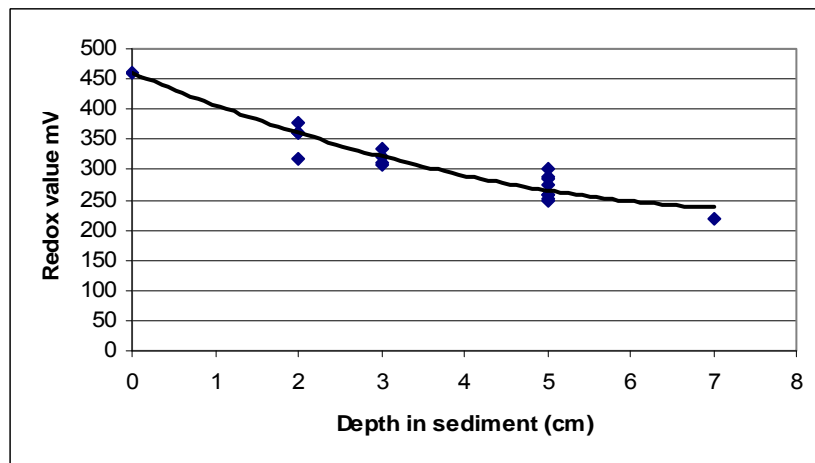


Figure 4.3 Section 1, adjacent to revetment, Loss at 5cm depth = 40.9%

The sediment conditions in the area of mussel habitat was one of the worst measured in Irish SAC populations.

In addition to the above survey work, three other surveys for private contracts were carried out on the Owenea Catchment in 2009, and the results have been submitted to NPWS via licence returns (Keys, 2009; Moorkens, 2009a and b).

Keys (2009) found an estimated 3,600 mussels in a deep pool just above the footbridge approximate 1 km upstream of Ardara, and a further 243 mussels in approximately 220m downstream of the footbridge. The estimated 3,600 mussels were considered to have been washed in and were not in stable adult mussel or potential juvenile habitat.

Moorkens (2009a) included a survey of the Stracashel River sub-catchment and no mussels and very little potential habitat was found.

Moorkens (2009b) included a survey of a section downstream of the footbridge mentioned in Keys (2009) above. Moderate numbers of living mussels (<250/100m length of river) were found both upstream and downstream of the confluence of a small stream entering from the south at Garvegort.

In addition to direct survey of mussels, an electrofishing exercise was undertaken to assess whether fish bearing glochidia were present in the river. Two sites on the Owenea River were surveyed on 25th May 2009 (Paul Johnston Associates, 2009), both sites were downstream of Glenties where living mussels have recently been found. At Site 1, a total of 2 trout and 21 salmon were counted, and no trout and 2 salmon were found to be encysted with glochidia. At Site 2, a total of 6 trout and 14 salmon were counted, and no trout and 1 salmon was found to be encysted with glochidia. This suggests that although good numbers of fish are present, the mussel population may be too low to encyst high percentages of fish, and that any glochidia surviving on the fish are not surviving following drop off due to poor habitat conditions.

From all of the above surveys, it can be concluded that the conservation status of the freshwater pearl mussel in the Owenea is very poor. The remaining mussels appear to be concentrated in the lower reaches of the river, where there is an absence of sufficiently favourable habitat to support juvenile mussels, and adult mortality is high. A comparison of the size profile from Beasley (1996) and the current survey shows the losses that have been incurred in the 14 years between the surveys (**Figure 4.4**).

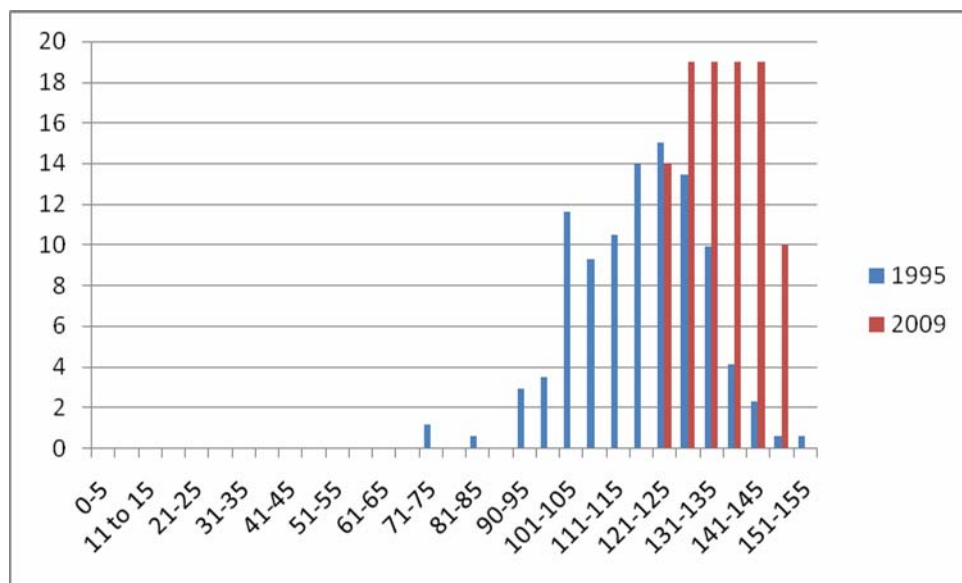


Figure 4.4 Size profiles from Beasley (1996) and Moorkens (2009)

The clear shift to the right indicates that modal classes are now older than in previous years. When transformed into age classes, this approximates to **Figure 4.5**, although the very large remaining mussels may be older than this scenario suggests.

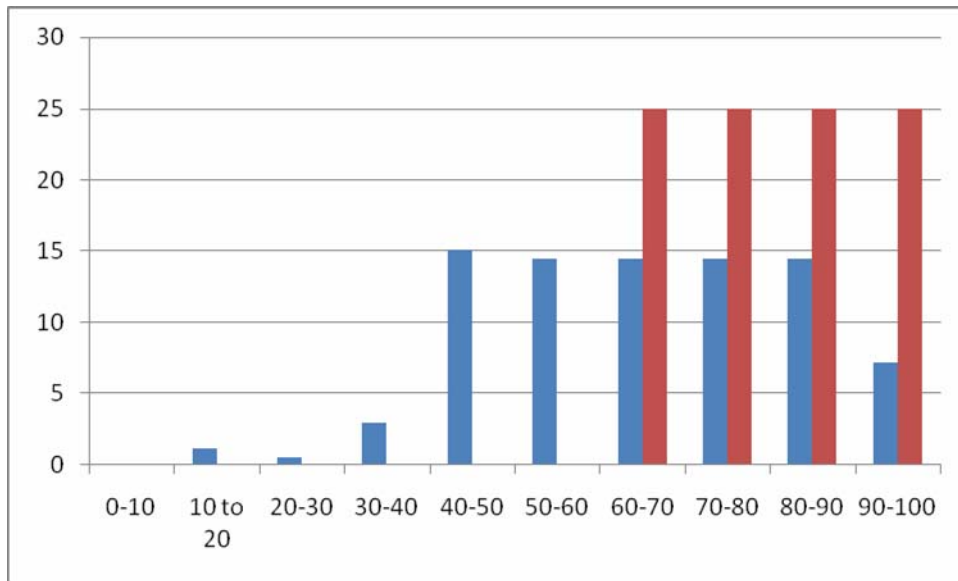


Figure 4.5. Estimated age profiles from Beasley (1996) (blue) and Moorkens (2009) (red)

The results of the 2009 monitoring show that silt and nutrients are the major negative influence on the population, although pearl fishing may have exacerbated the adult decline. The population is in unfavourable conservation status and this is summarised in **Table 4.2**.

Based on the numbers of mussels in the population, the current rate of loss compared with recruitment, and the age/size profile of the population, **Figure 4.6** shows the rate of loss of the population.

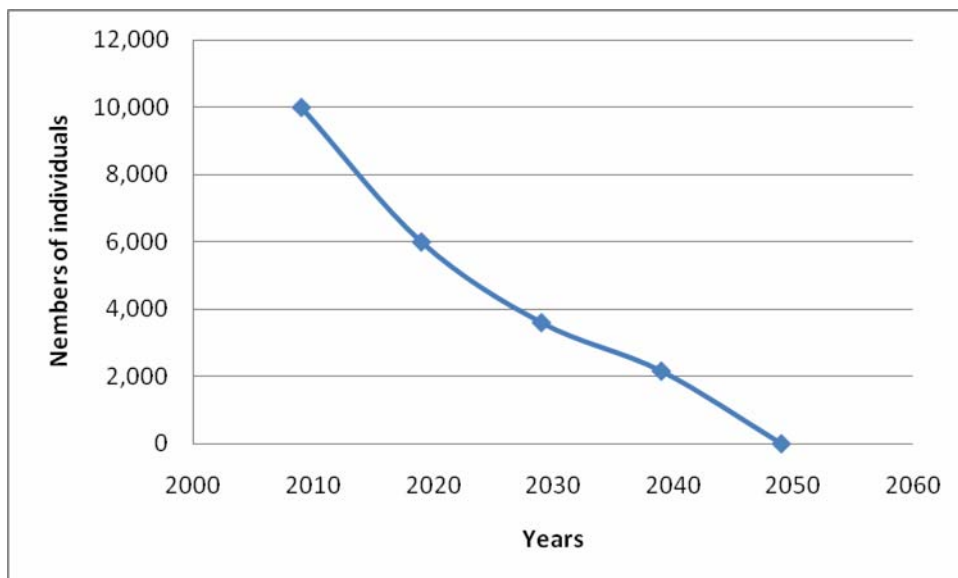


Figure 4.6 Predicted numbers of mussels over time in the Owenea River

If measures are implemented immediately and it takes ten to fifteen years for the habitat to recover sufficiently to support juvenile recruitment, 60% of the population or 6,000 individuals would be lost, and if measures are delayed or are insufficient, losses will be much higher and extinction more difficult to prevent. The prevention of extinction cannot be guaranteed, some captive breeding may be

necessary to provide a younger range of sizes within the timeframe of the implementation of measures, as many of the remaining mussels (although still reproductively functional) may be very old.

Table 4.2 Assessment of *Margaritifera* Regulations in Owenea River 2009.

<i>Margaritifera</i> parameter	Requirement under Regulations	Status in Owenea	Pass or Fail
Adult numbers	No recent decline in live adults	Recent decline in live adults	Fail
Dead shells	No evidence of non-natural dead shells (>1%)	> 1% present	Fail
% individual mussels under 65mm	20%	0%	Fail
% individual mussels under 30mm	5%	0%	Fail
Siltation level	No artificially elevated levels of siltation - No silt plumes.	Strong silt plumes. 39.15% loss at 5cm	Fail

4.3 CURRENT WATER QUALITY IN THE OWENEA CATCHMENT

Trends from the Monitoring Results

The Environmental Protection Agency as part of the National Rivers Monitoring Programme and now its replacement Water Framework Directive Monitoring Programme (operational since 2007), have monitored the Owenea Freshwater Pearl Mussel catchment since 1971. The latest Q value assessments from the catchment were carried out in 2009. **Table 4.3** summarises trends in water quality information as measured through the Q-value system from the Owenea catchment. The table is arranged with the results for the tributaries of the Owenea river detailed first – the Stracashel and the Shallogan, followed by results of the assessments of the Owenea river itself.

The trends in Q values for all three rivers since monitoring began in 1971, is one of deteriorating water quality. The Owenea river itself has dropped in Q ratings from Q5/4-5 to Q4/3-4. Stracashel site 200 was heavily impacted in 2009 with a Q rating of 3 or poor status.

Table 4.3 Q-values at EPA monitoring sites in the Owenea catchment since 1971 (SMN and OMN specify sites on the WFD surveillance and operational monitoring networks respectively)

RIVER	LOCATION	FULLCODE	SMN	OMN	X	Y	'71	'73	'77	'80	'81	'84	'90	'94	'97	'00	'03	'06	'09
Stracashel	Bridge d/s Shallogan R	38S010050	N	N	183825	396395	~	~	~	~	5	~	5	4-5	5	5	4-5	4	~
Stracashel	500 m d/s Bridge in Glenties	38S010200	N	Y	181655	394017	~	4-5	3-4	~	4-5	~	3-4	4	4	4	3	3	3
Shallogan	Just u/s Stracashel River	38S030300	N	N	183748	396566	~	~	~	~	~	~	4-5	4-5	4-5	4-5	4	4	3-4
Owenea	Br SW Tangaveane	38O040040	N	N	189049	393792	~	~	~	~	~	~	~	5	4-5	4-5	4-5	4	~
Owenea	Bridge S. of Mullanmore	38O040100	N	N	184774	393748	5	5	5	5	~	4-5	5	5	4-5	4-5	4	4	4
Owenea	Footbr 2 km d/s StracashelR	38O040300	N	N	180635	393332	5	5	5	5	~	5	4	4	5	4	4	3-4	~
Owenea	Owenea Bridge	38O040500	N	N	173693	392030	5	5	5	4	~	4	4	4	4-5	4	4	4	4

WFD Ecological Status

Surface water monitoring includes ecological and chemical parameters. For ecological status, quality elements, representing plants, insects and fish, along with supporting water quality, hydrology and morphological conditions are sampled and analysed in rivers and lakes to allow water bodies to be classified into one of five classes of ecological status; high, good, moderate, poor and bad. New standards were set in the *Surface Waters Environmental Quality Objectives Regulations (SI 272 of 2009)*. A range of elements are measured in each water body, and a classification is produced based on a 'one out, all out' principle. This uses the poorest individual element result to set the overall classification. Once the status of monitored water bodies is determined all water body types (e.g. river or lake) in the River Basin District (RBD) are clustered according to typology (physical characteristics) and risk assessment (from Article 5 characterisation) This provides a type and pressure profile of water bodies which allows status to be extrapolated from monitored (donor) water bodies to unmonitored (recipient) water bodies. The components of overall status are illustrated in **Figure 4.7** below.

In the case of some water bodies, they are designated as 'artificial' or 'heavily modified'. This is because they may have been created or modified for a particular use such as water supply, flood protection, navigation or urban infrastructure. By definition, artificial and heavily modified water bodies are not able to achieve natural conditions. Instead the classification and objectives for these water bodies, and the biology they represent, are measured against 'ecological potential' rather than status.

There are no artificial or heavily modified water bodies in the Owenea catchment.

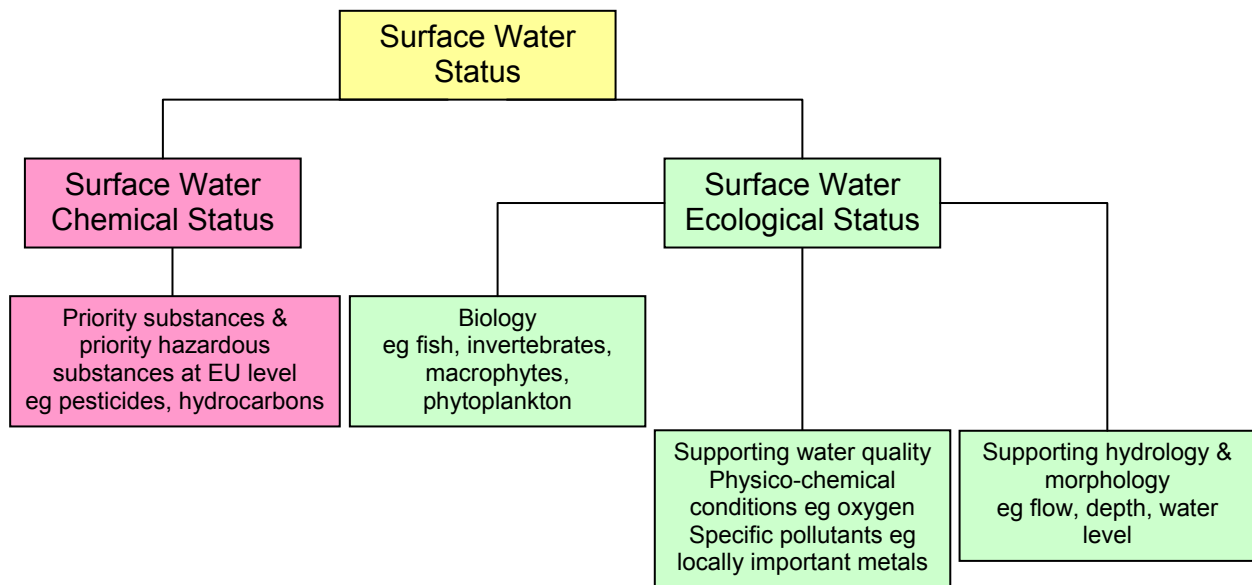


Figure 4.7 The components of overall status for surface water bodies

Under the assessment of ecological status macroinvertebrates include a special consideration of the conservation status of the freshwater pearl mussel in SACs protected for the species. In such areas where the freshwater pearl mussel is at unfavourable conservation status, the EPA must assign a status of 'less than good ecological status', where on the basis of specialist surveys undertaken to assess conservation status, the freshwater pearl mussel is found to be in unfavourable conservation status owing to water quality or hydrology in that water body (Freshwater Pearl Mussel Regulations, 2009).

Figure 4.8 shows the interim WFD status classification for the Owenea catchment as of December 2009 (note this does not include monitoring data from the 2009 survey year. Classification is based on data from 2006-2008). The Owenea catchment river water bodies were classified as follows: 4 high status, 9 good status, 1 moderate status and 1 poor status water body. All 4 high status water bodies

were determined via extrapolated status from donor monitored water bodies. Macroinvertebrates determined the status in 2 good status and 1 poor status water bodies, while the remaining 7 good status water bodies were determined via extrapolation. The freshwater pearl mussel is at unfavourable conservation status and downgraded status in 1 moderate status water body. This water body would otherwise have been classified at good status.

The Owenea catchment lake water bodies were classified as follows: 3 high status water bodies (Magrath Beg, Magrath More and Nadeal loughs), 1 good status water body (Anna lough) and 1 moderate status water body (Ananima lough).

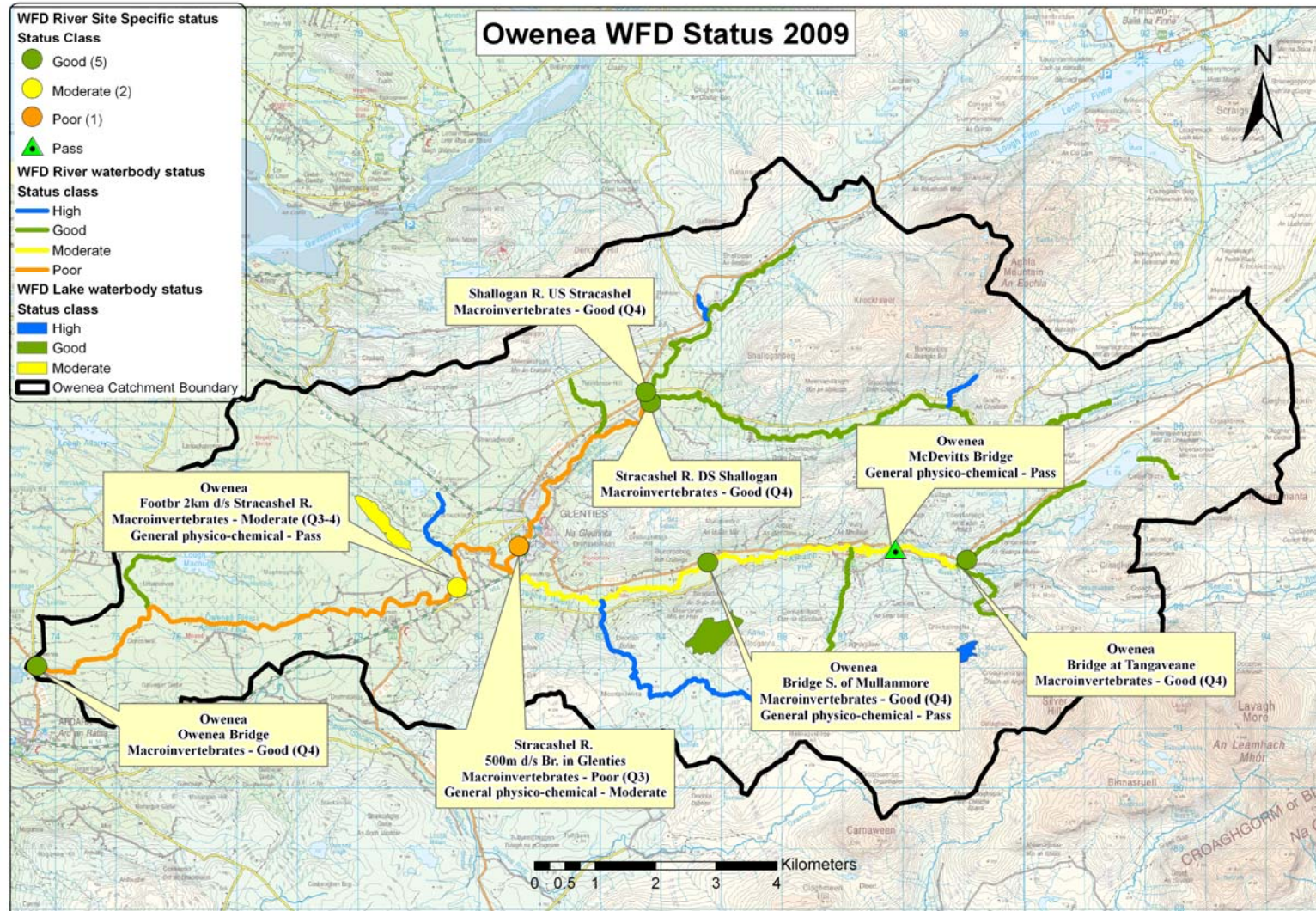


Figure 4.8 WFD river and lake status classification for the Owenea catchment

WFD Chemical Status

For chemical status, EU wide standards have been established for priority and priority hazardous substances which include certain metals, pesticides, hydrocarbons, volatiles and hormone-disrupting compounds. These standards have been transposed in Irish legislation (*SI 272 of 2009*). Exceedance of a standard results in a water body failing good chemical status. There are two classes for the chemical status of surface waters: good or fail.

The following Irish Dangerous Substances Monitoring Programmes were reviewed to see if any monitoring sites were located within the Owenea catchment:

- WFD Surveillance Monitoring Programme 2007-2009
- Dangerous Substances Screening Monitoring Programme (05-06)
- Local Authority Dangerous Substances Monitoring Programme (02-05)
- EPA Monitoring Data 99-00
- EPA Monitoring Data 02-03

There are no sites monitored in the Owenea catchment as part of the programmes reviewed.

Catchment Water Quality Monitoring 2009

A robust monitoring programme is required to assess the status of the freshwater pearl mussel population and their habitat. The Ecological Quality Targets for designated pearl mussel sites under the Freshwater Pearl Mussel Regulations (2009) are detailed in Table 1.2. Assessment of the compliance with these environmental objectives was ascertained during monitoring undertaken during 2009. This monitoring also involved a catchment walkover risk assessment where the pressures within the catchments were documented, and this is presented in Chapter 3.

Results from that survey work are summarised below for macroinvertebrates, filamentous algae, diatoms, macrophytes and siltation. The morphological condition of the catchment was also assessed and is also reported on below. A Monitoring Methods Manual and also detailed background reports for each element monitored should be consulted for more detailed information on methodologies, results, and conclusions, and are available at www.wfdireland.ie.

Macroinvertebrates

Sampling was carried out at 12 sites on the 28th and 29th June 2009 in fair weather. The Owenea catchment includes two larger rivers; the Owenea and Stracashel; both of which flow through the town of Glenties, confluencing just downstream of the settlement. Lough Ea outlet stream forms the headwaters of the Owenea River, while two tributaries - Owengarve (upper) and Owengarve (lower) - confluence directly with the Owenea between L. Ea and Glenties. The Shallogan River drains a significant sub-catchment, confluencing with the Stracashel upstream of Glenties.

Macroinvertebrate EQR's are below target value for pearl mussel sites (≥ 0.9) at all locations during these surveys, suggesting water quality is not presently meeting statutory ecological objectives for pearl mussels in the majority of the catchment.

It must be noted that conditions during these surveys may represent the worst case scenario for the system as river flows were low following an extended period of dry, hot weather. All sites sampled on the main channels of both the Owenea and the Stracashel, had EQR ratings of

between 0.6 and 0.7 placing the WFD status between 'Poor' and 'Moderate'. Interestingly, Q-values from this survey appear to be following a trend of consistent decline in water quality at sites in the catchment as evidenced by EPA monitoring over the past 38 years (see **Table 4.3**).

Sites ON3 (Owenea DS Glenties) and ON9 (Stracashel US Owenea confluence) had distinct "sewage" smell to the water and obvious signs of imbalance (enrichment related) in the faunal assemblages.

