Technical Appendix – Aquatic molluscs: *Margaritifera margaritifera* (freshwater pearl mussel FPM) and *Anodonta anatina* (duck mussel)

1. Introduction

This assessment was undertaken by Dr Evelyn Moorkens, based on a field survey undertaken in November 2016, and information from a field survey undertaken by Dr William O'Connor (Ecofact) in July and September 2016 and reported in September 2016.

***Margaritifera margaritifera* (freshwater pearl mussel FPM)**

The freshwater pearl mussel (FPM) is the longest living freshwater species in Ireland, with normal lifespan up to 120 years (Moorkens, 1999). The FPM simultaneously fulfils criteria of indicator, flagship, keystone and umbrella species and thus be considered an ideal target species for the conservation of aquatic ecosystem functioning (Geist, 2010). It is considered to be the most highly demanding of all Irish protected species, and one of the most endangered animals in Europe and on the planet. Ireland has a key international role in the protection of this species in the world.

Adult mussels are highly sensitive to direct disturbance and to flow, sediment and nutrient stresses. Juvenile mussels bury to approximately 5cm within the river bed and require highly oxygenated conditions in order to survive their first 5 years, after which they are robust enough to move nearer to the surface to filter open water. Juvenile mussels die within a very short time of oxygen deprivation and so it takes almost 2,000 days without a sedimentation incident for any one juvenile to survive this most critical time. Young mussels remain more sensitive than older mussels and mortality of mussels in the size range of 1-40mm is higher than those in the 40-130mm size range during sedimentation and eutrophication events. There is an interconnection between changes in flow and the settlement of fine sediment on the river bed and the subsequent loss of juvenile mussels through oxygen depletion. In situations where sediment impact is excessive, even for a short time period, juvenile mussels cannot survive and the population is slowly lost over time through lack of replacement of aging and dying adults (Moorkens, 2010).

Direct impact of the river bed through dredging or excessive disturbance destroys FPM habitat. In situations where artificial drainage of the terrestrial catchment habitat has occurred, fine sediment settles over a higher range of the river bed due to an impaired flow regime. In drained conditions, greater discharge to the river occurs during high flow conditions, and lower discharge occurs during low flow conditions. During low flow conditions in drained areas, more fine sediment drops into the river bed habitat.

The conservation effort needed to restore pearl mussel populations includes the protection of natural river bed habitats, restoration of natural flow conditions, including drain blocking or the prevention of drain maintenance, and reduction in the sources and pathways of sediment and nutrient inputs to the river. As well as a natural river bed, the surrounding riparian areas should function as wetland habitats.

The nature of FPM habitat is a combination of highly stable bed substrate in very clean condition. This combination is very rare and requires good velocity levels during dry periods as well as wet. Highly stable substrate where drainage has been excessive can easily become damaged through settlement of fine sediment, but the stable conditions make the substrate difficult to clean

compared with more unstable mobile gravels. Remaining habitats in declining rivers are associated with preferential flow paths through suitable quality river bed substrate (Moorkens, 2017).

The freshwater pearl mussel is a qualifying interest of the designated River Slaney Special Area of Conservation (Site Code 000781). The Conservation Objectives for the site (NPWS website) state that the conservation objectives for the species are under review. The generic conservation objective refers to the maintenance or restoration of favourable conservation status, considered to be achieved 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

The best remaining habitats for the FPM in the Slaney Catchment are found in the Derreen River tributary of the Slaney, with the Slaney and other tributaries providing supporting habitat and genetic contribution to the population. The 2009 *Margaritifera* regulations (S.I. No. 296/2009 - The European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009) refer to the Derreen population within the wider SAC.

The FPM is protected throughout its Irish range through Statutory Instrument No. 112 of 1990 under the Wildlife Act, 1976 and the Wildlife (Amendment) Act, 2000.

***Anodonta anatina* (duck mussel)**

The duck mussel is a species of rivers, canals and occasionally lakes of various flow regimes, where there is a stable habitat substrate that includes fine sands and gravels, and a suitable supply of native cyprinid fish (Moorkens & Killeen, 2009).

