

National Parks and Wildlife Service

Conservation Objectives Series

Leannan River SAC 002176



An Roinn Cultúir,
Oidhreacht agus Gaeltachta
Department of Culture,
Heritage and the Gaeltacht

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Introduction

The overall aim of the Habitats Directive is to maintain or restore the favourable conservation status of habitats and species of community interest. These habitats and species are listed in the Habitats and Birds Directives and Special Areas of Conservation and Special Protection Areas are designated to afford protection to the most vulnerable of them. These two designations are collectively known as the Natura 2000 network.

European and national legislation places a collective obligation on Ireland and its citizens to maintain habitats and species in the Natura 2000 network at favourable conservation condition. The Government and its agencies are responsible for the implementation and enforcement of regulations that will ensure the ecological integrity of these sites.

A site-specific conservation objective aims to define favourable conservation condition for a particular habitat or species at that site.

The maintenance of habitats and species within Natura 2000 sites at favourable conservation condition will contribute to the overall maintenance of favourable conservation status of those habitats and species at a national level.

Favourable conservation status of a habitat is achieved when:

- its natural range, and area it covers within that range, are stable or increasing, and
- the specific structure and functions which are necessary for its long-term maintenance exist and are likely to continue to exist for the foreseeable future, and
- the conservation status of its typical species is favourable.

The favourable conservation status of a species is 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.

Notes/Guidelines:

1. The targets given in these conservation objectives are based on best available information at the time of writing. As more information becomes available, targets for attributes may change. These will be updated periodically, as necessary.
2. An appropriate assessment based on these conservation objectives will remain valid even if the targets are subsequently updated, providing they were the most recent objectives available when the assessment was carried out. It is essential that the date and version are included when objectives are cited.
3. Assessments cannot consider an attribute in isolation from the others listed for that habitat or species, or for other habitats and species listed for that site. A plan or project with an apparently small impact on one attribute may have a significant impact on another.
4. Please note that the maps included in this document do not necessarily show the entire extent of the habitats and species for which the site is listed. This should be borne in mind when appropriate assessments are being carried out.
5. When using these objectives, it is essential that the relevant backing/supporting documents are consulted, particularly where instructed in the targets or notes for a particular attribute.

Qualifying Interests

* indicates a priority habitat under the Habitats Directive

002176	Leannan River SAC
1029	Freshwater Pearl Mussel <i>Margaritifera margaritifera</i>
1106	Salmon <i>Salmo salar</i>
1355	Otter <i>Lutra lutra</i>
1833	Slender Naiad <i>Najas flexilis</i>
3110	Oligotrophic waters containing very few minerals of sandy plains (<i>Littorelletalia uniflorae</i>)
3130	Oligotrophic to mesotrophic standing waters with vegetation of the <i>Littorelletea uniflorae</i> and/or <i>Isoeto-Nanojuncetea</i>

Please note that this SAC overlaps with Derryveagh and Glendowan Mountains SPA (004039) and Lough Fern SPA (004060) and is adjacent to Cloghernagore Bog and Glenveagh National Park SAC (002047). See map 2. The conservation objectives for this site should be used in conjunction with those for the overlapping and adjacent sites as appropriate.

Supporting documents, relevant reports & publications

Supporting documents, NPWS reports and publications are available for download from: www.npws.ie/Publications