Table 4.4 Macroinvertebrate survey results

EPA Site Code	Site No.	River	EPA Assessment 2009	Survey results 2009	EQR	WFD Status
38O040500	ON 1	Owenea	3-4	3-4	0.7	Moderate
-	ON 2	Owenea		3-4	0.7	Moderate
38O040300	ON 3	Owenea	4	3-4	0.7	Moderate
38O040100	ON 4	Owenea	4	3	0.6	Poor
	ON 5	Owenea		3-4	0.7	Moderate
	ON 6	Owenea		3	0.6	Poor
	ON 7	Owengarve (Upper)		4	0.8	Good
	ON 8	Owengarve (Lower)		4	0.8	Good
38S010200	ON 9	Stracashel	3	3-4	0.7	Moderate
38S010050	ON 10	Stracashel	4	3	0.6	Poor
	ON 11	Stracashel		3-4	0.7	Moderate
38S030300	ON 12	Shallogan	4	3-4	0.7	Moderate

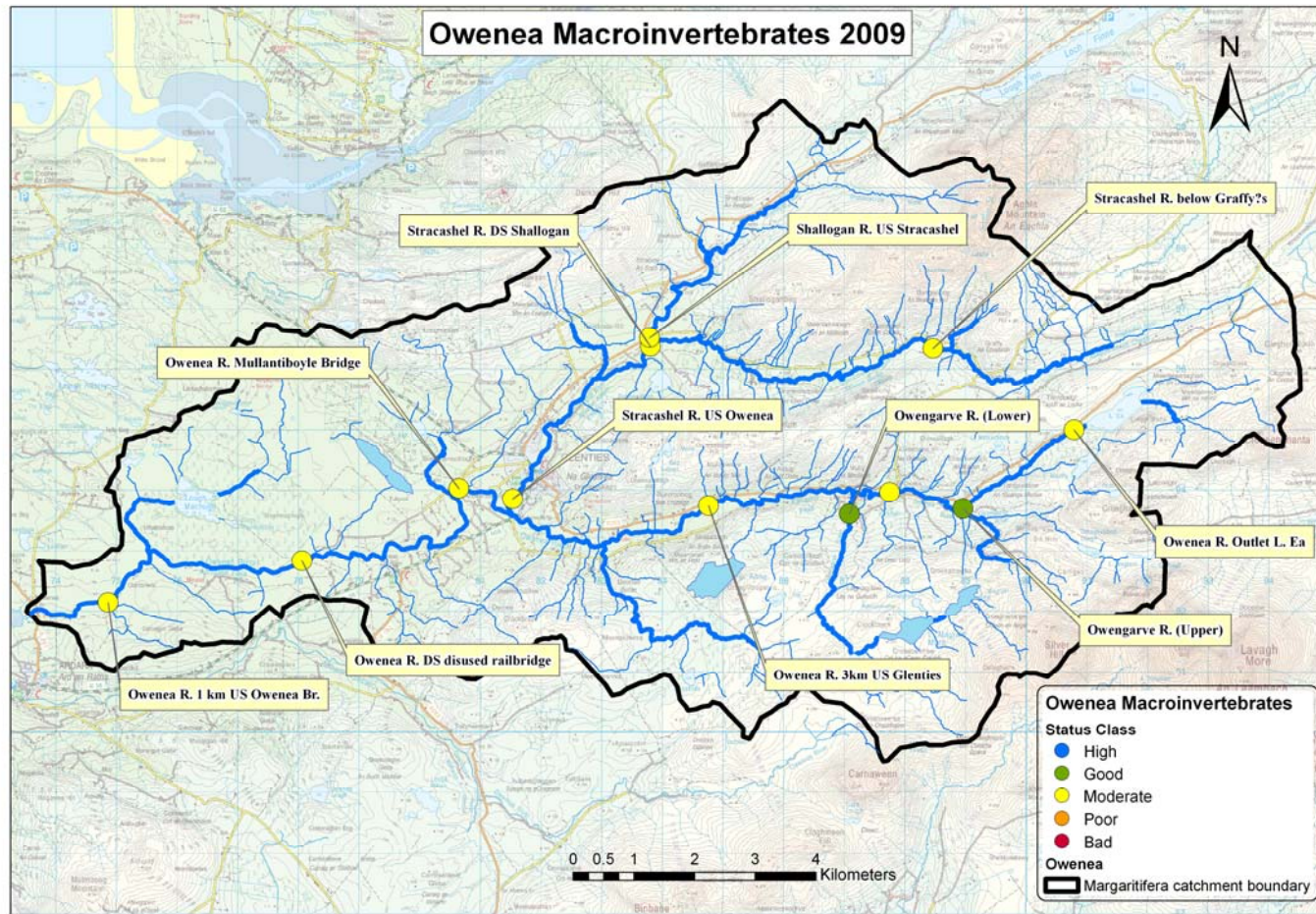


Figure 4.9 Macroinvertebrate survey results

Filamentous algae

Sampling was carried out at 4 sites in the Owenea catchment (**Table 4.5** below). A detailed inspection of a 10m length of each river site was conducted, and the nature of the stream environment, the substrata available for macroscopically visible growths and the nature and abundance of any macroscopic growth forms present were recorded. The abundance of each macroscopic element is estimated using a simple descriptor scale. This is based on the percentage of the stream or river bed (within the survey unit) that is covered by the assemblage as follows: 1=Rare, just visible in the field, covers <1% of the river bed; 2 = Occasional, covers 1% to <5% of the river bed; 3= Frequent, covers 5% to <25% of the river bed; 4 = Abundance, covers 25% to <50% of the river bed; 5 = Dominant, covers \geq 50% of the river bed. The quantification is based on “qualified judgment”.

Results are illustrated in **Figure 4.10** and detailed in **Table 4.5** below. The abundance of the macroscopically visible algae was unexpectedly high at all sites surveyed, particularly as it was so early in the season when sampling took place – 22nd of April 2009. All sites exceeded the objective of \leq 5% filamentous green algae by multiples of that amount. The site downstream of Lough Ea was dominated by *Batracospermum* sp., *Mougeotia* sp., and *Oedogonium* sp. (between 50 and 75%). The site upstream of Glenties was dominated by *Mougeotia* sp., *Microspora* sp. and *Ulothrix zonata* (between 5 and 25%). Downstream of Glenties, the assemblage was composed of *Microspora* sp. and *Oedogonium* sp. (25 to <50%), while at Owencarrow Bridge the assemblage was mono-dominant with *Oedogonium* sp., the only genus identified (between 5 and 25%).

Microspora and *Mougeotia* although present in high abundance at two of the sites (d/s L. Ea, u/s Glenties), the genera themselves are not indicative of elevated nutrient levels as far as current knowledge of the genera suggests. Genus-level identification of both permits a deduction about good ecological status and Kelly *et al.* (2006) found that for rivers they occurred at filterable reactive phosphorus levels < 30 $\mu\text{g l}^{-1}$, (and at TP < 35 $\mu\text{g l}^{-1}$ in lakes). However little more is known about its ecology, and therefore any deductions are cautious based on limited surveys.

The abundance of *Batracospermum* sp., at the site downstream of Lough Ea is considered acceptable by the author as this genus has been identified from previous analysis of macroscopic algal datasets in Ireland and the UK (Kelly *et al.*, 2006) as a likely indicator of high and good status, but requires further investigation through additional surveys in order to confirm this finding. The genus does not form mats which might cover river bed substrata, and neither does it trap silt in its assemblage – both which are characteristics of negative conditions for freshwater pearl mussel habitats.

Oedogonium sp, has little known about its nutrient preference, but was found at high abundance at all 4 sites surveyed. It has been consistently found in a number of the pearl mussel catchments e.g. Ownagappul and Owenriff and has formed a nuisance level of abundance in these cases, which is more pronounced in the Owenriff. No distinctive distribution pattern along a phosphorus gradient from Irish and UK sites could be found in Kelly *et al.* (2006), however this may have been as a result of the sites in the dataset which were mainly high quality sites with low phosphorus levels from the RivType dataset (see Kelly-Quinn *et al.*, 2005). Biggs and Kilroy (2000) comment on *Oedogonium* being normally associated with fairly enriched conditions, but it may also occur in streams with little apparent enrichment. *Oedogonium* is reported to grow over a wide range of pH conditions in nutrient poor and nutrient rich waters, however little more is known about its ecology (John *et al.*, 2002). The abundance of this species is worth monitoring on a frequent basis as it blankets a lot of freshwater pearl mussels and their habitat.

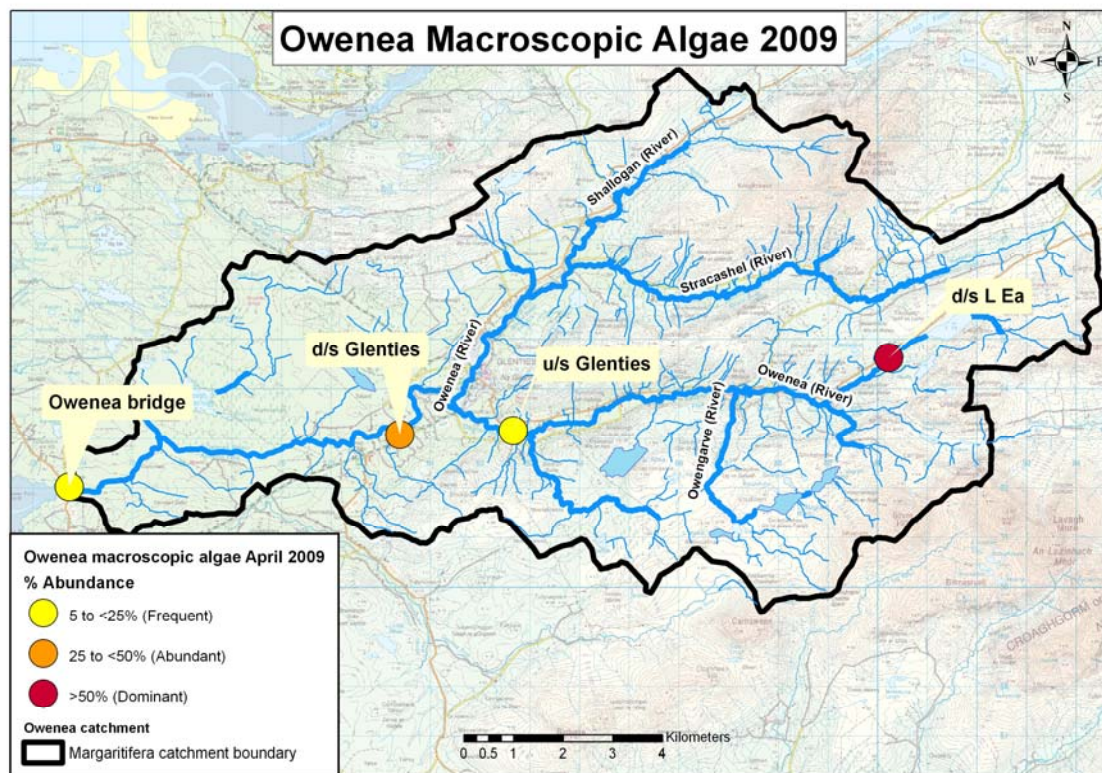


Figure 4.10 Macroscopic algal survey results

Table 4.5 April 2009 macroscopic algal composition and abundance for the Owenea river (final abundance: 1=Rare, just visible in the field, covers <1% of the river bed; 2 = Occasional, covers 1% to <5% of the river bed; 3= Frequent, covers 5% to <25% of the river bed; 4 = Abundance, covers 25% to <50% of the river bed; 5 = Dominant, covers \geq 50% of the river bed)

River	Owenea	Owenea	Owenea	Owenea				
Location	d/s L Ea	u/s Glenties	d/s Glenties on N56	Owenea bridge				
X	190218	182663	180375	173723				
Y	394627	393162	393081	392026				
Date sampled	21/04/2009	21/04/2009	21/04/2009	21/04/2009				
% Abundance of MA in field	\geq 50% (but <75%)	5 to <25%	5 to <50%	5 to <25%				
	Presence/ Absence	Final Abundance	Presence/ Absence	Final Abundance	Presence/ Absence	Final Abundance	Presence/ Absence	Final Abundance
<i>Audouinella hermanii</i>	Present	1						
<i>Batracospermum</i> sp	Present	4						
<i>Lemanea fluviatilis</i>	Present	1						
<i>Microspora</i> W=22.5 μ m		Present	3	Present	3			
<i>Mougeotia</i> sp	Present	4						
<i>Oedogonium</i> sp	Present	4	Present	3	Present	4	Present	3
<i>Ulothrix zonata</i>		Present	3					

Diatoms

Diatoms can be found growing on most submerged surfaces. Areas of the river bed with naturally occurring moveable hard surfaces (large pebbles, cobbles and boulders) are recommended wherever possible for water quality sampling. For accurate identification of diatoms, it is necessary to remove all the cell contents and mount the diatoms using a mountant with a high refractive index. Diatom valves are identified and counted at 1000x magnification until a minimum of 300 valves are enumerated and identified. Results are entered in to excel and then analysed using a Microsoft windows programme (DARLEQ project – Diatom Assessment of River and Lake Ecological Quality). The program implements a classification algorithm using a metric based on a revised Trophic Diatom Index (TDI). The programme calculates the TDI score, Ecological Quality Ratio (EQR) and status class for each sample. EQRs are produced by comparing the observed TDI with that expected to be obtained if the site was at reference condition i.e. in the absence of eutrophication pressures.

Results are illustrated in **Figure 4.11** and detailed in **Table 4.6** below. TDI results for all 4 sites sampled on the 22nd of April 2009 show a diatom community at high status. The samples were dominated by *Achnantheidium minutissimum* at all sites, and amongst the sites the following species were also abundant (approximately reached 10-15%): *Achnantheidium microcephalum*, *Encyonema silesiacum*, *Fragilaria vaucheriae*, *Gomphonema parvulum var exilissimum*, and *Tabellaria flocculosa*. *Achnantheidium minutissimum* is an indicator of high status, as are *Achnantheidium microcephalum*, *Fragilaria vaucheriae*, *Gomphonema parvulum var exilissimum*, and *Tabellaria flocculosa* when present in high relative abundance. *Encyonema silesiacum* is in general more typically found at lower relative abundance at high status, as was the case for 2 sites (approximately 10% abundance). Sampling was perhaps carried out too early in the season as Spring diatom samples can at times reflect an assemblage that has not yet fully established itself after the Winter period. This is reflected in the current results due to the high abundance of *Achnantheidium minutissimum*, which is generally an early colonist in a diatom assemblage, although it is common species throughout the succession of a diatom assemblage. It is recommended that sampling is repeated during the Summer, but specifically around August/September time in order to establish more confidence in the results from April 2009.

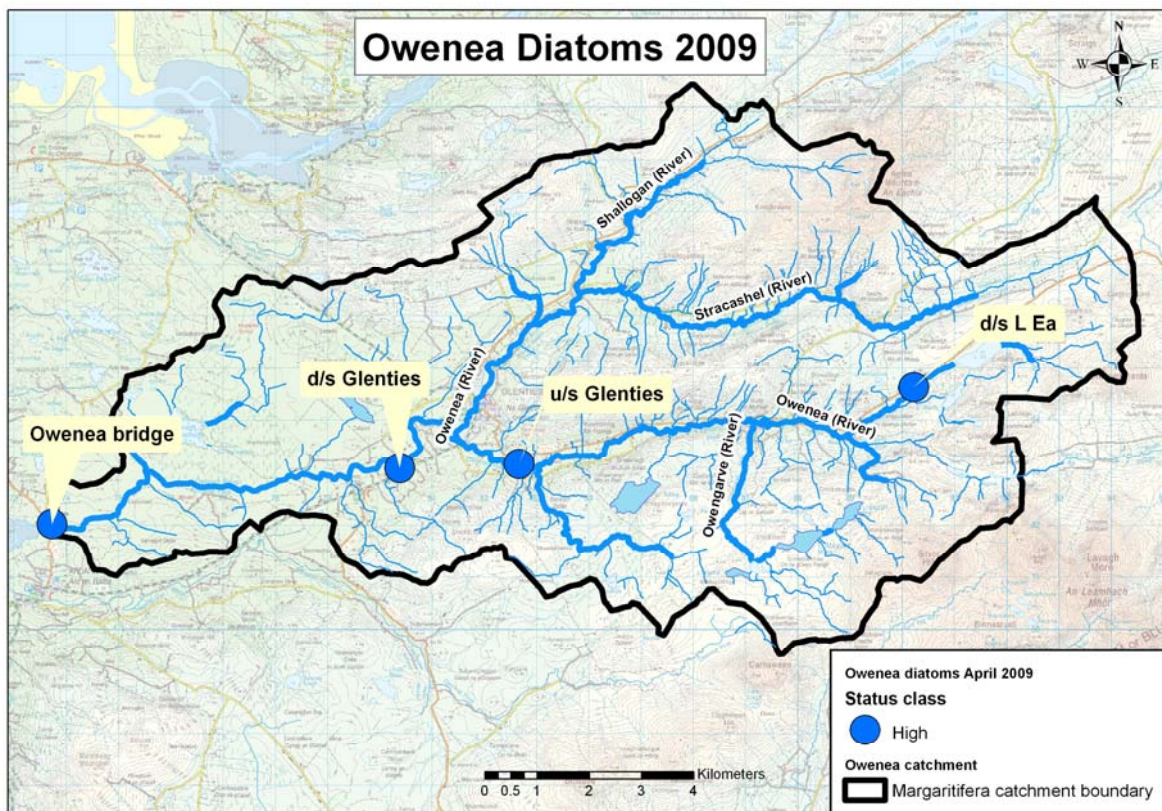


Figure 4.11 Diatom status results

Table 4.6 TDI Results – diatom index (column heading explanations: Sample Date – as stated; River – river name; Site – location from which sample was taken; EQR – Environmental Quality Ratio for each sampled based on predicted TDI for observed alkalinity and season; Class – WFD status class; % Planktic- % of taxa identified which were planktonic. These are excluded from status calculations; % Motile - % of taxa counted which were motile; % Organic tolerant - % of taxa which are organic tolerant)

Sample Date	River	Site	TDI	EQR	Class	% Planktic	% Motile	% Organic tolerant
21-Apr-2009	Owenea	Owenea bridge	30.11	0.99	High	0	6.17	4.22
21-Apr-2009	Owenea	d/s Glenties on N56	27.07	1	High	0.32	5.71	9.21
21-Apr-2009	Owenea	u/s Glenties	16.06	1	High	0	0.66	9.24
21-Apr-2009	Owenea	d/s L Ea	8.16	1	High	0	5.03	38.99

Macrophytes and filamentous green algae

Habitat assessment was carried out at each of the sites selected for macroinvertebrate assessment. Included in this assessment was an analysis of instream vegetation, listing plant species occurring and their percentage coverage of the stream bottom at the sampling site, and dominant bankside vegetation, listing the main species overhanging the stream.

Sampling was carried out at 12 sites on the 28th and 29th June 2009 in fair weather. In general, plant communities are comprised of bryophytes at most sites. There were no major issues with rooted macrophyte growth at the sites sampled. Filamentous Green Algae (FGA) was recorded to have high coverage values at some sites, but growths were not luxuriant.

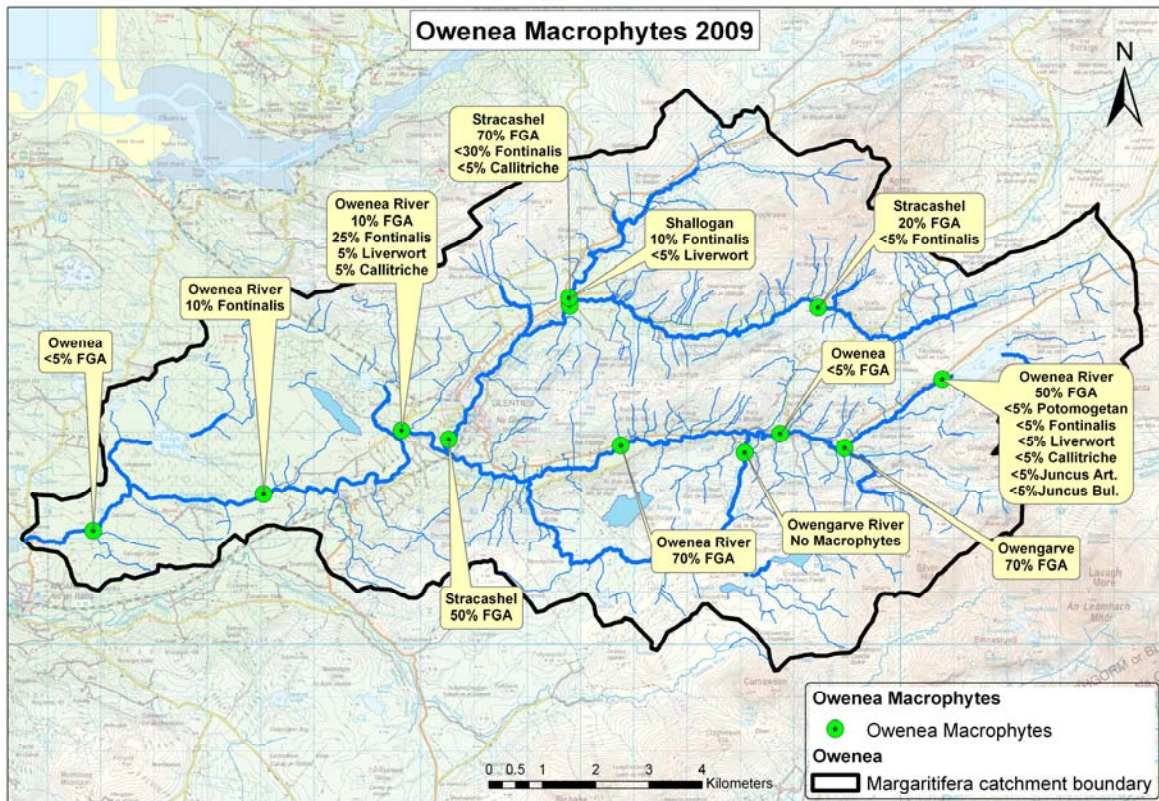


Figure 4.12 Macrophyte survey results

In addition to the general macrophyte catchment survey, macrophyte and filamentous green algae (FGA) growth were recorded in relation to their proximity to freshwater pearl mussels during the freshwater pearl mussel surveys.

While the 2009 freshwater survey work did not find excessive rooted macrophytes in mussel areas, there had been a number of flood events prior to the survey. In 2007, there were excessive quantities of *Myriophyllum* and *Callitriche* in mussel habitats, and in 2009 decayed organic matter was evident. Thus, although levels of rooted macrophytes were below 5%, i.e. within the target for favourable conservation status, there was clear evidence of excessive nutrient levels in the sediment. The Pearl mussel Regulations 2009 refer to macrophyte cover at the site of the mussels rather than within the whole river as it is the direct impact of inappropriate growth that affects the mussel individuals. Mussel beds occur at stable areas of river bed, and it is here that silt and nutrient effects are most severe. More unstable areas or areas of deeper or highly shaded water are unlikely to support high macrophyte or FGA growth, whereas show flowing areas with sediment accumulations are areas where macrophytes would be naturally present.

Siltation

As stated, habitat assessment was carried out at each of the sites selected for macroinvertebrate assessment. The Freshwater Pearl Mussel Regulations require that there is no artificially elevated levels of siltation present at the pearl mussel habitat. This is evidenced by the absence of plumes of silt when the substratum is disturbed. The surveyor performs a substrate kick in order to ascertain whether a plume of silt is generated or not. The surveyor must then note one of the following three observations;

1. No visible silt plume (none)
2. Some visible silt (moderate)
3. A lot of visible silt (significant/heavy)

It is important to note that the silt assessments are indicative of the catchment rather than individually significant. There may be reasons for absence of silt or pockets of silt in any river. Silt will not settle in unstable, fast flowing habitats of rivers, but where present will accumulate in the more stable habitats where the silt can slow down and drop to the river bed. Unfortunately, the freshwater pearl mussel always occurs at stable habitats. The most important individual areas of silt assessment are in the mussel habitat itself. The Freshwater Pearl Mussel Regulations 2009 refer to habitat conditions at the site of the freshwater pearl mussel habitat for this reason. As seen in Section 4.2 above, there were very high silt levels at the site of freshwater pearl mussel habitat, with average redox potential loss at 5cm of 39.15%. Geist & Auerswald (2007) found that average redox potential loss at 5cm of less than 20% was required for juvenile survival. Hence the siltation levels of the Owenea Catchment is currently unfavourable .

Figure 4.13 illustrates the results from this assessment in the broader catchment. In the Owenea catchment, the silt plume was recorded as not significant in 2 locations, moderate in 5 locations and significant in 5 locations assessed. Significant siltation was an issue at all sampling locations on the Stracashel and Shallogan and on the Owenea at the Lough Ea outlet.