The duck mussel has had a relatively wide but declining distribution in Ireland. Over the last twenty years this species has suffered from the spread of the zebra mussel *Dreissena polymorpha*, whose spat settles on hard surfaces, including living *Anodonta.* The zebra mussel has spread through many water bodies that have supported good populations of duck mussels in the past. Zebra mussels have free living larva, compared with the native *Anodonta* mussels, which require an intermediary fish host for larvae. This gives the zebra mussel a competitive advantage, and had has resulted in the loss of many species of native mussels where alien mussels can spread. This loss, along with ongoing habitat destruction has led to the inclusion of duck mussel on the Irish Red Data List for molluscs (Byrne et al., 2009).

The duck mussel is only known from two 10km squares in south east Ireland and thus the population in the Slaney is of high regional importance.

2. Statement of Authority

This assessment was undertaken by:
DR EVELYN A. MOORKENS B. A. (Mod.). H. Dip. (Ed.), M. Sc., PhD, M.C. I.E.E.M., C. Env.

Dr Evelyn Moorkens is an Environmental Scientist and Malacologist. She holds a Bachelor of Arts (Hons) degree in Natural Sciences, a Master of Science degree in Environmental Science, and a Doctor of Philosophy degree in Environmental Science, all from Trinity College, Dublin. Dr Moorkens' Master's and Doctorate theses specialised in *Margaritifera* status and requirements.

She is an acknowledged international expert in *Margaritifera.* She has twenty eight years national and international experience in research into the biology and ecology species of this species, and in environmental planning and assessment and advice for government policy making, European and national environmental law, ecological surveys and professional opinions towards the designation of Irish Natura 2000 sites, environmental impact assessment, Appropriate Assessment under Article 6 of the Habitat's Directive, planning compliance, baseline surveys, monitoring programme design and implementation, mapping of species distributions and captive breeding of *Margaritifera*.

Dr Moorkens is an expert in the interpretation and implementation of the Habitat's Directive and its transposition into national law, in the implementation of the Irish Wildlife Acts, and how they relate to Planning. She is a consultant to An Bord Pleanala, the planning review board in Ireland. She has provided independent expert opinion to planning hearings, High Court judicial reviews, High Court injunction proceedings, District Court proceedings and advice to numerous internal governmental policy papers in Ireland. She has acted as Environmental expert in court proceedings and in government policy papers in the UK. She has lectured in Environmental policy and implementation of European Law in Ireland, the UK and Germany. In addition, Evelyn Moorkens has produced over 30 peer reviewed papers and 400 reports over 28 years relating to molluscan surveys and expert opinion.

She is a member of the International Union of Nature Conservation (IUCN) species specialist group committee for Mollusca. She sits on the UK Steering Groups for EU Habitats Directive mollusc species.

She sat on the 5th Scientific Advisory Committee of the Irish Environmental Protection Agency (EPA), and maintains the Irish national database of non-marine molluscs. She is a member of the Environmental chamber of the Irish Standard Development Group of FSC (Forest Stewardship Council) certification. She runs the Irish *Margaritifera* captive breeding programme.

She has drafted the first CEN European Standard for freshwater pearl mussel requirements in Europe. She is currently producing best practice guidance documents for the freshwater pearl mussel for the Republic of Ireland and Northern Ireland for a range of sectors.

As well as running an independent consultancy, she is a research associate at Trinity College, Dublin. Her research interests are in catchment management affects, practical measures for conservation and appropriate monitoring protocols for species conservation assessment. She also supervises graduate students in their research.

Her research is widely published and referenced in peer reviewed journals. She is a member of the Chartered Institute of Ecology and Environmental Management and is a Chartered Environmentalist.