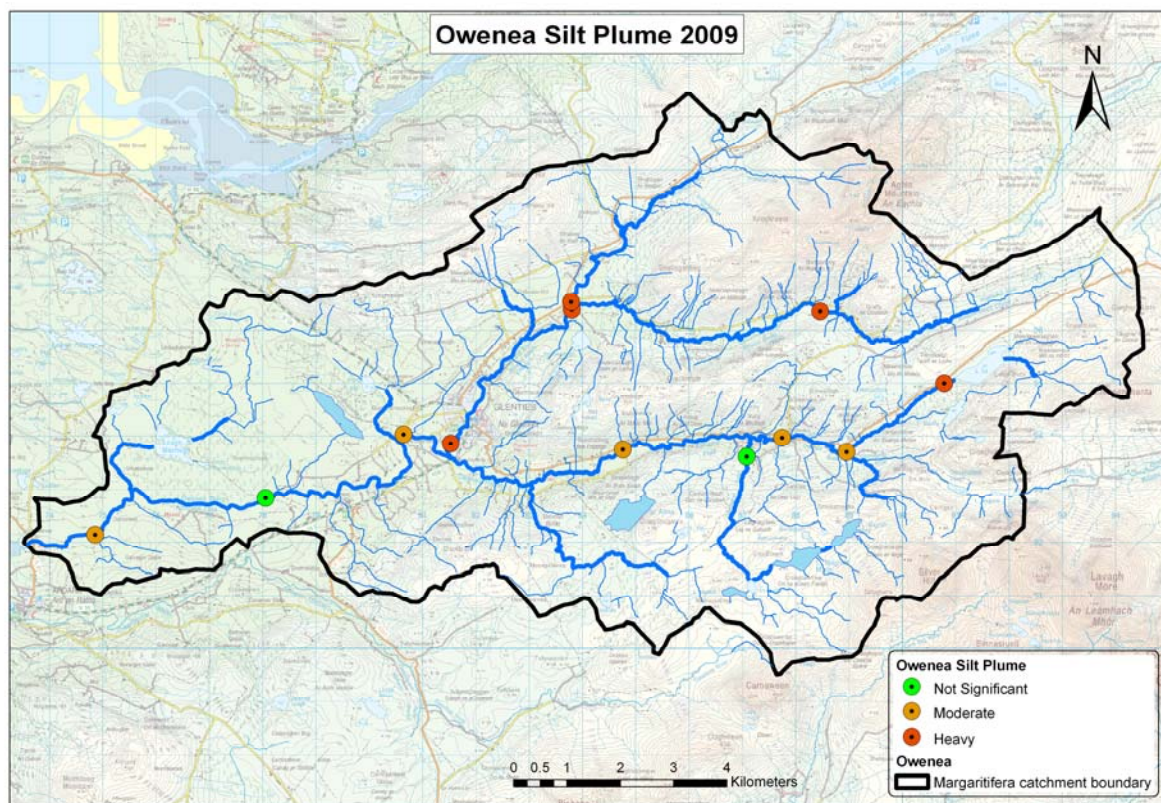


Figure 4.13 Silt plume survey results

Morphology

In order to assess the hydromorphological alterations within the catchment the EPA WFD classification tool called the River Hydromorphology Assessment Technique (RHAT) was utilised. It is a field

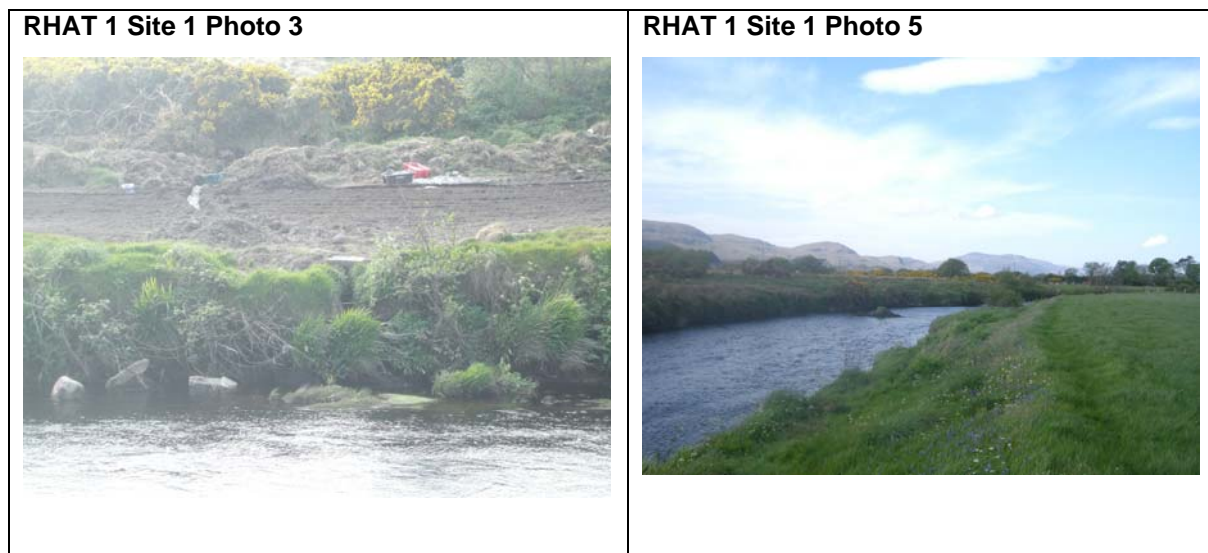
technique which assigns a channel typology. This influences the rivers physical attributes assessed in the field. The technique assigns a morphological classification directly related to that of the WFD – high, good, moderate, poor and bad. RHAT surveys were carried out within pearl mussel habitat. The methodology classifies river hydromorphology based on a departure from naturalness, and assigns a morphological classification, based on semi-quantitative criteria. It is designed to be a rapid visual assessment based on information from desktop studies, using GIS data, aerial photography, historical data and data obtained from previous field surveys as well as observations in the field.

Classification of hydromorphology can be used to contribute to the status classification of water bodies at high ecological status only. However, RHAT plays a vital role in identifying why a water body might be failing to achieve good ecological status as it is based on the observed impact in the field. It can assist in deciding what indirect and direct efforts are needed to improve status and in helping to prevent further deterioration.

Two RHAT surveys were carried out throughout the Owenea catchment.

RHAT Number 1 was carried out at the lower end of the catchment near Ardara on a lowland meandering channel over a 45m stretch. One major bridge and some over deepening was recorded along the survey stretch together with numerous land drains entering the channel. The channel appears to have been drained in the past. All attributes except for barriers to migration and substrate condition scored low. Bank structure and stability, bank vegetation and riparian landcover all only scored one out of four. This is due to the lack of buffer zone and the intensive landuse which in places is right up to the banks. Improved grassland can be found on one bank and recently ploughed land on the other bank with newly excavated drains discharging directly to the river channel. Along a significant stretch of the channel a new access road has been laid using rock with little to no buffer with the river channel. It is <1m in most parts of the stretch. (See Site 1 Photo 9). Overall this stretch was classified as moderate status. It has significant alterations which have occurred in the past together with on-going pressures and risks such as the numerous un-managed drains and direct discharges.

Plate 4.1 Representative photographs from reach:



RHAT 1 Site 1 Photo 9

The second RHAT survey was carried farther up the catchment just outside Glenties at site 5. This was carried out over a 298m survey stretch on a lowland meandering channel. One major and one minor bridge together with a minor weir were recorded along the survey stretch. This stretch has undergone significant morphological alterations with resectioning on both the left and right banks, excessive (>30%) reinforcement on the left bank and embankments on both the left and right bank. All attributes scored quite low along this survey stretch except for barriers to migration. In particular bank structure and stability, bank vegetation and riparian landcover all scored low due to the physical modifications. Very small amounts of algae were recorded on the bank side but largely the substrate was found to be in good condition.

Plate 4.2 Representative photographs from reach:

RHAT 1 Site 5 Photo 1**RHAT 1 Site 5 Photo 4**

RHAT 1 Site 5 Photo 11

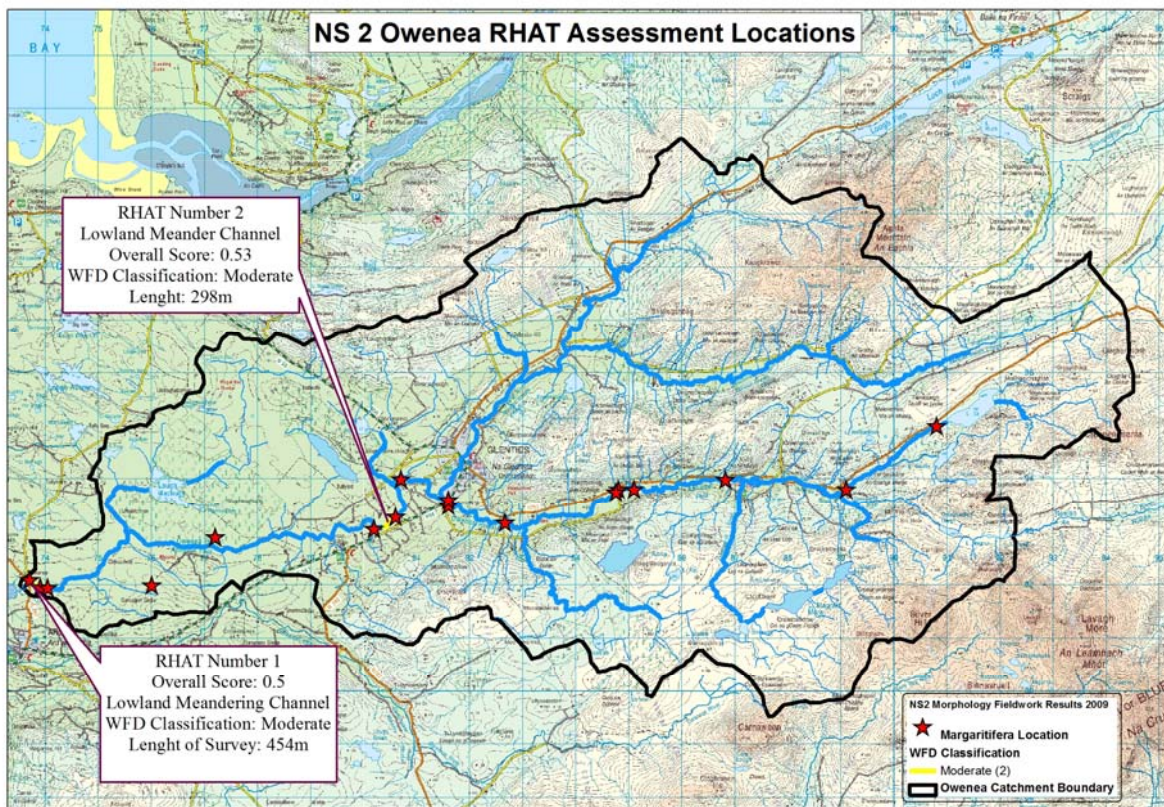


Figure 4.14 Morphology RHAT survey results

5 MONITORING

This chapter will be up-dated for the final plan to provide further detail on the future monitoring required for the Freshwater Pearl Mussel and its biological and general physico-chemical supporting elements. The specific stations at which each biological, physical and chemical element is to be monitored will be detailed in a background document and associated table. Further information on the methods, the timing of sampling and the responsible bodies will also be provided in the background material.

5.1 Overview

The monitoring programme for the Owenea catchment has been designed to evaluate the effectiveness of the measures in this Sub-basin Management Plan and the progress made towards restoring favourable conservation status.

This programme shall comprise monitoring of:

- Freshwater pearl mussels
- Other biological elements
- General physico-chemical components

And will fulfil the monitoring requirements set out in S.I. 296 of 2009 through monitoring the criteria listed in the Third Schedule and the elements listed in the Fourth Schedule.

5.2 Freshwater pearl mussels

For the purposes of examining the overall changes in the distribution and abundance of mussels, and their mortality rates permanent mussel transects (or similar, permanent count areas) will be counted annually, completing a full cycle of transect monitoring once every three years. Typically, six transects will be counted per population, with two counted per population per year. The locations of the permanent transects was chosen to cover the geographical range of mussels within the catchment, their range of population density and to best detect any changes resulting from the implementation of the measures. Further information on the location of the transects and the schedule for monitoring will be provided in the final plan and background documents. Transect monitoring involves counting the number of adult mussels visible on the substratum, as well as the cover abundance of silt, macroalgae and macrophytes, and is, thus, a good method of detecting events such as kills of adults, as well as providing an indication of the general health of the mussel habitat. This method does not yield information on the health of juvenile mussels or their riverbed habitat.

In order to monitor the conservation status of the mussel populations, in accordance with the two shell-length criteria set out in the Thrid Schedule of S.I. 296, 2009, quadrat searches will be conducted once every three years. Quadrat searches involve removing all of the mussels, both adults and juveniles, from a fixed area of substrate (50 cm X 50 cm) and measuring their length. This provides information on whether the population is recruiting or not and allows any changes in population age structure to be detected. Macroalgal and macrophyte cover is also assessed in each quadrat, along with sedimentation (through both visual means and redox potential measurement). Quadrat searches will be distributed throughout the mussel population, to determine the overall conservation status of the population, as well as targeted at sites subject to specific measures, in order to evaluate the effectiveness of such measures. In order to further elucidate whether the mussel population is recruiting or not, quadrat searches may be supplemented by experimental kick sampling to look for one to two year-old mussels. Further information on the schedule for quadrat monitoring will be provided in the final plan and background documents.

5.3 Monitoring of the biological and physical elements listed in the Fourth Schedule to S.I. 296 of 2009

Restoration of the mussel population to favourable conservation status is the ultimate criterion for measuring the success of the Sub-basin Management Plan. However, as this may take some time to achieve, objectives have been set for other more rapidly responding biological and physical elements under Schedule Four of S.I. 296, 2009 (see Table 1.1). Monitoring of these elements (macroinvertebrates, phytobenthos (diatoms and filamentous algae), rooted plants and silt) will be used to provide an early indication of progress towards restoration. See Chapter 4 for the results of the baseline surveys for these biological and physical elements conducted during 2009.

5.3.1 Macroinvertebrates and phytobenthos

One sampling station has been selected within the Owenea catchment for monitoring of macroinvertebrates and phytobenthos. This station is additional to the existing EPA surveillance and operational monitoring sites and is located within freshwater pearl mussel habitat. Both macroinvertebrates and phytobenthos will be sampled once every three years at this station.

5.3.2 Macroalgae, macrophytes and siltation

In addition to data on macroalgae, macrophytes and fine sediment gathered as part of the freshwater pearl mussel transect counts and quadrat searches (5.2 above), targeted surveys will be conducted at a minimum of two stations within mussel habitat in this catchment. Sites with easy access, such as bridges, will be selected to facilitate more frequent monitoring. Monitoring will be conducted once per month between June and September. Further information on the location of the monitoring stations and methods will be provided in the final plan and background documents.

5.4 Other monitoring of relevant biological elements and general physico-chemical components

In addition to the monitoring detailed in Sections 5.2 and 5.3 above, relevant biological and physico-chemical data will be provided by the on going WFD Monitoring Programme which includes a number of monitoring sites in the Owenea catchment (see Chapter 4).

6.0 SUMMARY OF MEASURES

Programmes of measures have been set out in the North Western IRBD River Basin Management Plan (RBMP) and these RBMP measures also apply in this freshwater pearl mussel catchment. Many of the measures are already provided for in national legislation and are being implemented. These include, for example, the Urban Waste Water Treatment Regulations 2001 to 2010 and the Good Agricultural Practice for the Protection of Waters Regulations of 2009. Others measures are under preparation (for example proposed authorisation regulations for abstractions and physical modifications). A full and detailed list of measures is provided in Table 6.1 and there is more information about the measures in the *national programme of measures background document* and also the suite of *programme of measures — technical studies background documents* where the specific measures for key water management issues are explained (available on www.wfdireland.ie).

A toolbox of freshwater pearl mussel measures has also been developed (Table 6.2) to address the specific pressures impacting on the mussel and its habitat in the 27 SAC catchments.

In the final Owenea Sub-basin Management Plan, detailed text and an additional table will be inserted to identify the specific measures from the toolbox of freshwater pearl mussel measures (Table 6.2) that are required to deal with the significant pressures in this catchment, as identified in Chapter 3, and the impacts detailed in Chapter 4. The specific locations in which the measures are to be applied will be identified, in so far as possible. Further explanations of the function of these measures shall be provided. **Summaries of these catchment-specific measures are provided in Chapter 7, Summary Action Programme.**

The generalized time frame for the implementation of the measures in this Sub-basin Management Plan is as follows:

- The relevant public authorities must examine and review, as required, authorised discharges by the 22nd of December 2011.
- All other measures in this sub-basin management plan shall be made operational by the 22nd of December 2012.

Progress on the implementation of the measures will be reported under the Habitats Directive in 2013 and under the WFD in 2015. Signs of improvement in the parameters listed in Schedule 3 and/or Schedule 4 of the Freshwater Pearl Mussel Regulations (S.I. 296 of 2009) should be evident by 2015.

Table 6.1 Measures under the RBMPs

What	Who leads	When & where
CO-ORDINATING ACTIONS		
<p>Water Policy Regulations (SI 722 of 2003) as amended in 2005: Purpose: provide statutory basis for the provisions of the Water Framework Directive</p> <p>Relevant Actions:</p> <ul style="list-style-type: none"> • Each public authority must exercise its functions in a manner which is consistent with, and contributes to, achieving the objectives of the plan. • • Coordinate activities for the purposes of Articles 4, 5, 7, 10, 11 and 13 of the Directive and report to the European Commission. Maintain a register of protected areas • • Coordinate plan implementation at district level • • Support ongoing public participation and RBD Advisory Councils • • • Coordinate with Northern Ireland authorities and participation groups on shared waters • • Conduct public awareness and targeted education campaigns, including disseminating information using tools such as Water Maps 	<p>Public authorities in Regulations</p> <p>EPA</p> <p>Local authorities</p> <p>Local & public authorities</p> <p>DEHLG, EPA, local authorities</p> <p>DEHLG, local authorities</p>	<p>2009–2015 National</p> <p>2009–2015 National</p> <p>2009–2015 Whole RBD</p> <p>2009–2015 Whole RBD</p> <p>2009–2015 Shared waters</p> <p>2009–2015 National</p>
<p>Surface Water Objectives Regulations (SI 272 of 2009) and Groundwater Objectives Regulations (SI 9 of 2010): Purpose: to give effect to the measures needed to achieve the environmental objectives under Water Framework Directive and the Dangerous Substances Directive</p> <p>Relevant Actions: Where necessary align the following plans and programmes with river basin management plans:</p> <ul style="list-style-type: none"> • land use and spatial plans • conservation and heritage plans • water services strategic plans • pollution reduction plans including national action plan, IPPC programme, local authority discharge authorisation programmes, groundwater and surface water pollution reduction programmes, shellfish waters pollution reduction programmes, bathing waters management plans, waste management plans, freshwater pearl mussel sub-basin plans, groundwater protection schemes, eel and salmon fishery conservation plans 	<p>Local authorities, DEHLG-NPWS, DEHLG, EPA, Coillte, OPW</p>	<p>2009–2015 National</p>

What	Who leads	When & where
<ul style="list-style-type: none"> • waste and sludge management plans • major accident emergency plans • forest management plans • flood risk management plans (forthcoming) 		
<p>Other potential measures which are being considered but which require further development as outlined in Section 5.3. Agreed measures in relation to these issues can be introduced through update of Water Management Unit Action Plans during the implementation process:</p> <ul style="list-style-type: none"> • Protection of high quality waters: • Mines and Contaminated Sites: • Physical impact of channelisation on river status: • Control of Abstractions, Impoundments and Physical modifications: • Estuarine and Coastal (Marine) Monitoring: • Integration of Water Quality and Planning: • Further research. 	To be confirmed	2009–2015 National
Develop guidance and training for local authorities as required	Environmental Services National Training Group	2009–2015 National
BATHING WATERS DIRECTIVE (2006/7/EC)		
<p>Bathing Water Quality Regulations (SI 79 of 2008): Purpose: to ensure that the quality of bathing water is maintained or improved to comply with bathing water standards in order to protect public health and the environment.</p> <p>Relevant actions: Identify bathing waters. Monitor and classify bathing water quality status. Develop Bathing Waters Management Plans, including any necessary measures, to achieve bathing water quality standards. Disseminate bathing water quality information to the public.</p> <p>Cooperate on cross border bathing waters including exchange of information and joint action.</p>	<p>Local authorities</p> <p>Local authorities, DEHLG, EPA</p>	2009–2015 Designated sites
BIRDS AND HABITATS DIRECTIVES (79/409/EEC and 92/43/EEC)		
<p>European Communities (Natural Habitats) Regulations (SI 94 of 1997) as amended in 1998 and 2005: Purpose: to ensure the protection of habitats and species of European importance.</p> <p>Relevant actions: Designate sites hosting habitats and species of European importance for inclusion in the Natura 2000 network as</p>	DEHLG-NPWS,	2009–2015 Designated sites

What	Who leads	When & where
<p>needed. Establish appropriate conservation measures, and management plans where necessary, to ensure achievement of favourable conservation status.</p> <p>Ensure that appropriate assessment is carried out in relation to activities which are likely to impact on designated sites and, where necessary, regulate activities. Introduce compensatory measures to ensure the coherence of the Natura 2000 network if damaging activities are allowed to go ahead.</p> <p>Promote education on the need to protect species and habitats, encourage research necessary to achieve the aims of the regulations.</p> <p>Environmental Objectives (Freshwater Pearl Mussel) Regulations (SI 296 of 2009): Purpose: To set legally binding objectives for water quality in rivers, or parts of rivers, inhabited by freshwater pearl mussels Margaritifera and designated as Special Area of Conservation (SAC) so as to protect this species. The regulations also require steps to be taken to attain those objectives.</p> <p>Relevant actions: Establish environmental quality objectives. Undertake monitoring, assess conservation status and investigate pollution. Develop management plans (sub-basin plans of River Basin Management Plans), including any necessary measures, to ensure achievement of environmental quality objectives.</p> <p>Examine discharge authorisations to designated areas and establish if they require review.</p> <p>Monitor the implementation of the sub-basin management plans and ensure their implementation.</p>	<p>DEHLG</p> <p>Relevant parties DEHLG-NPWS, DEHLG,</p> <p>DEHLG</p> <p>DEHLG-NPWS</p> <p>Public authorities</p> <p>DEHLG</p>	
DRINKING WATER DIRECTIVE (98/83/EC)		
<p>European Communities (Drinking Water) (No. 2) Regulations (SI 278 of 2007): Purpose: to ensure that drinking water intended for human consumption is wholesome and clean.</p> <p>Relevant actions: Monitor for compliance with drinking water quality standards. Maintain a register of water supplies. Immediately investigate non-compliances and inform consumers. Prepare Action Programmes where the drinking water quality standards are not met.</p> <p>Prohibit water supplies considered to pose a potential danger to human health.</p> <p>Ensure compliance with the regulations and supervise group water schemes.</p>	<p>Local authorities</p> <p>Local authorities, HSE EPA</p>	<p>2009–2015 Designated sites</p>

What	Who leads	When & where
<p>Water Services Act (No 30 of 2007): Purpose: to facilitate the provision of safe and efficient water services and water service infrastructure for domestic and non-domestic requirements.</p> <p>Relevant actions: Monitor public water supplies and monitor and supervise private drinking water supplies. Develop Water Services Strategic Plans, including measures, to meet the Act's requirements including achievement of drinking water standards. Prohibit or restrict water supplies that pose a potential threat to human health or the environment. Inform consumers of non-compliances and ensure that remedial actions are taken where necessary. Prohibit or restrict certain water uses if there is a deficiency of supply. Implement a Rural Water Programme and a licensing system for the Group Water Scheme sector.</p> <p>Supervise and monitor water services authorities and issue compliance notices in relation to non-compliances. Plan and supervise investment under the Water Services Investment Programme.</p> <p>Supervise public water supplies</p>	<p>Local authorities</p> <p>DEHLG</p> <p>EPA</p>	
MAJOR ACCIDENTS AND EMERGENCY DIRECTIVE (96/82/EC)		
<p>European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations (SI 74 of 2006): Purpose: to ensure that operators of establishments where dangerous substances are present take all necessary measures to prevent the occurrence of major accidents and to limit the consequences of accidents for people and the environment.</p> <p>Relevant actions: Prepare on-site emergency plans identifying major hazards and specifying prevention and mitigation measures.</p> <p>Prepare off-site emergency plans for action outside the establishment in the event of a major accident.</p> <p>Require written notification of activities involving specified dangerous substances. Require operators to demonstrate safe operation and storage and to investigate their operations in the event of a major accident. Organise inspections and measures where necessary. Supply information on major accidents to public authorities.</p> <p>Planning and Development Act (No. 30 of 2000) as amended in 2002: Purpose: to provide for the proper planning and development of urban and rural areas.</p> <p>Relevant actions:</p>	<p>Operators</p> <p>Local authorities</p> <p>DETE</p>	<p>2009–2015 Qualifying sites</p> <p>2009–2015 Qualifying sites</p>