3. Methodology including study area, limitations

The main survey for FPM was carried out by Ecofact (Ecofact, 2016, see Appendix 1) following the NPWS guidance '*Margaritifera margaritifera Stage 1 and Stage 2 survey guidelines. Irish Wildlife Manuals, No. 12* (Anon, 2004). The stretch of the river between the upper and lower extent of the proposed Enniscorthy drainage scheme was surveyed by snorkelling, and is some areas using batyhscopes. The aim was to record all FPM in this lower reach of the River, which included part of the river affected by the tide. The survey was carried out during July and September at a time when water levels in the river were low and when bright conditions prevailed. The survey of the lower stretch of the river was times to coincide with low tide (mid-day).

The survey involved two surveyors counting all FPM in the subject stretch of the river, where FPM were recorded by a bank manager who noted GPS coordinates and position of FPM instream. The banks-person also ensured that the instream surveyors provided complete coverage of the channel. FPM shell locations were also recorded, removed from the river and intact shells were retained. Standard field survey sheets were completed on site. The locations of other large bivalves (*Anodonta sp.*) were also recorded.

An assessment for potential for permanent adult and juvenile habitat of FPM and *Anodonta* was undertaken in November 2016 during a period of low flow (Moorkens, 2016, see Appendix 2). This consisted of visiting the locations of mapped mussels and making a visual assessment of the habitat they were living in to assess whether they were likely to have been born there (permanent juvenile and adult habitat) or whether they were likely to have been washed into an area unsuitable for juvenile recruitment. This survey included measurements of redox potential undertaken under the methodology of Geist & Auerswald (2007) as well as a range of habitat parameters that assist in the determination of potential juvenile FPM habitat.

Both surveys were selected to coincide with dry and bright weather conditions at a time when water levels were normal/low. However, there were still limitations with regard to water clarity/visibility especially in the southern end of the study area. The tidal reaches of the River Slaney downstream of the town proved to be difficult to survey due to water clarity and siltation issues. However, this area was not considered to have suitable FPM juvenile habitat, both in terms of substrate and tidal influence. In addition to these limitations there were also parts of the riverbed that could not be viewed owing to the degree of the following: algal growth (especially in some slow flowing shallow areas); instream vegetation (in some fast flowing shallow areas) and substrate siltation. Though a best effort was made to identify mussels in these areas, it is possible that some FPM and *Anodonta* present in these areas were not recorded. However, the permanent juvenile and adult FPM and *Anodonta* habitat was located in the upper more shallow and fast flowing sections, thus confidence in the limit of habitat with juvenile potential is high.

4. Results

A total of 51 live FPM (Photo 1) were recorded in the River Slaney in the surveyed stretch between the upper and lower extent of the surveyed stretch. With the exception of nine individuals, all live FPM were recorded in the uppermost 500m stretch of the river. Within this 500m stretch, the most

important area is the short reach between 297531, 140720 (upstream) and 297370, 140633 (downstream) over a distance of 180m. These FPM (n=32) were located between the centre of the channel and the right bank of the river in a substrate of rock/cobble. Of these, approximately the uppermost 10 are considered to be in permanent suitable juvenile FPM habitat, the rest are likely to have washed downstream and provide a role in producing larval glochidia for the next generation only if the fish that carry the glochidia move upstream to release juveniles into suitable habitat (see photos 3 and 4). The locations of the mussels found in the Ecofact survey are shown in Figures 1-3.

It is noted that the tidal reaches of the river downstream of the town could not be surveyed effectively. However, it is considered highly unlikely that FPMs are present, or, if present, are producing viable larval glochidia in this area.

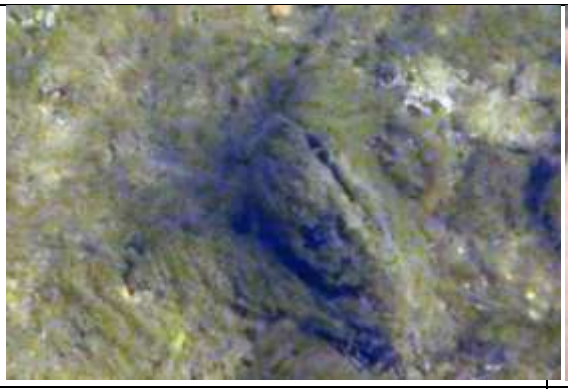
The duck mussel *Anodonta anatina* (Photo 2) was recorded in low numbers through the Ecofact survey. As with the FPM, it is unlikely that permanent habitat suitable for juvenile recruitment is present in the lower tidal areas.