What	Who leads	When & where
Ensure that adequate controls are in place for relevant new developments.	Local authorities	
ENVIRONMENTAL IMPACT ASSESSMENT DIRECTIVE (85/337/EEC)		
<p>Environmental Impact Assessment Regulations (SI 349 of 1989) as amended from 1994 to 2006: Purpose: require that certain developments be assessed for likely environmental effects before planning permission is granted.</p> <p>Relevant actions: Require certain developments, by either the private or the public sector, to prepare Environmental Impact Assessments for consideration before planning permission is granted (taking account of objectives established in river basin management plans) and make them available to the public. Notify authorities in Northern Ireland of any planning application which is likely to have significant effects on the environment in Northern Ireland.</p>	Planning authorities	2009–2015 National
SEWAGE SLUDGE DIRECTIVE (86/278/EEC)		
<p>Use of Sewage Sludge in Agriculture Regulations (SI 148 of 1998) as amended in 2001: Purpose: require that sewage sludge is used in accordance with a nutrient management plan.</p> <p>Relevant actions: Supervise the supply and use of sewage sludge in agriculture and ensure that it is used in accordance with nutrient management plans. Maintain a register of sludge biosolids movements and use and make it available to the public. Ensure adherence to the code of practice in relation to the use of biosolids in agriculture.</p> <p>Waste Management Act (No. 10 of 1996): Purpose: to regulate waste management in order to protect human health and the environment.</p> <p>Relevant actions: Prepare sludge management plans for the management of wastewater sludge (taking account of WFD objectives). Require measures to be taken in relation to the holding, recovery or disposal of waste in order to prevent or limit environmental pollution, where necessary. Require land owners to prepare nutrient management plans where necessary.</p>	Local authorities	2009–2015 National
URBAN WASTEWATER TREATMENT DIRECTIVE (91/271/EEC)		
<p>Urban Wastewater Treatment Regulations (SI 254 of 2001) as amended in 2004 and 2010: Purpose: to ensure that the environment is not adversely affected by the disposal of inadequately treated urban waste water through the provision of urban wastewater collection systems and treatment plants.</p> <p>Relevant actions: Design, construct, operate, maintain and monitor treatment plants to achieve requirements in relation to treatment standards, nutrient sensitive areas and WFD objectives. Choose discharge points so as to minimise impact on the</p>	Local authorities, DEHLG	2009–2015 National

What	Who leads	When & where
<p>environment. Ensure that sewage sludge can be disposed of safely. Financial investments can be made under the Water Services Investment Programme.</p> <p>Water Services Act (No 30 of 2007): Purpose: to facilitate the provision of safe and efficient water services and water service infrastructure for domestic and non-domestic requirements.</p> <p>Relevant actions: Plan and supervise provision of wastewater services under the Water Services Investment Programme. Prepare and implement Water Services Strategic Plans to support sustainable provision of wastewater services.</p>	Local authorities	2009–2015 National
PLANT PROTECTION PRODUCTS DIRECTIVE (91/414/EEC)		
<p>Authorisation, Placing on the Market, Use & Control of Plant Protection Products Regulations (SI 83 of 2003) as amended from 2003 to 2009: Purpose: to authorise plant protection product for use or placing on the market to ensure that no harmful effects arise for human and animal health and that there is no unacceptable impact on the environment</p> <p>Relevant actions: Notify the DEHLG of all new information on potentially dangerous effects of authorised plant protection products on the environment or groundwater.</p> <p>The conditions of authorisation are selected to minimise risks for consumers, workers and the environment. The use of a plant protection product in a manner other than specified on its approved label is illegal.</p>	Relevant persons	2009–2015 National
NITRATES DIRECTIVE (91/676/EEC)		
<p>Good Agricultural Practice for the Protection of Waters Regulations (SI 101 of 2009): Purpose: provide statutory support for good agricultural practice to protect waters against pollution from agricultural sources and give further effect to several EU Directives including the Nitrates Directive, dangerous substances in water, waste management, protection of groundwater, public participation in policy development and water policy (the Water Framework Directive).</p> <p>Relevant actions: Review the nitrates National Action Programme to determine its effectiveness, including Agricultural Catchment Programme studies, in consultation with all interested parties. Ensure implementation of the National Action Programme.</p> <p>Monitor as necessary for the purposes of the Regulations. Provide recommendations and direction to local authorities</p>	DEHLG, DAFF EPA	2009–2015 National

What	Who leads	When & where
<p>with respect to monitoring, inspections and measures.</p> <p>Carry out monitoring to establish the extent of pollution in surface and groundwaters attributable to agriculture and determine trends in the occurrence and extent of such pollution. Carry out farm inspections (to coordinate with other farm inspection programmes).</p> <p>Additional actions: Agriculture: Consider increasing farm inspections in karst areas with turloughs and piloting of environmentally friendly farming scheme Map turloughs' zones of contribution.</p>	<p>Local authorities, DAFF</p> <p>DAFF, DEHLG- NPWS</p>	
INTEGRATED POLLUTION PREVENTION CONTROL DIRECTIVE (2008/1/EC)		
<p>Environmental Protection Agency Acts (No 7 of 1992; No 27 of 2003) and Environmental Protection Agency (Licensing) Regulations (SI 85 of 1994) as amended in 1995, 1996, 2004 and 2008: Purpose: to prevent or reduce emissions to water, land and air, to reduce waste and to use energy and resources efficiently.</p> <p>Relevant actions: Ensure that operators of certain industrial and agricultural installations obtain IPPC licenses with conditions and ELVs based on BAT and relevant national and European legislation. Enforce licence conditions including monitoring. Maintain a register of licences and make available to the Commission and to the public. Undertake reviews of existing licences as required (taking account of WFD and Environmental Quality Objectives). Ensure cross border consultation where necessary.</p> <p>Obtain the consent of sanitary authorities for discharges to sewers</p>	<p>EPA</p> <p>Operator</p>	<p>2009–2015 National</p>
COST RECOVERY FOR WATER SERVICES		
<p>Water Pricing Policy: Purpose: to promote the conservation and efficient use of water resources in accordance with the Water Framework Directive</p> <p>Relevant actions: Develop and implement strategy to achieve water metering of domestic users connected to public water supplies.</p> <p>Introduce legislation to allow local authorities to charge domestic users for water services.</p> <p>Develop charging methodology for water services and introduce water charges for domestic users.</p>	<p>DEHLG</p> <p>DEHLG</p> <p>Local Authorities</p>	<p>2009–2015 National</p>
PROMOTION OF EFFICIENT AND SUSTAINABLE WATER USE		
<p>Water Services Act (No. 30 of 2007):</p>		<p>2009–2015</p>

What	Who leads	When & where
<p>Purpose: to facilitate the provision of safe and efficient water services and water service infrastructure for domestic and non-domestic requirements.</p> <p>Relevant actions: Develop and implement strategy to achieve water metering of domestic users connected to public water supplies. Facilitate the provision of efficient water services.</p> <p>Rehabilitate and repair water works.</p> <p>Ensure that water distribution systems are in a fit state and free from leaks.</p> <p>National Water Conservation (Leakage Reduction) Programme: Purpose: to establish water conservation and leakage control strategies.</p> <p>Relevant actions: Establish and maintain GIS-based water management systems. Establish an ongoing leakage control programme. Rehabilitate and replace defective water supply networks. Develop water conservation public awareness campaigns. Provide project-specific funding designed to meet specific leakage reduction targets.</p>	<p>DEHLG</p> <p>Local Authorities</p> <p>Premises owner/occupier</p> <p>Local authorities, DEHLG</p>	<p>National</p> <p>2009–2015 National</p>
PROTECTION OF DRINKING WATER SOURCES		
<p>Groundwater Protection Schemes: Purpose: to protect groundwater sources by enabling regulatory authorities to take account of the potential risks to groundwater when considering the control and location of potentially polluting activities.</p> <p>Relevant actions: Control the location and nature of developments and activities in accordance with groundwater protection schemes.</p> <p>Good Agricultural Practice for the Protection of Waters Regulations (SI 101 of 2009): Purpose: the protection of waters against pollution caused by nitrates from agricultural sources.</p> <p>Relevant actions: Exclude chemical and organic fertilisers and farm manures from within specified distances of wells, boreholes, springs or abstractions points</p> <p>Planning and Development Act (No. 30 of 2000): Purpose: to provide for the proper planning and development of urban and rural areas.</p> <p>Relevant actions:</p>	<p>Local authorities</p> <p>Farmers</p>	<p>2009–2015 National</p> <p>2009–2015 National</p> <p>2009–2015 National</p>

What	Who leads	When & where
<p>Control of developments and activities in order to protect water resources.</p> <p>Water Policy Regulations (SI 722 of 2003) as amended in 2005: Purpose: to provide a statutory basis for the provisions of the Water Framework Directive including the establishment and maintenance of a Register of Protected Areas.</p> <p>Relevant actions: Keep Register of Protected Areas, which includes protected drinking waters, updated.</p> <p>Also, identify and protect all surface and groundwater bodies that are used, or may be used in the future, as sources of drinking water for more than 50 people or where the rate of abstraction is > 10m³ per day. Establish monitoring programmes for bodies of water providing >100 cubic metres as an average. Ensure that there is no deterioration of quality in identified bodies of water so as to reduce the level of purification treatment required.</p> <p>Consideration is also being given to the designation of safeguard zones around current and future abstractions under the Drinking Water Regulations.</p>	<p>Local authorities, An Bord Pleanála DEHLG</p> <p>EPA</p> <p>To be assigned</p> <p>To be assigned</p>	<p>2009–2015 Designated sites</p>
ABSTRACTION AND IMPOUNDMENTS		
<p>Environmental Impact Assessment Regulations (SI 349 of 1989) as amended from 1994 to 2006: Purpose: require that certain developments be assessed for likely environmental effects before planning permission can be granted.</p> <p>Relevant actions: Undertake environmental impact assessment for drilling for water supplies above specified thresholds, groundwater abstraction and artificial groundwater recharge schemes above specified thresholds and works for the transfer of water resources between river basins above specified thresholds.</p> <p>Water Pollution Act (No 1 of 1977) as amended in 1990: Purpose: to provide for the control of water pollution thereby protecting possible drinking water sources</p> <p>Relevant actions: Maintain registers of abstractions and make available to the public.</p> <p>Water Supplies Act (SI 1 of 1942): Purpose: require that provisional orders be obtained by local authorities abstracting drinking water supplies.</p>	<p>Local authorities</p> <p>Local authorities</p>	<p>2012–2015 National</p> <p>2012–2015 National</p> <p>2009–2015 Prioritised sites</p>

What	Who leads	When & where
<p>Relevant actions: Local authorities must adhere to conditions set down in provisional orders when abstracting drinking water from a water source.</p> <p>Planning and Development Act (No. 30 of 2000) as amended in 2002: Purpose: to provide for the proper planning and development of urban and rural areas.</p> <p>Relevant actions: Local authorities must obtain planning permission for groundwater abstractions for public drinking water supplies.</p> <p>Additional actions: Abstractions: Good practice measures are available in the Programmes of Measures – technical studies – Abstractions and National Summary Programme of Measures background documents.</p>	<p>Local authorities, DEHLG</p> <p>Local authorities, An Bord Pleanála</p>	<p>2009–2015 Prioritised sites</p>
POINT SOURCE DISCHARGES		
<p>Environmental Objectives (Surface Water) Regulations (SI 272 of 2009): Purpose: The establishment of legally binding quality objectives for all surface waters and environmental quality standards for pollutants. Public authorities are required to examine and where appropriate, review existing discharge authorisations to ensure that the emission limits laid down in authorisations support compliance with the new water quality objectives/standards. .</p> <p>Relevant actions: Establish measures to achieve the quality objectives and standards. Where necessary, consult with other public authorities and with relevant competent authorities in Northern Ireland.</p> <p>Set emission limits based on BAT when authorising new discharges to ensure achievement of the quality objectives. Review all existing discharge authorisations to take into account the new quality standards. Prepare programmes for the monitoring and inspection of farm installations to verify compliance.</p> <p>Classify waters and make the classification available in GIS. Establish an inventory of emissions discharges and losses of priority substances, priority hazardous substances and other pollutants.</p> <p>Prepare a plan for the progressive reduction of pollution by priority substances and the ceasing or phasing out emissions, discharges and losses of priority hazardous substances.</p> <p>Environmental Objectives (Groundwater) Regulations (SI 9 of 2010): Purpose: The establishment of legally binding quality objectives for all bodies of groundwater and environmental</p>	<p>Public authorities</p> <p>Local authorities, EPA, DEHLG</p> <p>EPA</p> <p>Coordinating local authority</p>	<p>2009–2015 National</p> <p>2009–2015 National</p>

What	Who leads	When & where
<p>quality standards for pollutants. Public authorities are required to examine and where appropriate, review existing discharge authorisations to ensure that the emission limits laid down in authorisations support compliance with the new water quality objectives/standards.</p> <p>Relevant actions: All direct discharges of pollutants into groundwater are prohibited subject to certain exemptions.</p> <p>Point source discharges and diffuse sources liable to cause groundwater pollution must be controlled so as to prevent or limit the input of pollutants into groundwater.</p> <p>Identify hazardous and non-hazardous substances for the purpose of preventing and limiting pollutant inputs</p> <p>Where necessary or appropriate, issue advice and/or give directions to a public authority or authorities concerned on the measures to be taken to prevent and limit inputs of pollutants into groundwater.</p> <p>Where necessary or appropriate, issue advice and/or give directions to a public authority or authorities concerned on the measures to be taken to prevent and limit inputs of pollutants into groundwater.</p> <p>Where necessary or appropriate:</p> <p>(a) review, or cause to have reviewed, existing codes of practice including other such mechanisms and controls already in place for the purpose of preventing or limiting the input of pollutants into groundwater;</p> <p>(b) identify such other areas and/or activities requiring the introduction of similar type controls so as to prevent or limit the input of pollutants into groundwater ;</p> <p>(c) direct a public authority to undertake a review and, where necessary, update a code of practice, or in the case of an activity requiring the introduction of new controls, prepare a new code of practice or system of control for the activity in question. A public authority must comply with the direction given by the Agency within the timeframe prescribed;</p> <p>Examine and if necessary review all existing discharge authorisations to groundwater to take into account the new quality standards and to prevent or limit inputs of pollutants to groundwater.</p> <p>Water Pollution Act (No 1 of 1977) as amended in 1990 and Water Pollution Regulations (SI 108 of 1978) as amended in 1992 and 1996: Purpose: to provide for the control of water pollution through prosecution for water pollution offences; use of pollution control conditions in the licensing of effluent discharges; issue of notices specifying measures to prevent water pollution.</p>	<p>Local authorities</p> <p>EPA</p> <p>EPA</p> <p>EPA</p> <p>EPA</p> <p>EPA</p> <p>EPA</p> <p>Relevant authorities</p>	<p>2009–2015 National</p>

What	Who leads	When & where
<p>Relevant actions: License discharges to surface waters and sewers from small scale industrial and commercial sources. Review licenses at intervals of not less than 3 years. Keep registers of discharge licenses and make them available to the public.</p> <p>Prosecute for water pollution offences; attach appropriate pollution control conditions in the licensing of effluent discharges from industry, etc., made to waters or to sewers; issue notices specifying measures to be taken within a prescribed period to prevent water pollution; Issue notices to stop pollution of waters and requiring the mitigation or remedying within a period specified; seek court orders, including High Court injunctions.</p> <p>Notify local authorities of accidental discharges and spillages of polluting materials which enter, or are likely to enter, waters.</p>	<p>Local authorities</p> <p>Local authorities, Fisheries Boards, DEHLG-NPWS</p> <p>Relevant persons</p>	<p>2009–2015 National</p>
<p>Wastewater Discharge Authorisation Regulations (SI 684 of 2007): Purpose: to provide for the authorisation by the EPA of urban waste water discharges by local authorities.</p> <p>Relevant actions: Authorise Local Authority WWTPs (taking account of WFD objectives). Review licenses at intervals not less than 6 years. Enforce compliance with WWTP licensing conditions. Maintain a register of WWTP licences and certificates and make available on request.</p>	<p>EPA</p>	<p>2009–2015 National</p>
<p>Water Services Act (No 30 of 2007): Purpose: to facilitate the provision of safe and efficient water services and water service infrastructure for domestic and non-domestic requirements.</p> <p>Relevant actions: Prepare and implement Water Services Strategic Plans.</p>	<p>Local Authorities</p>	<p>2009–2015 National</p>
<p>Duty of care on owners of premises to ensure that treatment systems for wastewater are kept in good condition.</p>	<p>Relevant Persons</p>	<p>2009–2015 Prioritised Sites</p>
<p>Additional actions: Urban Wastewater Treatment Plants: Measures for improved management: keep register of plant capacity and update annually; install facilities to monitor influent loads and effluent discharges in accordance with EPA guidelines and best practice; put auditable procedures in place to monitor compliance of licensed discharges; implement training procedures for staff involved with licensing of discharges; monitor receiving water quality upstream and downstream of the point of discharge.</p>	<p>Local Authorities</p>	<p>2009–2015 Prioritised Sites</p>
<p>Optimise treatment plant performance by the implementation of a performance management system supported by the</p>	<p>Local Authorities</p>	

What	Who leads	When & where
<p>use of decision making tools.</p> <p>Actions have been identified for certain categories of treatment plant:</p> <ul style="list-style-type: none"> • Category 1 - Agglomerations with treatment plants requiring identifiable Capital Works. • Category 2 - Agglomerations with treatment plants requiring further investigation prior to Capital Works. • Category 3 - Agglomerations requiring the implementation of actions identified in Pollution Reduction Plans for Shellfish Waters designated under the Shellfish Water Regulations. • Category 4 - Agglomerations with treatment plants requiring improved operational performance through the implementation of Performance Management Systems. • Category 5 - Agglomerations requiring investigation of Combined Storm Overflows (CSOs). • Category 6 - Agglomerations where existing waste water treatment capacity is currently adequate but predicted loadings (based on assumed 3% growth in load per annum) would result in overloading requiring management of development. <p>Good practice measures are available in the Programmes of Measures – technical studies – Municipal and Industrial Regulations, Urban Pressures and National Summary Programme of Measures background documents.</p> <p>Minerals Development Act (No 31 of 1940) as amended from 1960 to 1999: Purpose: to provide for the development and working of the mineral resources of the State whilst managing potential impact on the water environment</p> <p>Relevant actions: Grant Prospecting Licenses for exploration of specified minerals in specified areas subject to conditions. Grant Minerals or Mining Licenses with respect to State owned minerals. Grant Mining Permissions to work substances in small quantities. Grant Unworked Minerals Licenses with respect to unworked minerals.</p> <p>Energy Act (No. 40 of 2006): Purpose: to regulate the energy industry whilst managing potential impact on the water environment</p> <p>Relevant actions: Prepare Mine Rehabilitations Plans for the long-term rehabilitation of mine sites where it is considered necessary for the purposes of public or animal health or the environment.</p> <p>Waste Management Act (No 10 of 1996) as amended in 2001: Purpose: to regulate waste management in order to protect human health and the environment.</p> <p>Relevant actions:</p>	<p>DCENR</p> <p>DCENR Local authorities,</p> <p>EPA, GSI</p>	<p>2009–2015 National</p> <p>2009–2015 Prioritised Sites</p> <p>2009–2015 Prioritised Sites</p>

What	Who leads	When & where
<p>Prepare an inventory of closed waste disposal or recovery sites.</p> <p>European Communities (Quality of Shellfish Waters) Regulations (SI 268 of 2006) as amended in 2009: Purpose: to protect or improve shellfish waters in order to support shellfish life and growth by setting water quality requirements to be met.</p> <p>Relevant actions: Undertake monitoring and investigate pollution. Develop and implement Shellfish Pollution Reduction Programmes, including any necessary measures, to achieve shellfish water quality standards.</p> <p>European Communities (Freshwater Pearl Mussel) Regulations (SI 296 of 2009): Purpose: For the purpose of achieving the water quality objectives established for designated sites for the protection of freshwater pearl mussel populations.</p> <p>Relevant actions: Public authorities that authorise discharge to any of the listed rivers to set down emission limit values that aim to achieve the prescribed ecological quality targets; and to examine existing authorisations within a set time and review them as appropriate.</p>	<p>DEHLG, Local authorities</p> <p>Public authorities</p>	<p>2009–2015 Designated sites</p> <p>2009–2015 Designated sites</p>
DIFFUSE SOURCE DISCHARGES		
<p>Water Pollution Act (No 1 of 1977) as amended in 1990 and Water Pollution Regulations (SI 108 of 1978) as amended in 1992 and 1996: Purpose: to provide for the control of water pollution through prosecution for water pollution offences; use of pollution control conditions in the licensing of effluent discharges made to waters or to sewers; issue of notices specifying measures to be taken to prevent water pollution.</p> <p>Relevant actions: Serve notices or directions on persons requiring measures to be taken in order to prevent or control pollution of waters, where necessary.</p> <p>Notify local authorities of accidental discharges and spillages of polluting materials which enter, or are likely to enter, waters.</p> <p>Planning and Development Act (No 30 of 2000) as amended in 2002: Purpose: to provide for the proper planning and development of urban and rural areas.</p> <p>Relevant actions: Grant permission for on-site waste water treatment systems subject to site suitability assessment.</p>	<p>Local authorities, Fisheries Boards, DEHLG-NPWS Relevant persons</p>	<p>2009–2015 National</p> <p>2009–2015 National</p>

What	Who leads	When & where
<p>EPA Code of Practice for Wastewater Treatment Systems serving Single Houses (2009) Purpose: to provide guidance on the provision of wastewater treatment and disposal systems for new single houses.</p> <p>Relevant actions: the guidance addresses the following Assess site suitability for on-site wastewater treatment systems and identify minimum environmental protection requirements Select suitable wastewater treatment systems for sites in un-sewered rural areas Design and install septic tank systems, filter systems, packaged treatment systems and tertiary treatment systems, Maintenance requirements for on-site wastewater treatment systems.</p> <p>The guidance is supported by DEHLG circular letter (Reference PSSP 1/10) and Planning Guidelines on Sustainable Rural Housing (2005)</p> <p>Amend the Technical Guidance Document supporting the 1997 Building Regulations (SI 497 of 1997) relating to standards for “drainage and waste water disposal” (TGD-H of 2005) and issue a supporting Circular Letter to all Local Building Control Authorities.</p> <p>For existing unsewered properties, bring forward and consult on proposals for legislation to provide standards for the performance, operation and maintenance of septic tanks and similar on-site wastewater treatment systems and also for the monitoring and inspection of the performance of such treatment systems and set out the responsibilities of households served by those systems, including requirements to carry out remedial actions where necessary.</p> <p>Additional actions: On-site systems: Good practice measures are available in the Programmes of Measures – technical studies – On-site wastewater treatment systems and National Summary Programme of Measures background documents.</p> <p>Forestry Act (No 13 of 1946) as amended in 1976 and 1988 and Aerial Fertilisation Regulations (SI 592 of 2006) as amended in 2007 and codes of practice, guidance documents administered through a grant support system: Purpose: to provide for the development and regulation of forestry.</p> <p>Relevant actions:</p>	<p>Local authorities</p> <p>Planning authorities, developers, manufacturers designers, installers and operators Planning authorities & An Bord Pleanála</p> <p>DEHLG</p> <p>Minister for the Environment, Heritage and Local Government</p>	<p>2009–2015 National</p> <p>2010</p> <p>2009–2015 National</p>

What	Who leads	When & where
<p>Promote forestry with financial incentives. License forestry activity and where necessary, attach additional conditions in sensitive areas.</p>	Forest Service	
<p>Encourage sustainable, commercial afforestation. Ensure compliance with guidance and codes of practice.</p>	Forest Service	
<p>A new Forestry Bill, replacing the 1946 Forestry Act, has been drafted to strengthen sustainable forestry management. Provisions relating to water protection are;</p> <ul style="list-style-type: none"> • All forestry operations must be carried out in accordance with any guidelines and regulations issued by the Minister for Agriculture, Fisheries and Food. • Allowing for change of land use from forestry to other sustainable uses. 	Minister for the Department of Agriculture, Fisheries and Food	
<p>In acid sensitive catchments apply a protocol agreed between the Department of Environment, Heritage and Local Government, the Forest Service, the EPA and COFORD for dealing with grant-aid applications in acid sensitive areas. All relevant applications received by the Forest Service are checked for alkalinity levels in run-off water. Borderline cases are referred to the Environmental Protection Agency for recommendations.</p>	Forest Service, EPA	
<p>2008 guidelines for the protection of Natura 2000 sites designated for the protection Freshwater Pearl Mussel populations from forestry activities are intended to ensure that forest operations such as afforestation, forest road construction, harvesting and forest planning are compatible with the protection of this particularly sensitive species. The guidelines describe a range of measures intended to reduce any potential negative impacts on the species arising from forest operations.</p>	Forest Service	2009–2015 National
<p>Strategic Plan for the Development of Forestry:</p>		
<p>Purpose: to provide for the development and regulation of forestry.</p>		
<p>Relevant actions:</p>		
<p>Adhere to forest management plans and the principles of sustainable forest management.</p>	All stakeholders	
<p>Ensure implementation of the National Forestry Standard and adherence to the code of best forest practice.</p>	Forest Service	
<p>Additional actions: Forestry:</p>		
<p>Good practice measures are available in the Programmes of Measures – technical studies – Forest and Water and National Summary Programme of Measures background documents.</p>		
<p>Environmental Objectives (Freshwater Pearl Mussel) Regulations (SI 296 of 2009)</p>		
<p>Purpose: For the purpose of achieving the water quality objectives established for designated sites for the protection of freshwater pearl mussel populations.</p>		2009–2015 Designated sites