The uppermost area from the small island upstream was considered to be good FPM habitat with juvenile potential (Photo 5). Redox potential measurements in this area were much better than those taken downstream, and 40% of the measurements were compatible with juvenile mussel survival. The rest of the proposed works area downstream of this small island was significantly silted and was not considered to be good FPM habitat (Photo 6). This stretch of the river appears to have been subjected to historical river works and the bed material in the river is very unstable in places, and quite compacted in others. Some of the FPMs recorded were submerged in mud/silt. The stretch of river immediately below the island at the upper end of the scheme provided the majority of the mussels recorded. Although these individuals are considered to have washed in and are not in suitable juvenile habitat, they are likely to produce significant quantities of larval glochidia. Young salmonids that have become encysted with these larvae could release juveniles in suitable habitat if they have moved upstream to appropriate areas. However, densities of host salmonid fish were found to be relatively low in this stretch of river and no 0+ salmon or trout were seen during the survey or recorded in the electrical fish survey undertaken in July 2016 as part of the ecological assessment of the proposed flood scheme.

A number of spot-checks were also undertaken on the Lower River Slaney at Scarawalsh. The FPM was confirmed to be present at Scarawalsh Bridge and also downstream from there at the River Bann confluence area. Mussels are present in the River Bann tributary. It is noted that dead shells were also found at Clohamon. It is likely that there are significant numbers of FPMs in the Lower River Slaney.

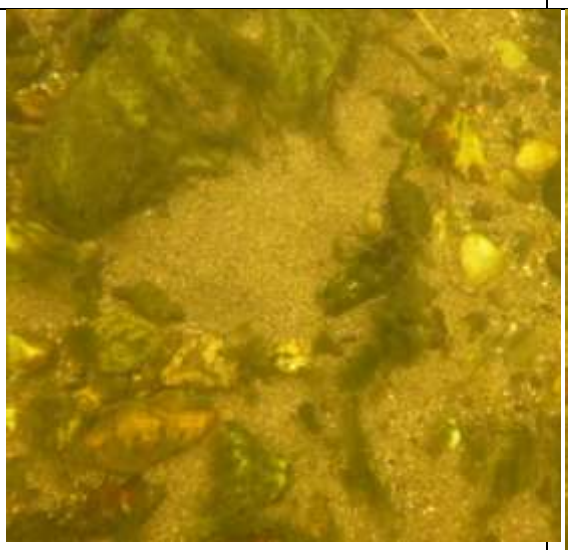
1. *Margaritifera* in Slaney (photo: Ecofact)

2.Duck mussel in Slaney (photo: Ecofact)

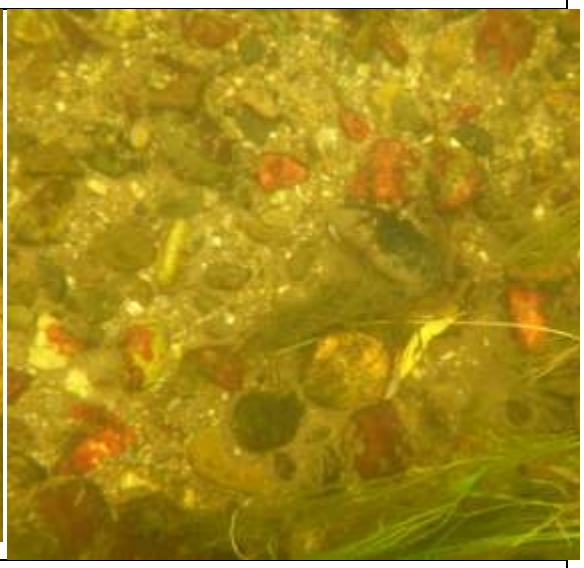


3. Live FPM downstream of island in unsuitable habitat, May 2016 (photo:Ecofact).

4. Dead FPM shells, Enniscorthy, April 2016 (photo:Ecofact). The shell at the left shows scarring indicative of considerable movement down the river, the right shell has not been disturbed and is more likely to be native to this part of the river.