What	Who leads	When & where
<p>Relevant actions: Develop management plans (sub-basin plans of River Basin Management Plans), including any necessary measures, to ensure achievement of environmental quality objectives.</p>	DEHLG-NPWS, relevant public authorities	
AUTHORISATION OF DISCHARGES TO GROUNDWATERS		
<p>Environmental Objectives (Groundwater) Regulations (SI 9 of 2010): Purpose: to provide for specifying the criteria for classifying groundwater status and identifying significant increasing pollution trends; provide for a proportionate risk-based response to groundwater protection.</p> <p>Relevant actions: Review all existing discharge authorisations to take into account the new quality standards.</p> <p>Wastewater Discharge Authorisation Regulations (SI 684 of 2007): Purpose: Where a local authority proposes to discharge urban waste water effluent to groundwater an authorisation by the Environmental Protection Agency is required.</p> <p>Relevant actions: Authorisation of Local Authority WWTPs effluent discharges discharging to groundwater.</p> <p>Water Pollution Act (No 1 of 1977) as amended in 1990: Purpose: to provide for the control of water pollution.</p> <p>Relevant actions: License discharges to groundwaters from small scale industrial and commercial sources. Review licenses at intervals of not less than 3 years. Keep registers of discharge licenses and make them available to the public.</p>	<p>Local authorities</p> <p>EPA</p> <p>Local authorities</p>	<p>2009–2015 National</p> <p>2009–2015 National</p> <p>2009–2015 National</p>
PRIORITY SUBSTANCES		
<p>Environmental Objectives (Surface Water) Regulations (SI 272 of 2009): Purpose: to provide for quality objectives for surface waters, EQSs for pollutants, review of discharge authorisations, classification of surface waters, inventories of priority substances.</p> <p>Relevant actions: Prepare a plan for the progressive reduction of pollution by priority substances and the ceasing or phasing out of emissions, discharges and losses of priority hazardous substances. Establish an inventory of emissions discharges and losses of priority substances, priority hazardous substances and other pollutants and publish a summary of the</p>	EPA, coordinating local authority	2009–2015 National

What	Who leads	When & where
<p>inventory.</p> <p>Chemicals Act (No. 13 of 2008): Purpose: to provide for the regulation of certain dangerous chemicals.</p> <p>Relevant actions: Administration and enforcement of the European Registration, Evaluation and Authorisation of Chemicals regulations (REACH).</p> <p>Identify and manage risks linked to the chemicals manufactured or imported and registration of chemicals produced or imported in quantities greater than 1 tonne.</p> <p>European Pollutant Release and Transfer Register Regulations (SI 123 of 2007): Purpose: the prevention and reduction of pollution by the establishment of a publicly accessible pollutant release and transfer register.</p> <p>Relevant actions: Submit required data in relation to releases of pollutants and off-site transfers of pollutants and waste.</p> <p>Provide for electronic collection, assessment of data and report data to the EU Commission in relation to releases of pollutants and off-site transfers of pollutants and waste. Enforce regulations.</p>	<p>Health and Safety Authority</p> <p>Manufacturers or importers of chemicals</p> <p>Operators</p> <p>EPA</p>	<p>2009–2015 National</p> <p>2009–2015 National</p>
PHYSICAL MODIFICATIONS		
<p>Planning and Development Act (No 30 of 2000) as amended in 2002; Environmental Impact Assessment Regulations (SI 349 of 1989) as amended from 1994 to 2006: Purpose: to provide for the proper planning and development of urban and rural areas. Require that certain developments be assessed for likely environmental effects before planning permission is granted.</p> <p>Relevant actions: Consider the environmental impacts of developments as part of the planning process.</p> <p>Additional actions: Physical modifications: Good practice measures are available in the Programmes of Measures – technical studies – Freshwater Morphology, Marine Morphology and National Summary Programme of Measures background documents.</p> <p>Investigate the ecological potential of heavily modified waters and implement identified mitigation measures.</p>	<p>Local authorities</p> <p>Relevant public authorities</p>	<p>2009–2015 National</p> <p>2009–2015 Prioritised sites</p>

What	Who leads	When & where
OTHER ACTIVITIES IMPACTING ON WATER STATUS		
<p>Alien species: Introduce new regulations under the Wildlife Act to control introduction or possession of any species of flora or fauna which may be detrimental to native species.</p>	DEHLG	2009–2015 National
PREVENTION OR REDUCTION OF THE IMPACT OF ACCIDENTAL POLLUTION INCIDENTS		
<p>Framework of Major Emergency Management Purpose: framework for emergency preparedness and response capability identifying hazards and risk to society, the economy, but also the environment including our natural water resource.</p> <p>Relevant actions: Prepare Major Emergency Plans with supporting plans, procedures and arrangements. Initiate a major emergency development programme for the implementation of the Major Emergency Plans. Co-ordinate the inter-agency aspects of major emergency preparedness and management in assigned regions.</p> <p>Ensure and promote implementation of the Framework.</p>	<p>Local authorities, An Garda Síochána, HSE</p> <p>Dept of Justice, Equality & Law Reform, Dept of Health & Children, DEHLG</p>	2009–2015 National
OTHER ISSUES		
<p>Climate change: all measures have been assessed to ensure that the plan adequately considers the potential impacts of climatic change (see Chapter 6) – this will be reviewed as climate change information improves.</p> <p>Invasive alien species: support measures being developed by the national alien species study (conducted by QUERCUS) and local investigations at district level</p> <p>Cruising and boating: enforce pump-out control and speed restrictions at district level.</p> <p>Peat extraction: enforce licensing controls and rehabilitation plans at district level.</p>	<p>DEHLG, EPA</p> <p>DEHLG-NPWS, local authorities</p> <p>Waterways Ireland, local authorities EPA, local authorities, Bord na Móna</p>	<p>2009–2015 National</p> <p>2009–2015 National</p> <p>2009–2015 Prioritised sites</p> <p>2009–2015 Prioritised sites</p>

Table 6.2 Freshwater pearl mussel additional measures.

The following is the full national list of measures to address all pressures impacting on the freshwater pearl mussel and its habitat in the 27 SAC catchments. These measures will only be implemented if and where required in the Owenea catchment, subject to resource availability, on a prioritized basis and at those sites where investigations and risk assessment show that specific pressures need to be remediated to restore pearl mussels to favourable conservation status. To reiterate, not all of the measures listed below will apply in this catchment and any measures that do apply may only be implemented in restricted areas. A summary of the specific measures that apply to the Owenea catchment is given in Chapter 7. Further detail on the catchment-specific measures will be provided in the final plan.

	Freshwater pearl mussel measure	Who Leads	When and where
1	Public Awareness		
	An education and awareness campaign shall include, farm visits, public meetings, clinics, talks (to schools, etc.) and the distribution of leaflets. Topics covered will include the biology and ecology of pearl mussels and damage caused by pearl fishing, in-stream activities, sedimentation and nutrient enrichment. The measures necessary for their conservation shall be explained. Other issues such as litter prevention, the use of low phosphate detergent, correct disposal of domestic wastewater and disposal of oil shall be included in the campaign.	DEHLG (National Parks and Wildlife Service) and Local Authorities	
2	Stakeholder Involvement		
	Stakeholder assistance in the further development and design of measures will be encouraged, through meetings with relevant individuals and organisations.	Relevant public authority	
3	Guidance		
	Appropriate guidance will be provided to different sectors to assist with their compliance with the Freshwater Pearl Mussel Regulations (S.I. 296 of 2009) and Article 6 of the Habitats Directive (i.e. Appropriate Assessment).	DEHLG (National Parks and Wildlife Service)	
4	Appropriate assessment under Article 6 of the Habitats Directive		
	All plans, programmes and projects with the potential to impact on the pearl mussel SAC population, or any other Natura 2000 sites and their qualifying features, must be screened for Appropriate Assessment in accordance with Article 6 of the Habitats Directive, and, where judged necessary, an Appropriate Assessment must be conducted. In addition, all plans (e.g. Development Plans, forestry catchment management plans) and programmes (e.g. agri-environmental schemes) are likely to require Strategic Environmental Assessment (SEA).	Relevant regulatory authority	
5	Habitats Directive Controls		
5a	Notify stakeholders of measures required under the Sub-basin Management Plan.	DEHLG (National Parks and Wildlife Service)	
5b	Certain operations or activities within SACs require the consent of the Minister for the Environment Heritage and Local Government under the Habitats Regulations (S.I. 94 of 1997). This list is currently being revised. Once the list of these operations or activities (activities requiring consent/ notifiable actions) has been revised, it shall be formally notified to the relevant owners, occupiers or users in the	DEHLG (National Parks and Wildlife Service)	

	pearl mussel SACs.		
6	Municipal and Industrial Discharges		
6a	Examine and review all authorizations to discharge to waters within Freshwater Pearl Mussel SAC catchments, and revise those authorizations to comply with Schedule Four of S.I. 296 of 2009.	Local Authorities/ Environmental Protection Agency	
6b	Upgrade treatment to ensure compliance with any revised discharge standards set by the Regulatory Authority to ensure achievement of objectives set out in Schedule Four of S.I. 296 of 2009.	Operator	
6c	Municipal wastewater. Conduct investigations into and mitigate as required: <ul style="list-style-type: none"> i) The condition of the sewerage network and containment areas, ii) The extent of the sewerage network and connection of peripheral properties, iii) Storm overflows, iv) Wastewater Treatment Plant (WwTP) performance, v) Discharge quality, vi) Impacts on receiving waters. 	Local Authorities	
6d	Municipal wastewater. Upgrade municipal wastewater treatment through: <ul style="list-style-type: none"> i) Provision of appropriate WwTP, ii) Connection of additional unsewered/sewered properties to WwTP, iii) Repair of damaged collecting systems, iv) Upgrade of WwTP capacity, v) Upgrade of treatment level, vi) Improvements in operational performance, vii) Additional monitoring. 	Local Authorities	
6e	Municipal wastewater. Prioritise investment in WwTPs within pearl mussel SAC catchments under the Water Services Investment Programme (WSIP).	DEHLG (Water Inspectorate)	
7	Quarries		
7a	Examine and review all authorizations to discharge from quarries to waters within pearl mussel SAC catchments, and revise those authorizations to comply with Schedule Four of S.I. 296 of 2009.	Local Authorities	
7b	Upgrade treatment and mitigation measures to ensure compliance with any revised discharge standards set by the Local Authority to achieve of the objectives set out in Schedule Four of S.I. 296 of 2009. Mitigation measures will be designed to reduce sediment loss at source and/or intercept sediment along the pathway to the river.	Operator	

8	Abstractions - Implementation of these measures will only occur at the specific sites where they are required.		
8a	An Appropriate Assessment, under Article 6 of the Habitats Directive, shall be conducted for each abstraction identified as a significant potential risk in this Sub-basin Management Plan.	Local Authorities/Operator	
8b	Further investigation and screening for Appropriate Assessment shall be conducted of other existing or future abstractions identified in this Sub-basin Management Plan or within the life-cycle of this plan to assess potential significant impacts on the pearl mussel. Appropriate Assessments shall be conducted where necessary.	Local Authorities	
8c	Introduce reduction and remediation measures as appropriate to mitigate the impacts on pearl mussels from abstractions.	Local Authorities/Operator	
9	Unnatural flows		
	Conduct further investigations and, where necessary, an Appropriate Assessment under Article 6 of the Habitats Directive into the impacts of any flow regulation identified in this Sub-basin Management Plan on the pearl mussel population. Where necessary, a plan shall be made and implemented to control flows in a manner that supports the sustainable reproduction of the pearl mussel. Monitoring of the success of changes implemented shall be carried out.	Operator	
10	Morphological alterations – appropriate control		
	Enact necessary legislative change to control morphological alterations of surface waters. (Note: this measure is linked to measure 19 below, as developments such as alteration of the bed and banks of a river are currently exempted).	DEHLG	
11	Morphological alterations - remediation of morphological pressures		
	Undertake the required morphological remediation measures at locations identified under this Sub-basin Management Plan, or through further investigation during the life-cycle of the plan (up to 2015).	DEHLG (National Parks and Wildlife Service), Central and Regional Fisheries Boards, DAFF (Marine)	
12	Morphological alterations - sand and gravel extraction		
	No sand, gravel or stone shall be removed from rivers designated for freshwater pearl mussel, unless an appropriate assessment determines that there will be no significant negative impacts on the pearl mussel. (Note: sand and gravel extraction should be controlled under measure 10 above).	Local Authorities/Planning Authorities	
13	Catchment Modelling		
	Model/predict sediment, nutrient, and dangerous substance losses in pearl mussel SAC catchments to assist in developing and targeting measures for diffuse pollution.	Local Authorities/ Environmental Protection Agency /DAFF /DEHLG	
	Agricultural Measures (Note: Appropriate agricultural measures shall be implemented in areas that have been identified as presenting significant actual or potential risks of sediment and/or nutrient loss, hydrological pressures and/or dangerous substances loss and are, therefore, likely to impact upon the pearl mussel population.)		

14	Agri-environmental scheme		
14a	Develop and roll-out an agri-environmental scheme, which could, if appropriate, be incorporated into other existing schemes, for target areas within pearl mussel SAC catchments to achieve the objectives of this plan. (Work is ongoing to identify the target areas).	DAFF and DEHLG	
14b	The overall objective would be that all farms within the target areas in pearl mussel SAC catchments would have a farm plan under Measure 14a.	Owner, occupier, user	
14c	The specific measures for each farm, required under the agri-environmental scheme (14a), will be produced with the assistance of appropriately trained advisers/planners.	Owner, occupier, user	
14d	Production of the farm plans under the agri-environmental scheme (14a) will require a comprehensive farm walk-over survey and risk assessment.	Owner, occupier, user and registered farm planners/advisers	
14e	Appropriate training in risk assessment and management responses shall be provided to all farm advisers.	DAFF and DEHLG	
14f	Farm plans in the target areas may include any of the following measures, but only if they are found, under Measure 14d, to be required:	Owner, occupier, user and registered farm planners/advisers	
14f	i) Fence livestock from watercourses to avoid direct damage to and trampling on pearl mussels.	Owner, occupier, user	
14f	ii) Nutrient and sediment management plans are required for all farms.	Owner, occupier, user and registered farm planners/advisers	
14f	iii) Soil testing for phosphorus, pH, organic content, aluminium, iron and calcium, on a field by field basis, shall inform the nutrient management plan.	Owner, occupier, user and registered farm planners/advisers	
14f	iv) Fence drains, streams and rivers to prevent bank and channel disturbance/erosion.	Owner, occupier, user	
14f	v) Prevent or mitigate machinery and/or livestock access to and through watercourses (ramps and fords)	Owner, occupier, user	
14f	vi) Locate drinking water troughs away from watercourses (>30 m), steep slopes adjacent to watercourses and waterlogged land.	Owner, occupier, user	
14f	vii) Reduce soil disturbance (tillage, ploughing, digging, cultivation, etc.), in critical source areas for sediment.	Owner, occupier, user and registered farm planners/advisers	
14f	viii) Reduce stocking rates to sustainable levels where there is significant risk of erosion due to overgrazing.	Owner, occupier, user and registered farm planners/advisers	

14f	ix) Install appropriately sized, designed and located sediment traps/barriers where required, e.g. in drainage ditches.	Owner, occupier, user and registered farm planners/advisers	
14f	x) Locate or relocate gateways away from high-risk areas, in order to prevent sediment loss to watercourses. Where risks to watercourses remain, mitigate by providing gravel hardcore around gateway.	Owner, occupier, user and registered farm planners/advisers	
14f	xi) Locate trackways away from drains and river margins. Prevent direct connectivity and sediment loss from tracks to watercourses.	Owner, occupier, user and registered farm planners/advisers	
14f	xii) Develop measures to increase infiltration and slow surface run-off, e.g. through tree planting.	Owner, occupier, user and registered farm planners/advisers	
14f	xiii) Reduce application of fertiliser, slurry or farmyard manure, particularly within critical source areas for nutrients.	Owner, occupier, user and registered farm planners/advisers	
14f	xiv) Establish site-specific buffer zones along drains and watercourses to intercept sediment and nutrients. Design of these buffer zones will factor-in precipitation, run-off, slope, soil type (including erodability, current phosphorus concentration and P-retention capacity), adjacent land use, stocking densities etc. (Options for buffer zones include grass, trees or Native Woodland Scheme)	Owner, occupier, user and registered farm planners/advisers	
14f	xv) Create artificial wetlands or filter beds in target areas to address point sources e.g. farmyards or eroding drains.	Owner, occupier, user and registered farm planners/advisers	
14f	xvi) Strict adherence to guidelines on pesticide usage (See measures 15 d and i and 22b). Pesticides, herbicides and veterinary products should not be applied near watercourses, on waterlogged land or on steeply sloping land adjacent to watercourses.	Owner, occupier, user and registered farm planners/advisers	
14f	xvii) Reduce application of lime, if required.	Owner, occupier, user and registered farm planners/advisers	
14g	Inspect implementation of all pearl mussel measures required by farm plans.	DAFF and DEHLG	
14h	Apply weighting to farms in agri-environmental scheme in the farm selection process for cross-compliance monitoring, in order to increase likelihood of inspection.	DAFF	
14i	Train agricultural inspectors in the risk assessment and pearl mussel measures required under the agri-environmental scheme.	DAFF	
14j	Monitor the effectiveness of pearl mussel measures implemented under agri-environmental schemes	DAFF and DEHLG	

14k	Make all data provided and collected under the agri-environmental scheme available to the relevant public authorities e.g. LA, DAFF, EPA, DEHLG.	DAFF and DEHLG	
15	General Agricultural Measures – to be applied only when and where necessary throughout all freshwater pearl mussel SAC catchments		
15a	Locate supplementary feeding stations away from watercourses (>30 m), steep slopes adjacent to watercourses and waterlogged land. Move such stations regularly to avoid nutrient build-up and excessive poaching.	Owner, occupier, user and registered farm planners/advisers	
15b	Avoid removal or disturbance of bank side/ riparian vegetation and maintain all existing buffer zones along watercourses.	Owner, occupier, user and registered farm planners/advisers	
15c	Assess possible impacts of drain maintenance works, and take appropriate steps to avoid or mitigate.	Owner, occupier, user and registered farm planners/advisers	
15d	Locate sheep dipping stations or other livestock treatment facilities away from watercourses.	Local Authorities, owner, occupier, user and registered farm planners/advisers	
15e	Include and promote measures for pearl mussel as options in other agri-environmental schemes that can be taken-up in non-target areas in the mussel SAC catchments. (Work is ongoing to identify the target areas).	DAFF and DEHLG	
15f	Utilise Native Woodland Scheme for conversion of agricultural land along riparian corridors and within identified critical source areas for sediment and nutrients.	DAFF (Forest Service)	
15g	Prioritise GAP Regulation (S.I. 101 of 2009) farm inspections within pearl mussel SAC catchments.	Local Authorities	
15h	Increase farmer awareness of Freshwater Pearl Mussel Sub-basin Management Plans through informal farm visits.	Local Authorities	
15i	Provide advice and training to farmers in relation to the use (location, frequency of application, volume, weather etc.), storage and disposal of sheep-dips toxic to freshwater pearl mussels.	DAFF (Veterinary Medicine Section)	
15j	Provide agricultural land-use data to relevant public authorities, including agriculture type, livestock density, soil phosphorus concentrations, fertiliser use, slurry spread grounds and application rates, to allow identification and mapping of target areas, etc.	DAFF	
16	On-site Wastewater treatment Systems		
16a	Prioritise the monitoring and inspection of on-site systems in pearl mussel SAC catchments.	Local Authorities	
16b	Within the Owenea pearl mussel SAC catchment, prioritise the monitoring and inspection of on-site wastewater treatment systems in accordance with this Sub-basin Management Plan, i.e. within priority sub-catchments, priority stretches and/or on extreme and very high risk potentials.	Local Authorities	

16c	Install new, and upgrade older, on-site wastewater treatment systems to comply with all standards issued by DEHLG and codes of practice issued by the EPA, e.g. Code of Practice Wastewater Treatment and Disposal Systems serving Single Houses.	Developers, manufacturers, designers, installers, owner, occupier, user	
16d	Operate and maintain all on-site wastewater treatment systems in accordance with any standards issued by DEHLG.	Owner, occupier, user	
16e	Where appropriate, use constructed wetlands for treating/polishing household effluent from unsewered properties.	Local Authorities/ owner, occupier, user	
16f	Where an on-site wastewater treatment system is impacting the pearl mussel population, remove by tanker as a temporary measure until system is upgraded/ connected to municipal systems.	Local Authorities/ owner, occupier, user	
17	Forestry		
17a	Develop a long-term, forestry catchment management plan, with key stakeholders, with the aim of minimising hydrological, sediment, nutrient and other potential impacts from forests and all forestry operations. The potential significant risks will be identified through detailed, site-specific risk assessment. Particular attention must be paid to sensitive areas. The target areas identified for Measure 14a above should be used to inform the definition of sensitive areas. The forestry catchment management plan will recognize that site specific measures for forest stands within the pearl mussel catchment are required and will identify, to the extent possible, the most appropriate measures for each site from the following suite of measures, which shall be implemented as and where appropriate:	DAFF (Forest Service)	
17a	i) The option of not felling to be considered in sensitive areas, on a site-by-site basis.	DAFF (Forest Service) and forest owner	
17a	ii) Coniferous plantations within sensitive areas of the catchment will be subject to final felling and replacement with continuous-cover native woodland or semi-natural bog/moor, where it is demonstrated to be technically feasible and silviculturally possible, and where adverse impacts on the protected area will not occur as a result of the measure.	DAFF (Forest Service) and forest owner	
17a	iii) Establish riparian zone management prior to clearfelling, where technically feasible and following specific site-by-site assessment to determine the most appropriate buffer width and vegetative cover. The establishment of such management should not result in adverse impacts on water status.	DAFF (Forest Service) and forest owner	
17a	iv) Change the tree species mix (for example to broadleaves) on replanting where soil-type permits and it is technically feasible and silviculturally possible. This measure will be site-specific. On sensitive sites, restocking with less nutrient demanding conifer species should also be considered.	DAFF (Forest Service) and forest owner	
17a	v) Limit felling coupe size where it is technically feasible and where a risk assessment indicates that wind-throw is not likely to occur. The measure is also site-specific and the coup size should be linked to a multi-year felling plan for a given waterbody that would indicate the percentage of forest area to be felled and the expected nutrient and sediment release.	DAFF (Forest Service) and forest owner	