5.Good juvenile habitat with adult mussel in clean gravel in the lee of boulder upstream of the island



6.Recently dead shell on river bed in more compacted river bed habitat downstream

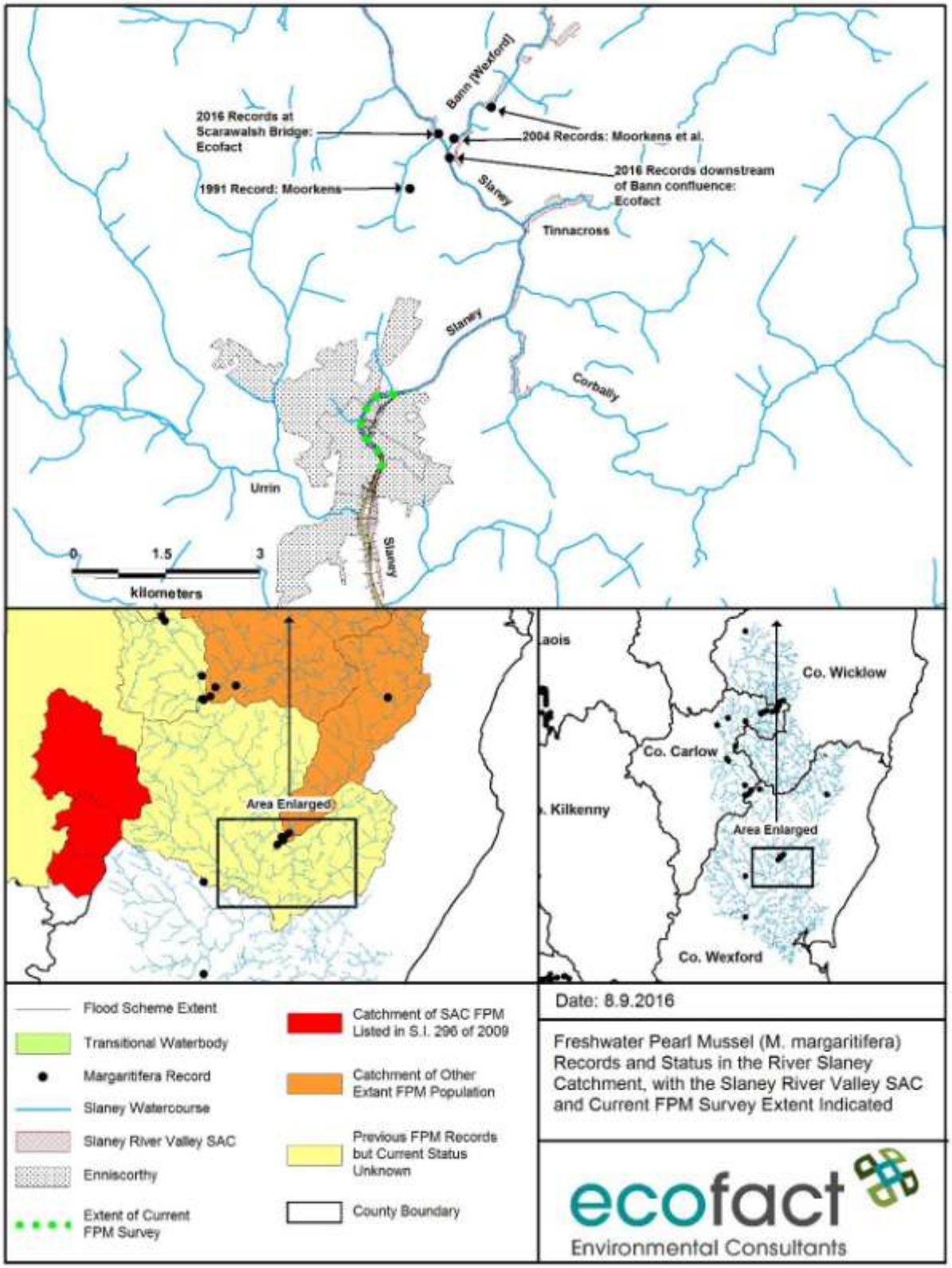


Figure 1 Study area and FPM catchments in the vicinity

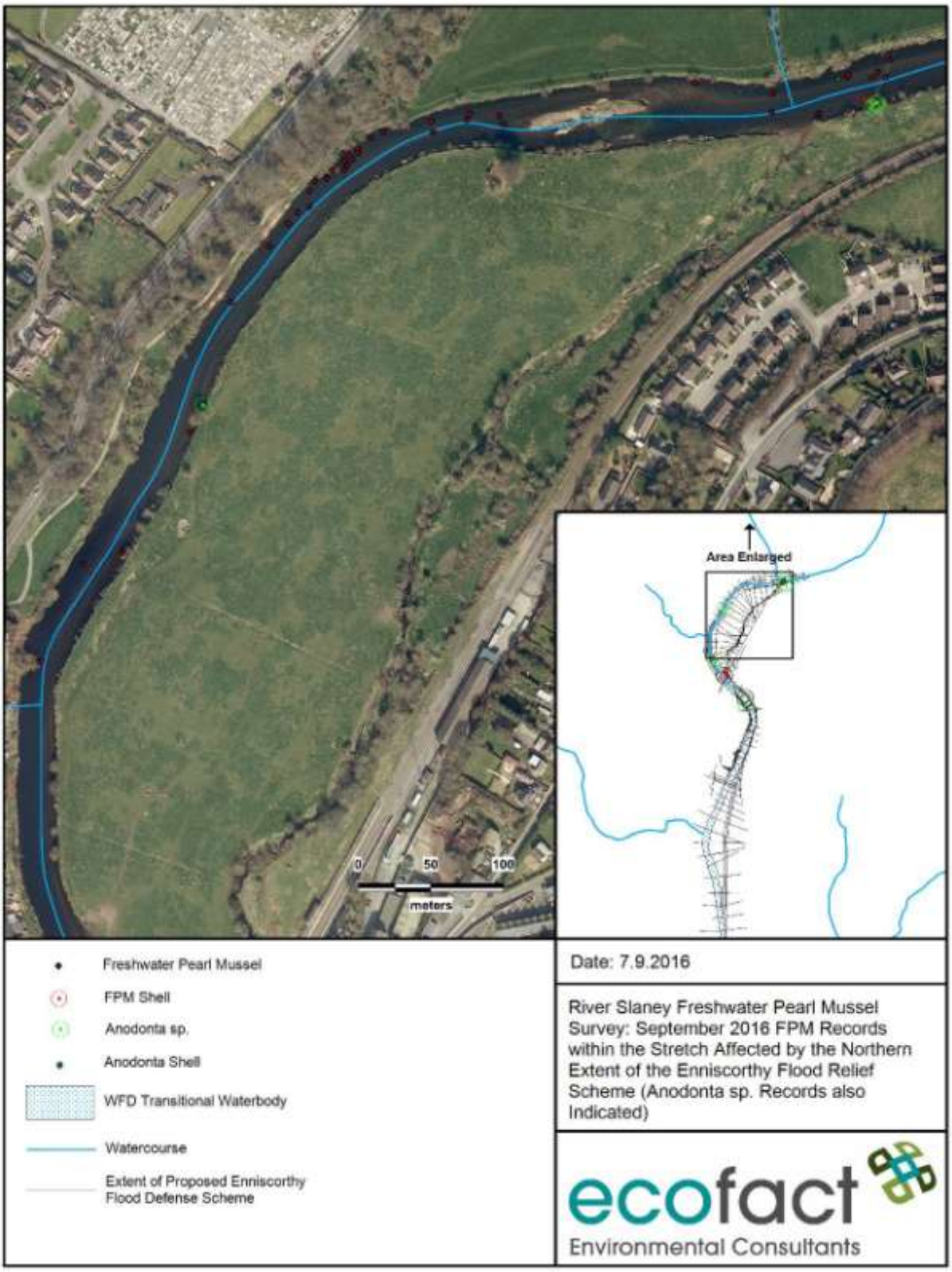


Figure 2, results of Ecofact mussel survey , upper section

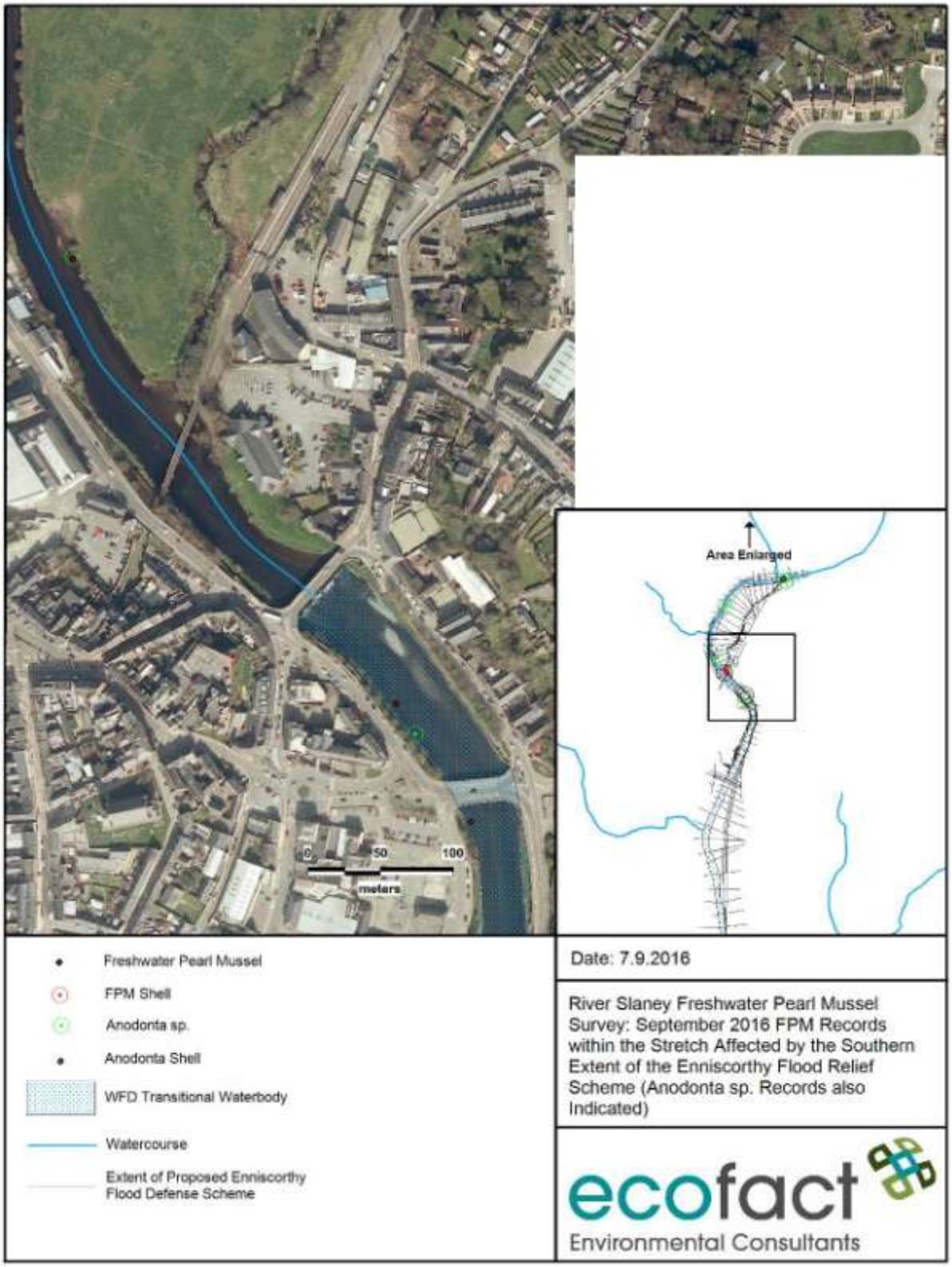


Figure 3 Results of Ecofact mussel survey, lower section

5. Evaluation of level of importance of ecological features

The two species of aquatic bivalves were assessed according to the criteria outlined in the NRA Ecological Impact Assessment Guidelines (NRA, 2009), and the CIEEM guidance on geographic scale of importance (CIEEM, 2016).