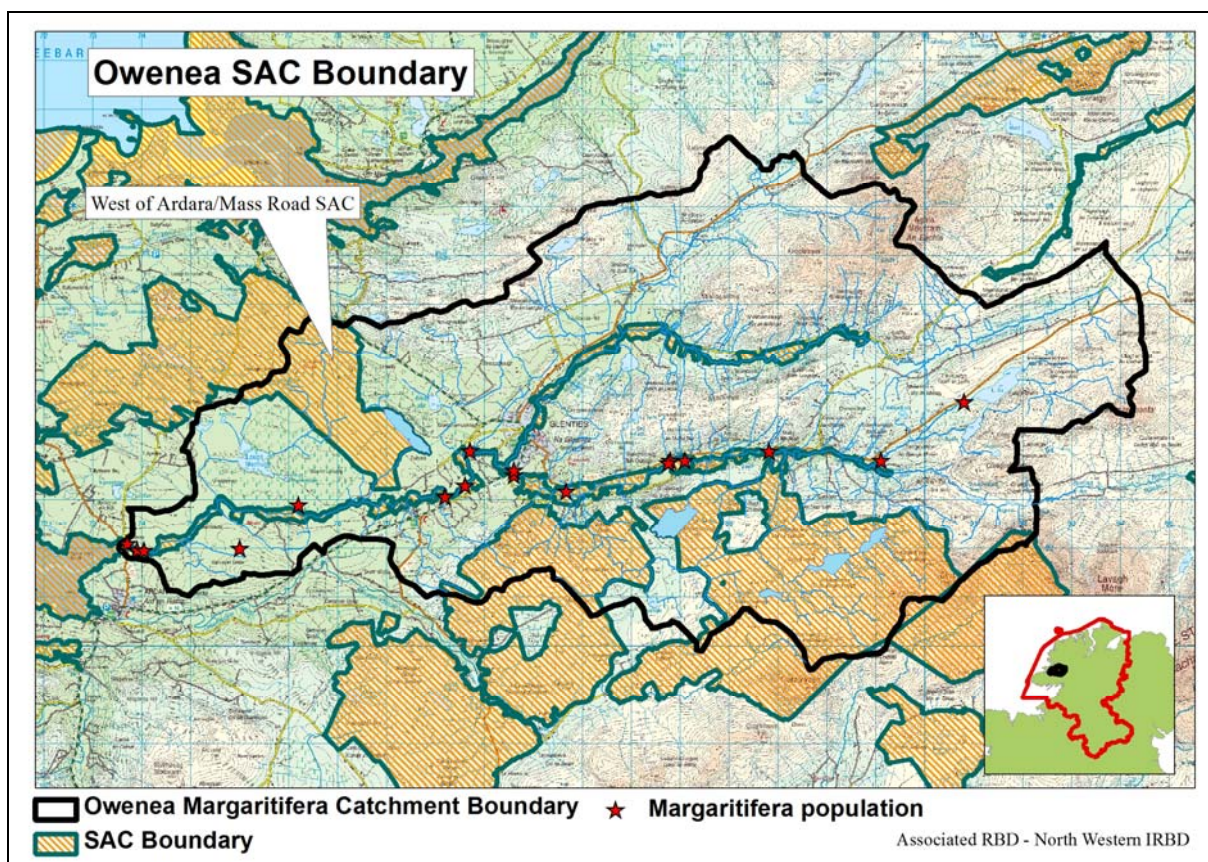
17a	vi) Felling coup size shall be determined through a multi-year forest management plan that will predict nutrient and sediment loading and identify acceptable annual felling as a percentage of the catchment. The measure shall take account of the potential for adverse impacts such as wind-throw and overall forest stand stability in the design of the coupe sizes to be felled. Strict adherence to the Forestry and Freshwater Pearl Mussel Requirements and any other appropriate requirements/guidance is also required.	DAFF (Forest Service) and forest owner	
17a	vii) Following felling of existing forest-stands, restore blanket bog and wet heath through drain blocking and appropriate site management, where it is demonstrated to be technically feasible and where adverse impacts on the protected areas will not occur as a result of the measure. The sites where this measure is to be applied must be agreed with NPWS.	DAFF (Forest Service) and forest owner	
17a	viii) Following site-specific assessment, remove bank-side trees by motor mechanical means and as whole trees where technically feasible and where the potential to impact on the protected species is identified as being less by these means than that by standard harvester and forwarder.	DAFF (Forest Service) and forest owner	
17a	ix) Eutrophication and sedimentation - enhance sediment control through improved design of sediment traps, increased numbers and wider distribution of sediment traps and blankets.	DAFF (Forest Service) and forest owner	
17a	x) Main silt traps will be large enough for <i>Margaritifera</i> conservation purposes. In the design of silt traps reference shall be made to Altmüller & Dettmer, 2006. Ensure that the sediment management system is capable of blocking sediment in preferential flow paths to watercourse.	DAFF (Forest Service) and forest owner	
17a	xi) Prohibition of fertilisation on sensitive sites	DAFF (Forest Service) and forest owner	
17a	xii) Avoid or limit planting on un-enclosed peatland sites (blanket bog, raised bog, fen peat and heathland) and limit forest cover on less sensitive peatland sites such as cutaway, enclosed and improved peats. The latter should be based on a site-by-site assessment.	DAFF (Forest Service) and forest owner	
17a	xiii) Ensure the audit of existing drainage networks in forest catchments is undertaken as per Best Management Practice prior to any felling	DAFF (Forest Service) and forest owner	
17a	xiv) Enhanced drainage network management – minimize drainage in peat soils to reduce potential for nutrient entry to surface waters, where technically feasible.	DAFF (Forest Service) and forest owner	
17a	xv) Pesticide use – reduce and monitor pesticide usage in forests. Reduce usage through allowing forest stands to lay fallow by delaying any restocking by 3-5 years, using pre-dipped plants from nurseries and by developing alternate biological control methods. Where feasible, a register of pesticide use should be maintained.	DAFF and forest owner	
17a	xvi) Establish native riparian woodland as a buffer including the establishment of continuous-cover, native bank-side tress at mussel habitat locations to produce dappled shade with no tunnelling of the river, where appropriate, technically feasible and silviculturally possible	DAFF (Forest Service) and forest owner	
17a	xvii) Roading associated with forestry should be subject to risk assessment and carried out strictly in	DAFF (Forest Service) and	

	accordance with existing national guidelines.	forest owner	
17a	xviii) Establishment of continuous-cover, native bank-side trees at mussel habitat locations to produce dappled shade with no tunnelling of the river.	DAFF (Forest Service) and forest owner	
17a	xix) Trees that are at risk of falling into the river shall be removed or partly removed (e.g. where some boughs are falling into the river) by suitably trained and experienced forestry personnel at mussel locations and, where necessary and technically feasible, be replaced by appropriate native species.	DAFF (Forest Service) and forest owner	
17a	xx) Undertake further research into buffer zones to identify optimum buffer zone design and establishment methods to enhance nutrient and sediment interception	DAFF (Forest Service)	
17a	xxi) Where the continued development of young forest stands is judged to pose a significant future threat to the pearl mussel population due to their location, stand size or being situated on blanket peats, fen peats, raised bogs or heath peats, then such immature forest stands shall be removed through felling-to-waste and any drainage system installed should be blocked and the natural hydrology restored, to the extent possible.	DAFF (Forest Service) and forest owner	
17a	xxii) Where the risk of felling-to-waste of immature forest stands on sensitive sites is regarded as high for the pearl mussel population, consideration shall be given to abandoning such stands and restoring the natural hydrology, where technically feasible.	DAFF (Forest Service) and forest owner	
17b	A monitoring programme to assess the effectiveness of the forestry measures will be developed.	DAFF and DEHLG	
17c	Produce guidance, including mitigation measures, for forest tracks and brash mats, especially in relation to crossings of drains, streams and other watercourses. Review the Forest Road Manual to update mitigation measures for all water crossings by forest machinery.	DAFF (Forest Service)	
18	Peat Cutting - Implementation of these measures will only occur at specific sites where they are required.		
18a	Where turf-cutting and associated drainage have been identified as a significant silt source, drains shall be filled or effectively silt trapped, and an effective buffer zone established to trap overland-movement of peat silt before it reaches the rivers.	DEHLG (National Parks and Wildlife Service), Environmental Protection Agency, Local Authorities	
18b	Where impacts from peat cutting (e.g.. hydrological & siltation) are identified and cannot be mitigated along the pathway, reduction and/or cessation of peat cutting will be required.	DEHLG (National Parks and Wildlife Service), Environmental Protection Agency, Local Authorities	
19	Planning		
19a	Activities such as field drainage, land reclamation, site/land clearance should be made subject to further planning control in sensitive areas of the catchment.	DEHLG	
19b	Areas where further development represents a significant risk to pearl mussel conservation shall be identified and development restrictions implemented, as necessary.	DEHLG and Local Authorities	

20	Infrastructure (roads and bridge) impacting on the river - Implementation of these measures will only occur at the specific sites where they are required.		
20a	All planned future roads or bridges of any size shall be assessed for potential negative impacts on mussel populations during construction and operation. Future roads or bridges of any size should be subject to morphological controls (see Measure 10).	Local Authorities and National Road Authority	
20b	Remediate hydromorphological damage caused by temporary or permanent roads and bridges, where such remediation work has been judged necessary and, through Appropriate Assessment and/or EIA, unlikely to significantly impact on the environment.	Local Authorities/NRA	
20c	Remediate hardcore or surfacing that includes substantial limestone content, where such work has been judged necessary and, through Appropriate Assessment and/or EIA, unlikely to significantly impact on the environment.	Local Authorities/NRA	
21	Leisure management - Implementation of these measures will only occur at the specific sites where they are required.		
21a	Angling – conduct surveys to determine whether fishing access is contributing to destabilising river banks and develop remedial measures, as necessary.	DEHLG (National Parks and Wildlife Service), Fisheries Boards, angling rights holders and angling clubs	
21b	Angling – avoid trampling on pearl mussels by fishing from the bank.	Anglers	
21c	Angling - provide notices and leaflets advising anglers of the sensitivity of pearl mussels, the areas where care is necessary to avoid trampling on mussels and/or disturbing river banks and bed, and the penalties for causing damage to the species and its habitat.	Fisheries Boards, angling rights holders and angling clubs, DEHLG (National Parks and Wildlife Service)	
21d	River morphological works shall comply with any new guidance for <i>Margaritifera</i> and fisheries enhancement to ensure that any works are beneficial to both. These shall be subject to morphological controls under Measure 10.	Fisheries Boards, Local Authorities and DEHLG (National Parks and Wildlife Service)	
21e	Kayaking/canoeing – liaise with kayaking/canoeing clubs using pearl mussel rivers, enforce restrictions on use where necessary and provide information to kayakers/canoeists and other recreational users through signs, leaflets etc.	DEHLG (National Parks and Wildlife Service)	
22	Dangerous Substances - Implementation of these measures will only occur at the specific sites where they are required.		
22a	Review the substances approved for use in sheep-dip and other pesticides in use in freshwater pearl mussel catchments. Incorporate findings of a review of <i>Margaritifera</i> toxicity research into such a review.	DAFF (Pesticides Control Unit)	
22b	Provide advice and training to pesticide users, e.g. public authorities and farmers, in relation to the use (location, frequency of application, volume, weather etc.), storage and disposal of pesticides toxic to freshwater pearl mussels.	DAFF (Pesticides Control Unit)	
23	Pearl fishing		

	Facilitate the early detection of pearl fishing incidents and ensure the prosecution of pearl fishing crimes	Garda Síochána, DEHLG (National Parks and Wildlife Service)	
24	Assisted breeding programmes		
	If and when necessary, augment freshwater pearl mussel population through assisted breeding and release programmes.	DEHLG/ DEHLG (National Parks and Wildlife Service)	

7.0 Owenea Summary Action Programme



Catchment details	Owenea Sub-Basin Management Plans
Species	<i>Margaritifera margaritifera</i>
Special Area of Conservation (SAC)	IE000197 West of Ardara/Maas Road SAC
River Basin District	North Western IRBD
Water bodies codes associated with catchment where measures may be applied	NW_38_1168, NW_38_1275, NW_38_2271, NW_38_2306, NW_38_2332, NW_38_2748, NW_38_2754, NW_38_2773, NW_38_2777, NW_38_3258, NW_38_3312, NW_38_3418, NW_38_3613, NW_38_3822, NW_38_395.
Water bodies containing Freshwater Pearl Mussels	NW_38_1168, NW_38_3822, NW_38_395.
County	Co. Donegal
Catchment area	126.08 km ²
Total river length in catchment	280.95 km
Total river length within SAC	82.65 km
Intentional and/or direct damage to Pearl Mussels	Damaging the pearl mussel or its habitat, including pearl fishing is strictly forbidden under the Wildlife Act (1976), the Wildlife (Amendment) Act (2000), and the European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations (2009), with a maximum penalty of €500,000, or imprisonment for a term not exceeding 3 years, or both

STATUS	
Freshwater Pearl Mussel Status	<p>The Freshwater Pearl mussel population is at unfavourable conservation status in the Owenea catchment. It is currently ranked as 22nd out of the 27 Freshwater Pearl Mussel SAC populations in the country on the basis of population status, habitat condition and current pressures.</p> <p>The population is failing in its habitat quality (through evidence of heavy siltation and macrophyte growth), and its population demographic profile, where it is evident that there are not the numbers of juveniles present in the population to provide sustainable replacement of the current adult numbers. A full river habitat survey is also needed within this catchment in order to establish a baseline of where the best pearl mussel habitat is located.</p> <p>The catchment fails all of the five Environmental Quality Objectives (EQOs) as specified in Schedule 4 of the European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations, S.I. 296 of 2009.</p>
Water Framework Directive Status	<i>Water Framework Directive Status from the River Basin Management Plans (classification is based on monitoring data from 2006-2008)</i>
River status	4 high status, 9 good status, 1 moderate status, 1 poor status waterbodies.
Status elements	<p>All 4 high status waterbodies were determined via extrapolated status from donor monitored water bodies. Macroinvertebrates determined the status in 2 good status and 1 poor status water bodies, while the remaining 7 good status waterbodies were determined via extrapolation.</p> <p>The unfavourable conservation status of the Freshwater Pearl Mussel led to the downgrading of 1 waterbody to moderate, these otherwise would have been good.</p>

RISKS	
Point sources	<p>Significant risks – impacts observed through survey/monitoring</p> <p>One point source was located within the catchment; this is for the Tazetta Ltd. Mink Farm which has a Section 4 licensed discharge from Donegal CoCo. This is a potential source of nutrient input to the Owenea catchment. Glenties WWTP is a significant factor leading to the loss of the Owenea pearl mussel population.</p> <p>Potential significant risks</p> <p>N/A</p>
Physical Modifications	<p>Significant risks – impacts observed through survey/monitoring</p> <p>Reinforced banks Deepened and widened channels Bank side clearance and drainage works were all recorded on a number of river stretches throughout the catchment.</p> <p>Significant works together with numerous culverts and outfalls were also found throughout the catchment largely associated with one-off housing and contained high levels of silt which was discharging to the river.</p> <p>The new bridge on the Owenea River is a large clear span bridge with a large central pier embedded in concrete with end piers at each side also encroaching into the natural bank area. Armouring upstream and downstream of the bridge has been placed in front of the river banks. There is evidence of loss of pearl mussels as a result.</p> <p>Potential significant risks</p> <p>Any future flood alleviation schemes or physical modifications to the bank or channel in the vicinity of the freshwater pearl mussel</p>
Agriculture	<p>Significant risks – impacts observed through survey/monitoring</p> <p>Throughout the catchment sheep and cattle grazing is an issue where</p>

	<p>adequate fencing is not provided. Animal trampling and poaching were also noted on a number of occasions. Lack of adequate buffer zones and fencing was also found throughout the catchment. A high concentration of farms was recorded along the rivers within the Owenea catchment.</p> <p>Potential significant risks The lack of access to detailed agricultural land-use data precludes detailed risk assessment, but data from orthophotos/NPWS Commonage Framework Plans, Livestock Unit Density maps and soil types indicates that a very small percentage of the catchment is covered by pasture generally in the bottom section of the catchment with associated risks of nutrient/sediment losses. All agricultural activities that can lead to soil erosion (e.g. drainage, land reclamation, ploughing, poaching, overgrazing) and/or nutrient losses (e.g. slurry-spreading, fertilisation) are potential significant risks within the Nore catchment.</p>
On-site waste water treatment systems	<p>Significant risks – impacts observed through survey/monitoring N/A</p> <p>Potential significant risks 562 on-site systems on extreme risk potential, 143 on very high risk potential, 3 on moderate risk potential settings. OSWWTS on high risk potential settings pose potential significant risks in terms of nutrient loss. In particular, inappropriately designed and/or poorly maintained OSWWTS are a potential significant risk.</p>
Forestry	<p>Significant risks – impacts observed through survey/monitoring Areas of forestry were noted adjacent to river stretches with no buffer zones.</p> <p>Potential significant risks Forestry on drained peat and peaty soils is considered a potential significant risk owing to resultant hydrological changes, sediment losses from eroding drains and nutrient losses (particularly ammonia) from peat decomposition. 1289 ha was planted before 1990 and is likely to have insufficient buffering. The following forest operations are also considered significant risks: fertilisation on peat and peaty soils (nutrient enrichment); drainage/other ground preparation, road-construction, thinning and clear-felling on peat, peaty and other highly erodible soil types, particularly on steep slopes (sedimentation).</p>
Other issues Fords	<p>Significant risks – impacts observed through survey/monitoring One ford crossing was recorded within the catchment. This had a concrete substrate which may indicate it is used for vehicular access.</p> <p>Potential significant risks</p>
Wind Farms	<p>Significant risks – impacts observed through survey/monitoring A number of applications for wind farms within the catchment together with submissions have been made to NPWS. Some applications are for a large number of turbines. The number and size of the wind farms are a cause of concern and could cause de-stabilisation.</p> <p>Potential significant risks</p>
Fisheries works	<p>Significant risks – impacts observed through survey/monitoring The bank side reinforcement associated with the fisheries works carried out within the pearl mussel habitat has led to erosion on the opposite bank</p>

ACTION PROGRAMME – MEASURES	
Function of Measures Proposed	The Owenea is currently ranked as 22 nd out of the 27 Freshwater Pearl Mussel SAC populations in the country on the basis of population status, habitat condition and current pressures. The level of siltation and nutrient input throughout the catchment is evident from the excessive macrophyte growth which was recorded. In particular, site clearance works associated with one-off housing and wind farm installations, animal trampling and poaching, forestry and agriculture are a cause of concern. The implementation of all measures is required for the Owenea catchment due to the considerable loss in pearl mussel numbers below Glenties. Measures should also be formulated with a view to further understanding the condition of habitat availability for the freshwater pearl mussel.
Policy and Regulatory Framework	This sub-basin management plan is published by the Minister for the Environment, Heritage and Local Government in accordance with S.I. 296 of 2009. It is the duty of a listed public authority to take such steps as are necessary and appropriate to the discharge of its functions to implement these measures. The Minister shall monitor the implementation by public authorities of the sub-basin management plans. Public authorities must track and report all relevant measures and actions. Progress on the implementation of measures will be reported under both the Habitats Directive (2013 and every six-years thereafter) and the WFD.
About the measures	<i>The measures below are priority measures specific to the Owenea catchment. (See also Table 6.2)</i> <i>Note: All measures listed in Tables 6.1, 6.2 together with the summary action programme are potentially applied to the catchment.</i>
Public Awareness	An education and awareness campaign shall include public meetings, talks (schools, etc.), clinics and the distribution of leaflets. Topics covered will include the biology and ecology of pearl mussels and damage caused by e.g. pearl fishing, in-stream activities, sedimentation and nutrient enrichment. The measures necessary for their conservation shall be explained.
Stakeholder Involvement	Stakeholder assistance in the further development and design of measures will be encouraged.
Guidance	Appropriate guidance will be provided to different sectors to assist with their compliance with the Freshwater Pearl Mussel Regulations.
Planning	Activities such as field drainage, land reclamation, site/land clearance shall be made subject to planning control, i.e. shall no longer be exempted developments.
Habitats Directive Controls	Stakeholders will be notified of the measures required under this Sub-basin Plan. The activities requiring consent (or Notifiable Actions) under S.I. 94 of 1997 are being revised and shall be formally notified to the relevant owners, occupiers or users in the mussel SACs.
Point Source	All discharge licences or authorisations must comply with the EQOs set out in SI 296 of 2009. All WwTP, IPPC and Section 4 and Section 16 discharge licences must be reviewed to assess compliance with EQOs and additional conditions imposed as required. WwTP improvements: the WwTP at Glenties requires: <ul style="list-style-type: none"> • Improvements are pivotal to the recovery of Owenea pearl mussel population. Connection of all developments within the village and environs to the WWTP and upgrade of WWTP as necessary. • Glenties WwTP has been prioritised and placed on the Water Services Investment Programme 2010-2012.
Physical Modifications	Implement necessary legislative change to control morphological alterations of surface waters.
Agriculture	Agricultural measures for freshwater pearl mussels will be rolled-out in target areas within Freshwater Pearl Mussel SAC catchments under an agri-environmental scheme(s). (Note: work is ongoing to identify the target areas). Measures shall include detailed assessment of soil nutrient

	<p>status, sediment and nutrient management plans, fencing to prevent erosion and trampling on mussels, etc. Guidance and training shall be provided in relation to risk assessment, and the implementation and inspection of required measures.</p> <p>Weightings shall be applied to increase GAP Regulation (S.I. 101 of 2009) and Cross-compliance inspections in these catchments.</p>
On-site waste water treatment systems	<p>The proximity of many one off houses to the river throughout the catchment is of particular concern. Inspection and appropriate remediation of these on site waste water systems (OSWWS) is a priority. The Department of the Environment, Heritage and Local Government will be bringing forward legislation in the first half of 2010 that provides for the setting of standards for the performance and operation of all septic tanks and similar on-site wastewater treatment systems. The legislation will also provide for the monitoring and inspection of the performance of such treatment systems and will set out the responsibilities of households served by those systems (including requirements to carry out remedial actions where necessary).</p>
Forestry	<p>A long-term, forestry catchment management plan shall be prepared with the aim of minimising hydrological, sediment, nutrient and other potential impacts from forests and all forest operations.</p>
Other issues	
Point Source	<p>A section 4 licence review for the point source discharge from the mink farm located within the catchment should be carried out as a priority. Improvement to Glenties WWTP is pivotal to the recovery of the Owenea pearl mussel population. Investigation and connection of all developments within the village and its environs is also required.</p>
Fisheries	<p>Any future knock on erosion from fisheries should be mitigated.</p>
Fords	<p>Further investigation as to the impact caused and/or release of siltation from this ford crossing should be investigated further.</p>
Wind Farms	<p>Some applications are for a large number of turbines. The proposed location of these turbines is the major concern in particular where they are located on peat and peaty soils, this together with the number and size of the wind farms are a cause of concern and could cause de-stabilisation.</p>
Future & Planning Issues	
<p>The Freshwater Pearl Mussel is extremely sensitive to sedimentation and eutrophication, therefore any activity that can give rise to sediment and nutrient inputs to water has the potential to impact on the species.</p> <p>It is the duty under S.I. 296 of 2009 of a listed public authority to take such steps as are necessary and appropriate to the discharge of its functions to implement the measures in this sub-basin plan.</p> <p>All plans (e.g. catchment management plans for forestry), programmes (e.g. new agri-environmental schemes) and projects (e.g. new one-off houses) with the potential to impact on Natura 2000 sites must be screened for Appropriate Assessment in accordance with Article 6 of the Habitats Directive, and an Appropriate Assessment must be conducted, where judged necessary (see http://www.npws.ie/en/WildlifePlanningtheLaw/AppropriateAssessment/; http://ec.europa.eu/environment/nature/natura2000/management/guidance_en.htm).</p> <p>In addition, all plans and programmes are likely to require Strategic Environmental Assessment (SEA).</p> <p>The key issues for the future management of the Owenea catchment are:</p> <ul style="list-style-type: none"> • Minimisation of sediment losses arising from site clearance works for development, agriculture or other purposes, • Minimisation of sediment and nutrient losses arising from land-use change (e.g. increased stocking-rates), • Prevention of nutrient and sediment losses from new on-site wastewater systems associated with one-off houses, • Control of hydro-morphological pressures, including drainage, drainage-maintenance, bank stabilisation works etc. 	

- Control of municipal and industrial discharges to meet Environmental Quality Objectives set out in Schedule 4 of SI 296 of 2009,

The key legal and policy measures required to mitigate impacts from on-going and future activities and to restore the Freshwater Pearl Mussel habitat are:

- Freshwater Pearl Mussel-measures in agri-environmental scheme
- Catchment management plans for forestry
- Proper licensing, upgrade and operation of WwTPs and associated infrastructure
- Proper licensing, mitigation and maintenance of other point-source discharges
- Changes to planning law to control currently exempted developments that can give rise to sediment and nutrient losses (e.g. land reclamation, clearance and in-fill for agriculture)
- Proper design, operation and maintenance of OSWWS

Objectives

Achievement of favourable conservation status for the freshwater pearl mussel population under the Freshwater Pearl Mussel Regulations S.I. 296, 2009.

Relevant public authorities must examine and review, as required, authorised discharges by 22nd December 2011.

All other measures in this sub-basin management plan shall be made operational by 22nd December 2012.

Implementation of the measures will be reported under the Habitats Directive in 2013 and under the WFD in 2015.

Signs of improvement in the parameters listed in Schedule 3 and/or Schedule 4 of the Freshwater Pearl Mussel Regulations (S.I. 296 of 2009) should be evident by 2015.

8 REFERENCES & BIBLIOGRAPHY

- Allott, N.A., Mills, W.R.P., Dick, J.R.W., Eacrett, A.M., Brennan, M.T., Clandillon, S., Philips, W.E.A., Critchley, M. & Mullins, T.E. (1990). *Acidification of surface waters in Connemara and South Mayo*. Report, DuQense Ltd, Dublin.
- Altmüller, R. & R. Dettmer (2006): Erfolgreiche Artenschutzmaßnahmen für die Flussperlmuschel *Margaritifera margaritifera* L. durch Reduzierung von unnatürlichen Feinsedimentfrachten - Erfahrungen im Rahmen des Lutterprojekts. Informationsdienst Naturschutz Niedersachsen. Heft 4/06, 192-204
- Anonymous (2004). *Margaritifera margaritifera: Stage 1 and Stage 2 survey guidelines*. Irish Wildlife Manuals No. 12. The National Parks and Wildlife Service, Dublin.
- Anonymous (2005). Northern Ireland Species Action Plan: Freshwater Pearl Mussel *Margaritifera margaritifera*. Northern Ireland Environment Agency. http://www.ni-environment.gov.uk/fwpearlmussel_pdf.pdf.
- Araujo, R. & Ramos, M.A. (2001). *Action plans for Margaritifera auricularia and Margaritifera margaritifera in Europe*. Nature and Environment, No. 117. Council of Europe Publishing, Strasbourg.
- Baillie, J. & Groombridge, B. (1996). *The 1996 Red List of Threatened Animals*. IUCN, Gland, Switzerland. 368pp.
- Barko, J.W, Gunnison, D & Carpenter, S.R. (1991). Sediment interactions with submersed macrophyte growth and community dynamics. *Aquatic Botany* 41, 41-65.
- Barko, J.W. & Smart, R.M. (1980). Mobilization of Sediment Phosphorus by Submersed Freshwater Macrophytes. *Freshwater Biology* 10, 229-238.
- Bauer, G. (1987). Reproductive strategy of the freshwater pearl mussel *Margaritifera margaritifera*. *J. Anim. Ecol.* 56, 691-704.
- Bauer, G. & Vogel, C. (1987). The parasitic stage of the freshwater pearl mussel *Margaritifera margaritifera*. I. Host response to Glochidiosis. *Arch. Hydrobiol.* 76, 393-402.
- Bauer G., Hochwald, S. & Silkenat, W. (1991). Spatial distribution of freshwater mussels: the role of host fish and metabolic rate. *Freshwater Biology* 26, 377-386.
- Bauer, G. (2000). Factors affecting Naiad occurrence and abundance. In: Bauer, G. & Wächtler, K. (Eds.). *Ecology and Evolution of the Freshwater Mussels Unionoida*. Ecological Studies 145. Springer, Berlin. P155-161.
- Beasley, C.R. & Roberts, D. (1996). The current distribution and status of the freshwater pearl mussel *Margaritifera margaritifera* L. in northwest Ireland. *Aquatic Conservation: Marine and Freshwater Ecosystems* 6, 169– 177.
- Berry, P.M., O'Hanley, J.R., Thomson, C.L., Harrison, P.A., Masters, G.J. & Dawson, T.P. (Eds.) (2007). *Modelling Natural Resource Responses to Climate Change (MONARCH): MONARCH 3*. UKCIP Technical Report, Oxford
- Bogan, A.E. (1993). Freshwater Bivalve Extinctions (Mollusca: Unionoida): A Search for Causes. *Integrative and comparative Biology* 33, 599-609.
- Bowman, J.J. & Bracken, J.J. (1993). Effect of runoff from afforested and nonafforested catchments on the survival of brown trout (*Salmo trutta*) in two acid sensitive rivers in Wicklow, Ireland. *Biology and the Environment: Proceedings of the Royal Irish Academy* 93B, 143–50.
- Clarke, S.J. (2002). Vegetation growth in rivers: influences upon sediment and nutrient dynamics. *Progress in Physical Geography* 26, 159-172.
- Cosgrove, P.J., & Young, M. (1998). *The status of the freshwater pearl mussel Margaritifera margaritifera in Scotland*. A report to Scottish Natural Heritage, Edinburgh.
- Cranbrook, Earl of (1976). The commercial exploitation of the freshwater pearl mussel, *Margaritifera margaritifera* L. (Bivalvia: Margaritiferidae) in Great Britain. *J. Conch. Lond.* 29: 87-91.
- Colosimo, M, & Wilcock, P.R. (2005). Alluvial sedimentation and channel adjustment in an urbanizing Maryland watershed. *J. American Water Resources Association*. ? Colosimo, M. & P.R. Wilcock, (2007), Alluvial sedimentation and erosion in an urbanizing watershed, Gwynns Falls, Maryland, *J. American Water Resources Association* 43(2),499-521.
- Cunjak, R.A. (1991). The parasite-host relationship of glochidia (Mollusca: Margaritiferidae) on the gills of young-of-the-year Atlantic salmon (*Salmo salar*). *Can. J. Zool.* 69, 353-358.
- Curran, J.C. & P.R. Wilcock (2005). The Effect of Sand Supply on Transport Rates in a Gravel-Bed Channel. *J. Hydraulic Engineering*. 131 (11), 961pp.
- Daly, K., Jeffrey, D. & Tunney, H. (2001). The effect of soil type on phosphorus sorption capacity and desorption dynamics in Irish grassland soils. *Soil Use and Management* 17, 12-20.
- Department for Environment, Food and Rural Affairs UK (2004). *Water quality: A diffuse pollution review*. DEFRA, London. , 12-28.

- Dietrich, W.E., Kirchner, J.W., Ikeda, H. & Iseya, F. (1989). Sediment supply and the development of the coarse surface layer in gravel-bedded rivers. *Nature* 340, 215-217.
- Dolmen, D., Arneklev, J.V., & Haukebo, T. (1995). Rotenone tolerance in the freshwater pearl mussel *Margaritifera margaritifera*. *Nord. J. Freshwater Res.* 70, 21-30.
- Donald T. Monteith*, John L. Stoddard*, Christopher D. Evans³, Heleen A. de Wit⁴, Martin Forsius⁵, Tore Høga[°]sen, Anders Wilander⁶, Brit Lisa Skjelkva[°], Dean S. Jeffries, Jussi Vuorenmaa⁵, Bill Keller, Jiri Kopa[°]cek & Josef Vesely, Dissolved organic carbon trends resulting from changes in atmospheric deposition chemistry, *Nature*, Volume 450, 22 November 2007, p 537 – 540.
- Ellis, M.M. (1936). Erosion silt as a factor in aquatic environments. *Ecology* 17, 29-42.
- Eriksson, M.O.G., Henrikson, L., & Oscarson, H.G. (1981). Effects of acidification on freshwater molluscs in Alvsborgs lan. *Lansstyrelses, Alvsborgs lan* 2, 1-12.
- Eriksson, M.O.G., Henrikson, L., & Oscarson, H.G. (1982). Acidification - a threat against the pearl mussel. *Sveriges Natur* 73, 16-19.
- Eriksson, M.O.G., Henrikson, L., & Oscarson, H.G. (1983) The pearl mussel in Sjuharadsbygden. *Sjuharadsnatur* 4, 58-63.
- European Commission (2006). Assessment, Monitoring and Reporting under Article 17 of the Habitats Directive: Explanatory Notes and Guidelines.
- Evans C.D, D.T. Monteith, D.M. Cooper, Long-term increases in surface water dissolved organic carbon: Observations, possible causes and environmental impacts, *Environmental Pollution* 137 (2005) 55-71.
- Fischenick, J.C., (2003). *Effects of rip rap on riverine and riparian ecosystems*. Wetlands Regulatory Assistance Programme. US Army corps of Engineers.
- Geist, J. (2005). *Conservation genetics and ecology of European freshwater pearl mussels* (*Margaritifera margaritifera* L.). PhD Thesis. Technischen Universität München.
- Geist, J., Porkka, M. & Kuehn, R. (2005). The status of host fish populations and fish species richness in European freshwater pearl mussel (*Margaritifera margaritifera*) streams. *Aquatic Conservation: Marine and Freshwater Ecosystems* 16, 251-266.
- Geist, J., Porkka, M., & Kuehn, R. (2006) The status of host fish populations and fish species richness in European freshwater pearl mussel (*Margaritifera margaritifera*) streams. *Aquatic Conservation: Marine and Freshwater Ecosystems*, 16, 251–266.
- Hastie, L.C., & Young, M.R. (2003). *Conservation of the Freshwater Pearl Mussel. 2. Relationship with Salmonids*. Conserving Natura 2000 Rivers. Conservation Techniques Series No. 3. English Nature, Peterborough.
- Hastie, L.C., Boon, P.J. & Young, M.R. (2000). Physical microhabitat requirements of freshwater pearl mussels, *Margaritifera margaritifera* (L.). *Hydrobiologia* 429, 59-71.
- Hastie, L.C., Cosgrove, P.J., Ellis, N., & Gaywood, M.J. (2003). The threat of climate change to freshwater pearl mussel populations. *Royal Swedish Academy of Sciences Ambio* 32, 40-46.
- Henriksen, A., Posch, M., Hultberg, H. & Lien, L. (1995). Critical loads of acidity for surface waters - Can the ANC(limit) be considered variable? *Water Air and Soil Pollution* 85, 2419-2424.
- Johnston, G. (1850) *Introduction to Conchology*. Bentley & Fley, London.
- Karna, D.W. & Millemann, R.E. (1978). Glochidiosis of Salmonid fishes. III. Comparative susceptibility to natural infection with *Margaritifera margaritifera* (L.) (Pelecypoda: Margaritanidae) and associated histopathology. *J. Parasitol.* 64, 528-537.
- Kelly-Quinn, M., Tierney, D., Coyle, S. & Bracken, J.J. (1997). *A study of the effects of stream hydrology and water quality in forested catchments on fish and invertebrates*. AQUAFOR report Vol. 3: *Stream Chemistry, Hydrology and Biota, Wicklow Region*. COFORD, Dublin.
- Killeen, I.J., Oliver, P.G. & Fowles, A.P. (1998). The loss of a freshwater pearl mussel (*Margaritifera margaritifera*) population in NW Wales. *Journal of Conchology Special Publication* 2: 245-250.
- Killeen, I.J. & Moorkens, E.A., 2008. A rapid survey for the freshwater pearl mussel *Margaritifera margaritifera* (L., 1758) in the Aughavaud river, County Carlow. Report for the National Parks and Wildlife Service, Dublin.
- Levasseur, M., Bergeron, N.E., Lapointe, M.F., & Bérubé, F. (2006). Effects of silt and very fine sand dynamics in Atlantic salmon (*Salmo salar*) redds on embryo hatching success. *Can. J. Fish. Aquat. Sci.* 63, 1450-1459.
- Lacroix, G.L. (1989). Ecological and physiological responses of Atlantic salmon in acidic organic rivers of Nova Scotia, Canada. *Water, Air and Soil Pollution* 46, 375-386.
- Lucey J. (1993). The distribution of *Margaritifera margaritifera* in southern Irish rivers and streams. *J. Conch. Lond.* 34, 301-310.
- Lucey J. (2005). *The Irish Pearl. A cultural, social and economic history*. Wordwell, Bray.
- Lucey, J. (2006). The pearl mussel, *Margaritifera margaritifera* (L.), in hard water in Ireland. *Biology and Environment: Proceedings of the Royal Irish Academy* 106 B: 143-153

- Madsen, J.D., Chambers, P.A., James, W.F., Koch, E.W. & Westlake, D.F. (2001). The interaction between water movement, sediment dynamics and submersed macrophytes. *Hydrobiologia* 444, 71-84.
- Maitland, P.S., Lyle, A.A. & Campbell, R.N.B. (1987). *The status of fish populations in waters likely to have been affected by acid deposition in Scotland*. Natural Environment Research Council contract report to the Department of Environment and the Commission of the European Communities. Institute of Terrestrial Ecology, Edinburgh.
- Marking, L.L. & Bills, T.D. (1979). Acute effects of silt and sand sedimentation on freshwater mussels. In: Proceedings of the UMRCC symposium on Upper Mississippi River Bivalve molluscs. J.R. Rasmussen, (Ed.). Upper Mississippi River Conservation Committee, Rock Island, Illinois. 204-211.
- McAllister, D., Craig, J., Davidson, N. & Seddon, M. (1999). *The Biodiversity Impacts of Large Dams*. Report to IUCN, Gland.
- Mellinger, P.J. (1973). The Comparative Metabolism of Two Mercury Compounds as Environmental Contaminants in the Freshwater Mussel, *Margaritifera margaritifera*. In: Trace Substances in Environmental Health-VI. D.D. Hemphill (Ed.). University of Missouri, Columbia, MO. 173-180.
- Meyers, T.R. & Millemann, R.E. (1977). Glochidiosis of salmonid fishes. I. Comparative susceptibility to experimental infection with *Margaritifera margaritifera* (L.). (Pelecypoda: Margaritanidae). *J. Parasitol.* 63, 728-733.
- Moorkens, E. A. (1991). *The freshwater pearl mussel Margaritifera margaritifera in the south east of Ireland*. M.Sc. Thesis, Trinity College, Dublin.
- Moorkens, E. A. (1995). *Mapping of proposed SAC rivers for Margaritifera margaritifera*. Volumes 1 & 2. Report for the National Parks and Wildlife Service, Dublin.
- Moorkens, E. A. (1996). *Studies on the Biology and Ecology of Margaritifera in Ireland*. PhD Thesis, Trinity College, Dublin.
- Moorkens, E.A. (1999). *Conservation Management of the Freshwater Pearl Mussel Margaritifera margaritifera. Part 1: Biology of the species and its present situation in Ireland*. Irish Wildlife Manuals No. 8. The National Parks and Wildlife Service, Dublin.
- Moorkens, E. A. (2004). *Pilot Project for Monitoring Populations of the Freshwater Pearl Mussel. Baseline survey of the Owenriff River SAC, County Galway*. Report for the National Parks and Wildlife Service, Dublin.
- Moorkens, E. A. (2005a). *Monitoring Populations of the Freshwater Pearl Mussel. Baseline survey of the Newport River cSAC, County Mayo*. Report for the National Parks and Wildlife Service, Dublin..
- Moorkens, E. A. (2005b). *Monitoring Populations of the Freshwater Pearl Mussel. Baseline survey of the Bundorragha River cSAC, County Mayo*. Report for the National Parks and Wildlife Service, Dublin..
- Moorkens, E. A. (2005c). *Monitoring Populations of the Freshwater Pearl Mussel. Repeat survey of the Owenriff River SAC, County Galway*. Report for the National Parks and Wildlife Service, Dublin.
- Moorkens, E. A. (2005d). *Margaritifera margaritifera survey of the River Owenea in the vicinity of Glenties, County Donegal*. Report for Donegal County Council.
- Moorkens, E. A. (2006a). *Monitoring Populations of the Freshwater Pearl Mussel. Baseline survey of the Eske River cSAC, County Donegal*. Report for the National Parks and Wildlife Service, Dublin.
- Moorkens, E. A. (2006b). *Monitoring Populations of the Freshwater Pearl Mussel. Baseline survey of the Clady River cSAC, County Donegal*. Report for the National Parks and Wildlife Service, Dublin.
- Moorkens, E. A. (2006c). *Monitoring Populations of the Freshwater Pearl Mussel. 2006 repeat survey of the Owenriff River cSAC, County Galway*. Report for the National Parks and Wildlife Service, Dublin.
- Moorkens, E. A. (2006d). Irish non-marine molluscs – an evaluation of species threat status. *Bull. Ir. biogeog. Soc.* 30, 348-371.
- Moorkens, E.A. & Costello, M. J. (2004). Survival of the freshwater pearl mussel *Margaritifera margaritifera* after opening with mussel tongs. In: Molluscan Biodiversity and Conservation. I.J. Killeen & M.B. Seddon (Eds). Journal of Conchology Special Publication No. 3, 91-94.
- Naden, P., Smith, B., Jarvie, H., Llewellyn, N., Matthiessen, P., Dawson, H., Scarlett, S. & Hornby, D. (2003). *Siltation in Rivers. A review of monitoring techniques. Conserving Natura 2000 Rivers*. Conservation Techniques Series No. 6. English Nature, Peterborough.
- Nezlin, L.P., Cunjak, R.A., Zotin, A.A. & Ziuganov, V.V. (1994). Glochidium morphology of the freshwater pearl mussel (*Margaritifera margaritifera*) and glochidiosis of Atlantic salmon (*Salmo salar*): a study by scanning electron microscopy. *Can. J. Zool.* 72, 15-21.
- O'Grady, M. (2006). *Channels and Challenges. The enhancement of salmonid rivers*. Central Fisheries Board, Dublin. 142pp.
- Okland, J. & Okland, K.A. (1986) The effects of acid deposition on benthic animals in lakes and streams. *Experientia* 42, 471-486.
- Oliver, G., Meechan, C.J. & Trew, A. (1993) *Report on the 1992/93 survey of the freshwater pearl mussel (Margaritifera margaritifera L., 1758) in the river Wye*. Report to the Countryside Council for Wales.
- Purser, G.J. (1988). *Factors affecting the distribution of the freshwater pearl mussel (Margaritifera margaritifera L.) in Britain*. PhD Thesis, University of Aberdeen.

- Raddum, G.G. & Fjellheim, A. (2004) Acidification in Norway — Status and trends biological monitoring — Improvements in the invertebrate fauna. *Water, Air & Soil Pollution* 85, 647-652.
- Rooney, N., Kalff, J. & Habel, C. (2003). The role of submerged macrophyte beds in phosphorus and sediment accumulation in Lake Memphremagog, Quebec, Canada. *Limnology and oceanography* 48, 1927-1937.
- Ross, E.D. (1984). *Studies on the biology of freshwater mussels (Lamellibranchia: Unionacea) in Ireland*. MSc Thesis, National University of Ireland, Galway.
- Ross, E.D. (1988). *The reproductive biology of freshwater mussels in Ireland, with observations on their distribution and demography*. PhD Thesis, National University of Ireland, Galway.
- Ross, E.D. (1999). *A survey of four rivers in the south-west of Ireland for the freshwater pearl mussel Margaritifera margaritifera (L.)*. Report for the National Parks and Wildlife Service, Dublin.
- Ross, E.D. (2004a). *A Pilot Project to Develop a Monitoring Protocol for the Freshwater Pearl Mussel Margaritifera margaritifera (L.) in the Blackwater River, County Kerry, Ireland*. Report for the National Parks and Wildlife Service, Dublin.
- Ross, E.D. (2004b). *A Pilot Project to Develop a Monitoring Protocol for the Freshwater Pearl Mussel Margaritifera margaritifera (L.) in the Caragh River, County Kerry, Ireland*. Report for the National Parks and Wildlife Service, Dublin.
- Ross, E.D. (2005a). *Initiation of a monitoring program for the freshwater pearl mussel, Margaritifera margaritifera (L.) in the Licky River*. Report for the National Parks and Wildlife Service, Dublin.
- Ross, E.D. (2005b). *Initiation of a monitoring program for the freshwater pearl mussel, Margaritifera margaritifera (L.) in the Ownagappul River*. Report for the National Parks and Wildlife Service, Dublin.
- Ross, E. (2006a). *Initiation of a monitoring program for the freshwater pearl mussel, Margaritifera margaritifera (L.) in the Clodiagh River (Suir)*. Report for the National Parks and Wildlife Service, Dublin.
- Ross, E. (2006b). *Initiation of a monitoring program for the freshwater pearl mussel, Margaritifera margaritifera (L.) in the Mountain River (Barrow)*. Report for the National Parks and Wildlife Service, Dublin.
- Ross, E.D. (2006c). *Report on searches for juvenile Margaritifera margaritifera (L.) in the Blackwater River (Co. Kerry)*. Report for the National Parks and Wildlife Service, Dublin.
- Ross, E.D. (2006d). *Report on searches for juvenile Margaritifera margaritifera (L.) in the Caragh River, Co. Kerry*. Report for the National Parks and Wildlife Service, Dublin.
- Ross, E.D. (2006e). *Report on searches for juvenile Margaritifera margaritifera (L.) in the Dereen River (Co. Carlow)*. Report for the National Parks and Wildlife Service, Dublin.
- Skinner, A., Young, M. & Hastie, L. (2003). *Ecology of the Freshwater Pearl Mussel*. Conserving Natura 2000 Rivers. Ecology Series No. 2. English Nature, Peterborough.
- Smith, D.G. (1976). The distribution of the Margaritiferidae: A review and a new synthesis. *Bull. Amer. Malac. Union* 42.
- Smith, D.G. (1978). Biannual gametogenesis in *Margaritifera margaritifera* (L.) Northeastern North America. *Bull. Amer. Malac. Union* 1978, 49-53.
- Smith, D.G. (1979). Sexual characteristics of *Margaritifera margaritifera* (Linnaeus) populations in Central New England. *Veliger* 21, 381-383.
- Southern Regional Fisheries Board, Central Fisheries Board & Compass Informatics (2008). *Assessment of the Risk of Barriers to Fish Migration in the Nore Catchment*. Report for the Shannon River Basin District Project Freshwater Morphology Programmes of Measures and Standards Study. www.wfdireland.ie
- Stelfox, A.W. (1911). A list of the Land and freshwater Mollusks of Ireland. *Proc. R. Ir. Acad.* 29B, 65-164.
- Stelfox, A.W. (1929). Land and freshwater Mollusca. *Proc. R. Ir. Acad.* 39B, 6-10.
- Valovirta, I. (2001). Restoration of Rivers for *Margaritifera margaritifera*. In: The Freshwater pearl mussel in Europe: Population status and conservation strategies.. Wasserwirtschaftsamf, Hof. 120-123
- Vinogradov, G. A., Klerman, A. K., Komov, V. T. & Kheming, T. A. (1987). Regulation of acid-base mantle fluid homeostasis in bivalve mollusc *Margaritana margaritifera* (Eulamellibranchia, Margaritiferidae) on drying up and acidification of medium. *Zoologičeskij žurnal* 66, 989-995.
- Wells, S.M., Pyle, R.M. & Collins, N.M. (1983). *The IUCN Invertebrate red data book*. International Union for the Conservation of Nature and Natural Resources, Gland (Switzerland), 145-156.
- Wood, P.J. (1997). Biological Effects of Fine Sediment in the Lotic Environment. *Environmental Management* 21, 203-217.
- Young, M. (2005). *A literature review of the water quality requirements of the freshwater pearl Mussel (Margaritifera margaritifera) and related freshwater bivalves*. Commissioned report No. 84. Scottish Natural Heritage, Inverness.
- Young, M.R. & Williams, J.C. (1983a). Redistribution and local recolonisation by the freshwater pearl mussel *Margaritifera margaritifera* (L.). *J. Conch. Lond.* 31, 225-234.

Young, M.R. & Williams, J.C. (1983b). The status and conservation of the freshwater pearl mussel *Margaritifera margaritifera* Linn. in Great Britain. *Biol. Cons.* 25, 35-52.

Ziuganov, V.V. & Nezlin, L.P. (1988). Evolutionary aspects of symbiosis of pearl mussels and salmonid fishes. In: The problems of macroevolution. Moscow, Nauka. 110-111. (In Russian).

Ziuganov, V., Zotin, A., Nezlin, L. & Tretiakov, V. (1994). *The freshwater pearl mussels and their relationships with salmonid fish*. VNIRO, Moscow. 104pp.

Ziuganov, V.V. (2005). A paradox of parasite prolonging the life of its host. Pearl mussel can disable the accelerated senescence program in salmon. *Biology Bulletin* 32, 360-365 (In Russian with English abstract).

http://circa.europa.eu/Public/irc/env/monnat/library?l=/habitats_reporting/reporting_2001-2007/guidelines_reporting&vm=detailed&sb=Title

APPENDIX A

Literature Review

INTRODUCTION TO THE FRESHWATER PEARL MUSSEL MARGARITIFERA MARGARITIFERA

Background

1.1 Current status

Margaritifera margaritifera

- 1.1.1 The family *Margaritiferidae* (Bivalvia : Unionoida) consists of a number of different genera with a disjunct relictar distribution in the holarctic, east and south-eastern Asia (Baranescu, 1990). The largest genus is *Margaritifera* which is circumpolar in distribution.
- 1.1.2 Within the genus *Margaritifera*, the most widely distributed species is *Margaritifera margaritifera*. Populations are known from North America, northern and central Europe and Russia. The species is very seriously declining throughout its range and is listed in the IUCN red data book as endangered worldwide (Baillie & Groombridge, 1996). In a recent review of conservation status of Irish molluscs, *Margaritifera margaritifera* was found to be “critically endangered” in Ireland (Moorkens, 2006a).
- 1.1.3 The freshwater pearl mussel is protected under Annex II and V of the European Community Council Directive on Conservation of Natural Habitats and of Wild Fauna and Flora (92/43/EEC). It is listed on Appendix 3 of the Bern Convention. Under Irish law, it is illegal to interfere with *M. margaritifera* (Statutory Instrument No. 112, 1990). This in turn conferred protected faunal species status for the species under the fifth schedule of the Wildlife Act (1976), and other subsequent protections under the Wildlife (Amendment) Act 2000.
- 1.1.4 It is estimated that 90% of individuals of this species died out within Europe during the 20th Century (Bauer 1986). In the EU, most countries’ pearl mussel populations are considered to be completely extinct (e.g. Poland), almost extinct (e.g. Denmark) or have small senescent populations which, in the absence of major river habitat recovery, will become extinct by the end of the lives of the current generation (e.g. Austria, Latvia, Luxembourg, Belgium) (Araujo & Ramos, 2001). A few countries have populations with some juvenile recruitment (Scotland, Finland, Sweden), but recruitment in most cases is found to be inadequate to replace existing adults.
- 1.1.5 Freshwater pearl mussels are flagship, indicator, keystone and umbrella species (Geist, 2005).
- 1.1.6 Greater than 70% of Unionidae and Margaritiferidae taxa are listed as endangered or threatened, making them one of the most endangered faunal groups throughout the world. Of the 300 species of freshwater mussels living in North America, where this faunal group has reached its peak of radiation, 210 species are imperilled (Bringolf *et al.*, 2007b).

- 1.1.7 In Ireland, *M. margaritifera* is geographically widespread in rivers of low pH, and the Republic of Ireland has an estimated 12 million individuals, or approximately 46% of the EU population (Geist, 2005).
- 1.1.8 The high number of individuals belies the seriousness of the status of *M. margaritifera* in Ireland, as most populations have experienced a dramatic decline in recent years (Moorkens, 1999; Moorkens & Costello, 1994, Moorkens *et al.*, 1992). Deterioration in river bed and river water quality has resulted in the majority of mussel populations failing to recruit young mussels over the last 30 year period, and widespread extinction of mussel populations is predicted if causal factors of decline remain in place.

1.2 *Margaritifera durrovensis* (*Margaritifera margaritifera*)

- 1.2.1 In 1926, B.B. Woodward found an unusual shell in the P.B. Mason collection which was labelled from the river Nore at Durrow (Phillips, 1928). He wrote to R.A. Phillips, who went to look for further specimens. In October 1926, Phillips, along with A.W. Stelfox, R.J. Welch and C. Oldham found the population. Five specimens from this expedition are preserved in spirit in the Dublin museum, labelled from the river Nore below Abbeyleix. Descriptions of the Nore mussels were given (Bloomer, 1927, 1928). Anatomical distinctions were based on a furrow present in the *M. durrovensis* foot and differences in muscle scarring patterns on the *M. durrovensis* shell compared with *M. margaritifera* (Bloomer, 1928). This was followed by Phillips (1928) paper naming *M. durrovensis* as a species new to science.
- 1.2.2 The taxonomic status of *M. durrovensis* has been argued ever since Phillips first published his species description. A year after Phillips' paper, Stelfox (1929) published additions to his Irish list. He included *M. durrovensis*, but compared its thickened form with the forms of *Pisidia* found in hard water, and stated, in his opinion, that the Nore mussel was a variety of *M. margaritifera* which had become acclimatised to hard water. However, he stated that "considerable research work will be necessary before these problems can be settled", thereby showing his uncertainty.
- 1.2.3 Haas (1948) concurred with Stelfox, and called *M. durrovensis* the "lime-phase" of *M. margaritifera*. His investigation was limited to one Nore specimen, which he thought was similar in form to *Unio brunneus* Bonhomme, 1840, of which he had also seen only one specimen.
- 1.2.4 The dismissal of the species and subspecies classification of *M. durrovensis* was supported by Chesney *et al.* (1993), who formed their conclusions on the basis of shell, anatomical and enzyme polymorphism comparisons of *M. durrovensis* with a number of *M. margaritifera* populations. Subsequently, Moorkens (1996) looked at morphometric taxonomical differences between shell sets from various rivers and different species within the *Margaritifera* genus. While it was evident that there were large "within species" differences among populations of *M. margaritifera*, it was shown in the study that *M. durrovensis* demonstrated greater morphometric differences to *M. margaritifera* than *M. falcata* and *M. auricularia* do.