The freshwater pearl mussel *Margaritifera margaritifera* (FPM) was rated as internationally important as it is an Annex II species listed as a qualifying interest within a SAC. The conservation objectives are under review by NPWS; however the extent of the qualifying interest as listed in the 2009 *Margaritifera* regulations was restricted to the Derreen River. The assessment of impact on the live FPM population within the study area should take into consideration that:

- The majority of the mussels (downstream of the small island) are likely to have washed in to this area and their ability to brood larval glochidia is likely to be impaired, and they are unlikely to be playing a significant role in producing glochidia for the next generation of mussels

- A minority of mussels are present from the small island upstream in potential juvenile habitat. These mussels are likely to be playing a significant role in the production of glochidia, and the habitat may support ongoing generations of this critically endangered species.

- The permanent habitat at the upper end of the study area is of high importance as it is part of a network of small microhabitats that are suitable for the FPM due to a combination of river bed substrate and preferential flow. These microhabitats are important in the conservation and recovery of FPM populations and preventing ongoing extinctions of this species throughout its range in Ireland (Moorkens, 2017).

- The mussels in suitable habitat are also contributing to the genetic diversity of the wider Slaney Catchment population. Genetic studies from samples of mussels from the Derreen River have demonstrated that the genetic resource of this population is of high importance as it displays a high level of genetic differentiation from other Irish FPM populations (Feind et al., 2016).

- The assessment of salmonid fish should take into consideration the essential role they play in the life cycle of the FPM.

The duck mussel *Anodonta anatina* was rated as regionally important as it is a red data list species known from a very restricted area of south east Ireland (2 x 10km squares), as seen in Figure 4. It is therefore somewhat more important than the “county” level as defined in the NRA guidelines. Genetic work undertaken to date demonstrates that some *Anodonta* genetic conservation units are seriously declining and further research is needed for the conservation of this species (Lopes-Lima et al., 2016).

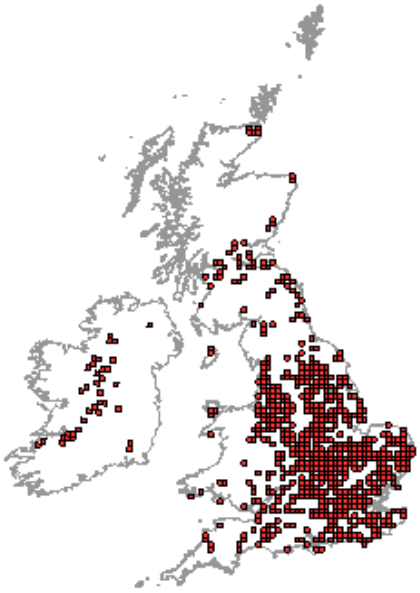


Figure 4 Distribution of *Anodonta anatina* in UK and Ireland (from Moorkens & Killeen, 2009)

A summary of the level of importance of the Slaney populations of these species within the study area is provided below:

Feature	Protection Status	Conservation Status	Distribution	Importance
Margaritifera margaritifera (FPM)	General protection under Wildlife Act, Annex II species, within SAC at edge of population	Critically Endangered (Ireland and Europe), Endangered (worldwide)	Restricted	International
Anodonta anatina (duck mussel)	None	Red Data List species, vulnerable (Ireland), least concern (worldwide)	Local and declining	Regional /County importance, known from two 10km squares in the South east of Ireland

6. References

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Appendix 1 Ecofact report (2016)
Appendix 2 Moorkens report (2016)