- 1.2.5 Holmes *et al.* (2001) found good genetic separation between *M. durrovensis* and *M. margaritifera* populations.
- 1.2.6 Machordom *et al.* (2003) found that Ireland had populations linked genetically to two separate lineages. Two mitochondrial lineages (albeit very closely related) were identified: a northern lineage extending from Ireland to the Kola Peninsula including the western Atlantic coast, and a second cluster distributed from Ireland to the Iberian Peninsula.
- 1.2.7 Geist & Kuehn (2005) studied the genetics of 24 European pearl mussel populations. The analyses of nine microsatellite loci with different levels of polymorphism revealed a high degree of fragmented population structure and very different levels of genetic diversity within populations. These patterns were explained by historical and demographic effects and have been enforced by anthropogenic activities. Even within drainages, distinct conservation units were detected.
- 1.2.8 Early indications from examination of *M. durrovensis* genetic material by Geist (pers. comm.) suggest that this genetic population fits in to this fragmented population model.
- 1.2.9 Recent work by Geist *et al.* (2008) suggests that recently dead shells may be a good source of DNA for future genetic work. The genetic material is derived in this case from periostracum.
- 1.2.10 The taxonomic status of *Margaritifera durrovensis* remains inconclusive but is probably best described as a rare ecophenotype of *M. margaritifera*, a status which concurs with Machordom *et al.* (2003) and Chesney *et al.* (1993), the most recent bivalve guide to the region (Killeen *et al.*, 2004), and the most recent published Irish list of Molluscs (Anderson, 2005).
- 1.2.11 *Margaritifera durrovensis* was known from the Barrow, Nore and Suir main channels, but living specimens have not been found outside the Nore since 1993 (Moorkens, 1996).
- 1.2.12 Some rivers with hardness levels that are intermediate between the Nore and the typically acid stream habitats of *Margaritifera* have been found, e.g. the varieties known as *Unio brunneus* from the River Viaur, France (Haas, 1948) and *M. margaritifera var. siluriana*, from the River Wye, Wales (Ellis, 1962). However, none have the distinctive slender shape that is particular to *M. durrovensis*.
- 1.2.13 The taxon that relates to *Margaritifera durrovensis* is considered to be restricted to the River Nore in the Republic of Ireland.
- 1.2.14 The Council Directive 97/62/EC of 27 October 1997 adapting to technical and scientific progress Directive 92/43/EEC on the conservation of natural habitats and of wild fauna placed *Margaritifera durrovensis* on Annex II and Annex V as a separate taxon.

- 1.2.15 The most recent monitoring surveys for *M. durrovensis* indicate that, while there may be outliers downstream, its main population is now restricted to approximately 10km length of river and 500 individuals, and that there is no evidence of reproduction (Moorkens, 2004a, 2005a).
- 1.2.16 *Margaritifera durrovensis* is listed by the IUCN as “Critically endangered” (Baillie & Groombridge, 1996). It clearly also falls into this category in an Irish context (Moorkens, 2006a).

2.0 CURRENT FACTORS CAUSING LOSS OR DECLINE

2.1 *Margaritifera margaritifera*

- 2.1.1 There are a number of factors leading to the decline and loss of pearl mussel populations internationally and most of those are evident in Ireland and are outlined below.
- 2.1.2 The loss of pearl mussel populations mostly occurs from continuous failure to produce a new generation of mussels due to loss of clean gravel beds, which have become infiltrated by fine sediment. This blocks the required levels of oxygen from reaching young mussels. Juvenile mussels spend their first five years buried within the river bed substrate.
- 2.1.3 Other losses that lead to unsustainable populations are from untimely deaths of adult mussels through kills from major pollution incidents, such as toxic poisoning (e.g. from sheep dip), eutrophication (through smothering of adult mussels by filamentous algae or macrophyte growth).
- 2.1.4 Losses of adult mussels typically begin in the central channel of the river where the effects of pollution are most seriously manifested, leaving residual surviving mussels lying close to river banks. The *Margaritifera* life strategy relies on the production of very large numbers of early life stages due to the high percentage of losses over time (Young & Williams, 1984). Sustainable *Margaritifera* populations require the prevention of both chronic pollution and once-off pollution incidents from their freshwater habitat.

3.0 ENVIRONMENTAL FACTORS CONTRIBUTING TO LOSS OR DECLINE

3.1 Sediment quality

- 3.1.1 In the field, sediment quality can be measured using redox potential differences between various depths in the stream bed. Redox potential at sites without juvenile mussel recruitment differ significantly from those with juvenile recruitment (Geist & Auerswald, 2007). The latter has no detectable differences between the redox potential (Eh) of the open water and the interstitial water at 5 or 10 cm depth.

- 3.1.2 Excessive siltation to river beds can lead to compaction or concretion of the river bed, which further lowers the chances of oxygen exchange at depth. Compaction can be measured by penetration resistance using commercial penetrometers. Stream beds where pearl mussel recruitment is absent were found to have a more variable and higher penetration resistance, indicating unfavourable compaction is a problem (Geist & Auerswald, 2007).
- 3.1.3 Changes of river bank vegetation from more natural to more unnatural vegetation and hydrogeology are considered to have a negative impact on *Margaritifera*. Juvenile mussels can gain early nutrition through movement of water from *Carex*-dominated vegetation from the river bank rhizosphere into the hyporheic zone (Hruska, 1999).
- 3.1.4 Other ways in which mussel populations can decline and be lost is through adult mussel kills, or loss of host fish which are essential to the life cycle of *Margaritifera*. Further details of the life cycle can be found in Moorkens (1999).
- 3.1.5 The Republic of Ireland currently has approximately 120 rivers with *Margaritifera*. A small number of *Margaritifera* populations were extirpated in the 19th Century by chronic pollution (e.g. mine waste, Avoca River). Many other rivers ceased recruitment in the 1970's, which is thought to be linked with the intensification of agricultural practices, in particular the introduction of artificial fertilisers and the change from hay to silage management of fields in mussel catchments following Ireland's entry into the then European Economic Community.
- 3.1.6 Rivers that have retained large numbers and had successful recruitment in the 1990's were mainly found in remote small catchments with low intensity agriculture, often downstream of large water bodies i.e. one or more lakes.
- 3.1.7 Decline in these most important mussel rivers in recent years has been linked with the first intensive usage of the catchment, mainly clearfelling of coniferous forestry, overgrazing and housing development.
- 3.1.8 Physical siltation, once introduced to a pearl mussel river, can continue to cause very serious effects on a long term basis (Ellis, 1936, Marking & Bills, 1979, Naden *et al.*, 2003, Araujo & Ramos, 2001, Killeen *et al.*, 1998). Direct ingestion of silt by adult mussels can lead to rapid death. If, however, the mussels clam-up as a response to a siltation episode and if the siltation is prolonged, they will die from oxygen starvation over a period of several days. During a time of year when water temperatures are high, oxygen depletion in the body occurs more rapidly, and they will die more rapidly. The evolutionary primitive *Margaritifera* gills and the annual brooding of young in all four of the gills demand a continuous and high supply of oxygen. If the mussels survive the initial silt episode, the food/oxygen deprivation from clamming will cause them to become stressed from which they will take a long time to recover. If during that recovery period, there are further incidents of mobilisation of silt then the stressed mussels are more susceptible to death than mussels in a cold river in unstressed conditions. Thus they may continue to die over a period of several months, particularly over a summer.

- 3.1.9 Once a silt load enters a river that holds a pearl mussel population, it can continue to cause harm. Silt causes river changes, which in turn change the dynamics of the river into the future (Curran & Wilcock, 2005; Colosimo & Wilcock, 2005; Dietrich *et al.*, 1989). Both bed and suspended materials, and subsequent changes in channel form associated with changes in sediment supply, may affect mussels in many ways at various stages in their life cycle. The direct kill to adults is only the first stage in the damage that silt causes to the population. Sediment that infiltrates the sediment decreases oxygen supply in the juvenile habitat, which prevents recruitment of the next generation. The sediment subsequently provides a medium for macrophyte growth, a negative indicator in pearl mussel habitats. Macrophytes then smother the juvenile habitat even further, and the macrophytes trap more sediment which exacerbates the problem in the long term. One of the most essential requirements for pearl mussel conservation is the removal of risk of any sediment reaching the river, as any one single incident has such long term ramifications.
- 3.1.10 Silt infiltration of river bed gravels can also have a negative effect on the essential species of fish that host the mussel glochidial stage (Levasseur *et al.*, 2006).
- 3.1.11 Major physical silt threats arise from land clearance for development, ploughing, coniferous forestry, overgrazing of land leading to loss of vegetation cover, road and bridge building and peat cutting, particularly mechanical peat extraction. Direct access of grazing animals to the river can lead to bank erosion and poaching.
- 3.1.12 Nutrient and organic pollution leading to eutrophication is associated with agriculture, coniferous clearfell forestry, industrial effluents and insufficient treatment of urban wastewater and wastewater from on-site systems.
- 3.1.13 The low levels of nutrient input that lead to damage are most important to note. In particular, the normal background ortho-phosphate level of 0.005mg/l P is considered to be essential to the maintenance of oligotrophic waters for reproducing pearl mussel rivers (Moorkens, 2006a).
- 3.1.14 Small increases in ortho-phosphate can lead to deleterious algal or macrophyte growth, so maintaining low levels at all times is considered to be essential. One large input of ortho-phosphate can lead to an algal bloom incident, which in turn leads to organic silt, causing adult and juvenile deaths and increased trophic status in the river on a long term basis.
- 3.1.15 An increase in trophic status can lead to a major habitat change, particularly a change from *Fontinalis*-dominated river bed to *Myriophyllum* and *Ranunculus*-dominated riverbed. These macrophytes are indicators of unfavourable condition in *Margaritifera* rivers and provide conditions for further silt trapping and continued loss of habitat due to changes of flow, sediment and nutrient dynamics (Clarke, 2002; Wood, 1997; Madsen *et al.*, 2001; Barko *et al.*, 1991). Phosphorus pollution events that have resulted in macrophyte growth result in phosphorus that continues to be released and mobilised by the macrophytes at later dates (Barko & Smart, 1980; Rooney *et al.*, 2003).

- 3.1.16 Fine silt arising from organic decay infiltrates juvenile gravel habitat in the same way that physical silt does. It also provides a further inappropriate nutrient source for the future and its decomposition leads to significant decreases in oxygen.
- 3.1.17 Habitat destruction can occur through canalisation, boulder removal, arterial drainage and other physical changes, replacing natural channel reach patterns of pools and riffles with more uniform runs that suit neither the pearl mussel nor its host fish (Valovirta, 2001; Moorkens, 1999, 1996; Hastie *et al.*, 2000).
- 3.1.18 Bank reinforcement actions are a response to external damage to river banks at the site of reinforcement or elsewhere but has had ramifications at the site of reinforcement. The reinforcement structures in themselves can affect river dynamics both upstream and downstream of the works (Fischenick, 2003; O'Grady, 2006). Hard reinforcement measures are considered to be damaging activities in pearl mussel rivers.
- 3.1.19 Flow regulation can have serious negative effects on pearl mussel populations (Mc Allister *et al.*, 1999; Araujo & Ramos, 2001). These manifest mainly in two ways. Firstly, consistent unnatural flows, particularly more prolonged low flows can cause stress to adult and juvenile mussels by raising temperature, reducing oxygen, concentrating pollutants and providing conditions for silt deposition. Secondly, rapid changes in flow regime such as where sluices or dams are opened and closed regularly, is damaging to pearl mussel populations by causing energy effort of individuals to be concentrated on digging into substrate or moving around leading to a state of continuous stress, and by disrupting natural stages of the life cycle due to regular flooding and spate flow. High losses of annual glochidial production or newly dropped juvenile mussels occur during flood conditions. Recent monitoring surveys of *Margaritifera* rivers with regulated flows in Ireland (Moorkens survey) and the UK (Killeen survey) have found reduced recruitment.
- 3.1.20 Fisheries activities have increased in rivers as a response to a lowering of river habitat quality. Fishing weirs, dams, croys, fishing platforms, pool dredging, footbridges and weed control all threaten the conservation status of *Margaritifera* populations during both their construction and operation stages (Hastie & Young, 2003).
- 3.1.21 While wood products are considered to be less harmful in bank protection than rock armouring (O'Grady, 2006), these wood products should not have been treated with preservatives including copper, chromium or other compounds that are toxic to unionids. Copper and chromium leaching from preserved wood into damp soil were shown to result in significant losses (5.34-15.6% Cu; 1.85-2.35% Cr) to the environment (García-Valcárcel & Tadeo, 2007).
- 3.1.22 Liming of land has a negative effect on *Margaritifera* populations, through direct toxic effects, and through increased growth rates leading to shortened life expectancy and, thus, loss of reproductive years (Bauer *et al.*, 1991; Skinner *et al.*, 2003). In some countries, acidification problems are so severe that liming is considered to have a more positive than negative effect (Henrikson *et al.*, 1995). However, environmental water chemistry analysis in declining Irish pearl mussel rivers are associated with high peaks of calcium and conductivity levels.

- 3.1.23 Toxic pollution can have very serious and long term effects on a pearl mussel river. Juvenile and adult pearl mussels, being benthic suspension feeders, are exposed to pollutants in surface water, sediment, interstitial water and through ingestion of filtered particles with sorbed contaminants. Associations between mussel decline and upstream reduced water quality have been documented for decades (Augsburger *et al.*, 2007; Fuller, 1974).
- 3.1.24 Early life stages of mussels were shown to be among the most sensitive aquatic organisms in toxicity testing with copper and ammonia, and this led to the development of captive breeding of mussels of various species for glochidial production for toxicity testing (Augsburger *et al.*, 2007; Keller *et al.*, 2006; Milam *et al.*, 2005; Augspurger *et al.*, 2003). There is now a standard guide for methodologies for reliable toxicity testing of freshwater mussels (American Society for Testing and Materials, 2006).
- 3.1.25 Unionid mussels are considered to be among the most sensitive of all invertebrates to water pollution, and of these, *Margaritifera* is considered to be particularly sensitive, so much so that it is difficult to breed adequate numbers of glochidia for toxicity testing. Results from other species of unionids are considered to be relevant to *Margaritifera*, but may perhaps underestimate their further sensitivity to some pollutants. Nevertheless, recent advances in Unionid toxicity testing has determined that reviews are needed for US EPA water quality criteria (WQC) in order to bring them up to standards that will be protective of freshwater mussels (Augsburger *et al.*, 2007).
- 3.1.26 The EC (Quality of Salmonid Waters) Regulations 1988 state that at a water hardness level of 50mg/l the copper levels should be less than 0.022 mg/l Cu. Glochidial testing of a variety of unionid mussels in the USA found copper 48hour EC50 values at a water hardness level of 50mg/l of as low as 0.0065 mg/l Cu, with six out of eight species tested with lower EC50 levels than the Salmonid Regulation values (Wang *et al.*, 2007). The results of juvenile mussel toxicity testing were even more serious, with ten day EC50 values at a water hardness level of 50 mg/l of as low as 0.0048 mg/l Cu, with all newly transformed juveniles of 6 species tested with lower EC50 levels than the Salmonid Regulation values.
- 3.1.27 Glochidia and juvenile mussels of a range of unionid species were found to be much more sensitive than typical surrogate species (*Daphnia magna*, *Ceriodaphnia dubia*, *Hyalella azteca*, fathead minnow, and rainbow trout) in acute toxicity responses to ammonia (Wang *et al.*, 2007). Lethal and sub-lethal effects of ammonia were seen on juvenile unionids (Newton & Bartsch, 2007).
- 3.1.28 Standardised chronic toxicity tests with two month old juvenile mussels indicate that the early life stages of freshwater mussels are chronically sensitive to copper and ammonia, and may not be adequately protected by U.S. EPA levels (March *et al.*, 2007).
- 3.1.29 The use of median levels in standard water quality requirements and in water quality reporting can be unhelpful to species that are highly sensitive to acute effects of rare events. A risk assessment of water quality in three streams supporting endangered freshwater mussels found that chlorine concentrations exceeded regulatory standards up to 17-fold upstream of endangered mussel beds, and that in some habitat areas the

levels rapidly decreased with distance from the source, in other areas with little turbulence elevated chlorine levels were found up to 300m from an outfall (Ward *et al.*, 2007). Outfalls with even slightly elevated copper, chlorine and ammonia can be a limiting factor in mussel survival and recovery.

- 3.1.30 A significant threat is agricultural and forestry pesticides, and chemical sheep dip is considered to be a very serious risk to pearl mussel populations, and the most likely cause of a number of major mussel kills (Moorkens, 1999; Skinner *et al.*, 2003; Young, 2005; Cosgrove & Young, 1998). Organophosphates and synthetic pyrethroids used in sheep dipping are highly toxic to species that are a lot less sensitive to pollution than *Margaritifera*. The pearl mussel is too endangered to justify specific laboratory toxicity testing, but this should not be used as a reason to be ambiguous about the threat such pesticides present to *Margaritifera*. Pesticides present the greatest risk when used in a form that requires mixing in large quantities of water, which is why sheep dip is the most obvious threat. However, there are also a number of pesticides that are used in a concentrated state for spraying and prolonged or large scale use close to water courses, or spillage into watercourses also presents a risk. The most common example is permethrin but there are likely to be others. Other substances which have been shown to be directly toxic to *Margaritifera* are rotenone, methylmercury chloride and mercuric nitrate (Mellinger, 1973; Dolmen *et al.*, 1995). Negative effects of diffuse and direct sources of heavy metals zinc, lead, cadmium, copper, nickel, silver, mercury, persistent organic pollutants (POPs), such as DDT and its metabolite DDE, and polychlorinated biphenyls (PCBs) on other bivalve species have led to the conclusion that *Margaritifera* would be also at risk from these substances. Given the sensitivity of the pearl mussel, exact quantities below which risks from these substances are removed is not known and a precautionary approach should be used to ensure such products do not enter watercourses inhabited by *Margaritifera*. Chronic toxicity testing suggests that juvenile mussels may be at risk from prolonged exposure to environmentally relevant concentrations of chlorpyrifos and permethrin and their formulations (Bringolf *et al.*, 2007c).
- 3.1.31 The technical grade fungicides chlorothalonil, pyraclostrobin and propiconazole were found to be highly deleterious to glochidia and juvenile unionid mussels (Bringolf *et al.*, 2007a).
- 3.1.32 Glyphosate, alone and in combination with surfactant blends that allow penetration of the waxy surfaces of plant leaves, is in widespread use, and are expected to increase further with the spread of genetically modified strains of crop (Monsanto Roundup and variations). Roundup was found to be acutely toxic to glochidia and juvenile mussels, and toxicity testing found that the surfactant was the most toxic component, and likely to be responsible for much of the toxicity of the overall product (Bringolf *et al.*, 2007b).
- 3.1.33 Road wash and surface drainage is a source of diffuse pollution, of nutrients, silt and toxic substances on an ongoing basis, as well as the severe siltation risks during construction (Araujo & Ramos, 2001; Department for Environment, Food and Rural Affairs, 2004). As the road network development in Ireland is still actively underway, road development as well as ongoing risks from roads that are proximal to pearl mussel rivers are considered to present a significant threat to this species.

- 3.1.34 Other sources of contaminants from surface drainage, particularly in more urban sections of mussel rivers, are domestic household and garden activities, and intermittent release of sewage during periods of malfunction, where such a pathway exists.
- 3.1.35 Loss of host fish is regularly cited as a potential reason for pearl mussel decline (Araujo & Ramos, 2001; Anon, 2005). A study on the status of host fish populations and on fish species richness in European pearl mussel populations (Geist *et al.*, 2005) characterised typical fish communities in pearl mussel streams and revealed that a lack of host fish only seems to be limiting pearl mussel reproduction in specific areas. It has also been found that the most genetically diverse pearl mussel populations are associated with postglacially colonised rivers that retain oligotrophic status and high numbers of individuals (Geist & Kuehn, 2008). The host fish from these rivers displayed low genetic diversity. Intact and functional pearl mussel populations were found to occur under extremely oligotrophic conditions with lower host fish densities and biomasses than in disturbed central European populations without juvenile recruitment. In Ireland, adequate numbers of host fish occur in at least some rivers with inadequate *Margaritifera* recruitment, however, where nutrient levels have increased, more host fish may be required as compensation. A comparison of trout versus salmon dominated rivers of Ireland quickly shows that 100% of pearl mussel rivers are salmon and sea trout rivers, thus while brown trout make an effective host fish, the natural home of *Margaritifera* in Ireland is within low productivity rivers dominated by salmonids that go to sea to get nutrition. Salmon and *Margaritifera* have been cited as symbiotic in their relationship, with both species providing a beneficial role for the other (Ziuganov & Nezhlin, 1988; Ziuganov *et al.*, 1994). Pearl mussels filter the river water and increase its purity, and salmon gills host mussels during their glochidial stage. Pearl mussels have also been shown to prevent early senility in salmon and thus extend their life expectancy (Ziuganov, 2005). It is likely that host fish numbers need not be very high due to the natural adaptation of pearl mussels to live in rivers with low food levels and very low productivity (Bauer *et al.*, 1991), but an unnatural decline in host fish will inevitably threaten *Margaritifera*. As well as habitat decline and acidification (see below), impediments to fish movement from artificial barriers can result in losses of mussel populations (Bogan, 1993).
- 3.1.36 Acidification has been well documented as a threat to salmonid populations both internationally (e.g. Maitland *et al.*, 1987; Henrikson *et al.*, 1995; Lacroix, 1989) and in Ireland (Bowman & Bracken 1993; Allott *et al.*, 1990; Kelly Quinn *et al.*, 1997). In Ireland, acidification is linked with coniferous plantations in acid-sensitive areas rather than industrial pollution. As salmonid hosts can come from anywhere within the pearl mussel catchment, protection for the entire catchment from acidification is essential.
- 3.1.37 Acidification has also been noted a direct threat to *Margaritifera* from the first international IUCN red data book for invertebrates (Wells *et al.*, 1983). Work carried out in Scandinavia has provided evidence for pearl mussel decline from acidification (Okland & Okland, 1986; Eriksson *et al.*, 1981, 1982, 1983; Henriksen *et al.*, 1995; Raddum & Fjellheim, 2004). A lowering of pH directly influences pearl mussels through a gradual destruction of their calcareous shell, and also their genital organs (causing infertility), and through problems with regulation of acid-base mantle fluid homeostasis (Vinogradov *et al.*, 1987).
- 3.1.38 Climate change is likely to contribute to the serious threat to survival of *Margaritifera*. It is unlikely (in the foreseeable future) that Irish habitats will be outside the temperature range of the species, but increased temperatures will lead to a

faster metabolic rate and consequently a shorter life expectancy and thus reduced reproductive episodes per individual, that may exacerbate an already lowered recruitment level. The likely scenario of increased summer droughts and winter storm and flood events may negatively affect the species by increasing the frequency of stressful “natural” events. These may result in increased siltation incidents during flooding. Habitat space may be reduced due to loss of river bed in drought conditions, or instability of gravel beds that are currently stable, through frequent flooding. Climate change may have an as yet unforeseen affect on the salmonid host species or on the food web that they rely on. Changes in sea level may increase the salinity of a higher percentage of the lower reaches of some mussel rivers, and this would have particularly serious ramifications for populations that have now become restricted to the bottom end of rivers. Hastie et al. (2003) predict that a number of Scottish populations may be lost due to climate change.

- 3.1.39 *Margaritifera margaritifera* has been exploited for its pearls since Roman times, and Ireland’s mussels were well known sources of pearls for many years (Lucey, 2006; Cranbrook, 1976). Pearl fishing has been cited as a threat to pearl mussels across most of its range, and in countries with very low numbers of individuals such as Germany, there are historical records of pearl fishing causing population decline. Recent records of pearl fishing in Ireland are anecdotal, and generally involve Scottish visitors, some of whom come from families that traditionally made a visit to known haunts at periodic intervals. The decline in pearl mussels and the lack of sufficient recruitment has made any pearl fishing unsustainable and the use of tongs to open mussels for pearls has been shown to be damaging (Moorkens & Costello, 2004). Thus pearl fishing is outlawed in Ireland and any illegal fishing is considered to pose a threat to that population.