NPWS Documents

Year :	1995
Title :	Mapping of proposed SAC rivers for <i>Margaritifera margaritifera</i> . A report for the National Parks and Wildlife Service on work carried out from August to October 1995 (in two volumes). Volume 1
Author :	Moorkens, E.
Series :	Unpublished report to NPWS
Year :	2006
Title :	Otter survey of Ireland 2004/2005
Author :	Bailey, M.; Rochford, J.
Series :	Irish Wildlife Manuals, No. 23
Year :	2007
Title :	Rapid Assessment of rivers with prior records of <i>Margaritifera margaritifera</i>
Author :	Moorkens, E.
Series :	Unpublished report to NPWS
Year :	2007
Title :	Supporting documentation for the Habitats Directive Conservation Status Assessment - backing documents. Article 17 forms and supporting maps
Author :	NPWS
Series :	Unpublished report to NPWS
Year :	2009
Title :	NS II Freshwater pearl mussel sub-basin management plans: fisheries survey. Stage 1 report
Author :	Paul Johnston Associates
Series :	Unpublished report to NPWS
Year :	2009
Title :	NS II Freshwater Pearl Mussel Sub-basin Management Plans: Monitoring of the Freshwater Pearl Mussel in the Leannan
Author :	Moorkens, E.A.
Series :	Unpublished report to NPWS
Year :	2009
Title :	NS2 Freshwater Pearl Mussel Sub-Basin Management Plans. Phytobenthos monitoring of the Leannan Catchment, Co. Donegal. (NWIRBD). June 2009
Author :	Ní Chatháin, B.
Series :	Unpublished report to NPWS
Year :	2009
Title :	NS II Freshwater Pearl Mussel Sub-basin Management Plans: Report on Biological Monitoring of Surface Water Quality in Leannan Catchment, Co. Donegal
Author :	Williams, L.
Series :	Unpublished report to NPWS
Year :	2010
Title :	Second Draft Leannan Freshwater Pearl Mussel Sub-basin Management Plan (2009-2015). March 2010
Author :	NPWS
Series :	Unpublished document to the Department of Environment, Heritage and Local Government, Dublin, Ireland.

Year :	2012
Title :	Monitoring Populations of the Freshwater Pearl Mussel <i>Margaritifera margaritifera</i> . A condition assessment survey of the freshwater pearl mussel in the Leannan River, Co. Donegal
Author :	Moorkens, E.A.
Series :	Unpublished report to NPWS
Year :	2013
Title :	National otter survey of Ireland 2010/12
Author :	Reid, N.; Hayden, B.; Lundy, M.G.; Pietravallo, S.; McDonald, R.A.; Montgomery, W.I.
Series :	Irish Wildlife Manuals, No. 76
Year :	2013
Title :	The status of EU protected habitats and species in Ireland. Volume 2. Habitats assessments
Author :	NPWS
Series :	Conservation assessments
Year :	2013
Title :	The status of EU protected habitats and species in Ireland. Volume 3. Species assessments
Author :	NPWS
Series :	Conservation assessments
Year :	2015
Title :	Habitats Directive Annex I lake habitats: a working interpretation for the purposes of site-specific conservation objectives and Article 17 reporting
Author :	O Connor, Á.
Series :	Unpublished document by NPWS
Year :	2015
Title :	Monitoring Populations of the Freshwater Pearl Mussel <i>Margaritifera margaritifera</i> . 2015 Monitoring Survey of the Leannan River, County Donegal
Author :	Moorkens, E.
Series :	Unpublished report to NPWS
Year :	2018
Title :	Electrofishing survey to identify fish hosts for the freshwater pearl mussel <i>Margaritifera margaritifera</i> in 12 populations in the Republic of Ireland. 2017 Survey
Author :	Johnston, P.M.; Moorkens, E.A.
Series :	Unpublished report to NPWS
Year :	2019
Title :	Leannan River SAC (002176) Conservation objectives supporting document- <i>Najas flexilis</i> V1
Author :	NPWS
Series :	Conservation objectives supporting document
Year :	2019
Title :	The Status of EU Protected Habitats and Species in Ireland. Volume 3: Species Assessments
Author :	NPWS
Series :	Conservation assessments
Year :	in prep.
Title :	A study of the mixed <i>Najas flexilis</i> lake habitat (3130), 2015-2018
Author :	Roden, C.; Murphy, P.; Ryan, J.
Series :	Unpublished report to NPWS

Other References

Year :	1982
Title :	Otter survey of Ireland
Author :	Chapman, P.J.; Chapman, L.L.
Series :	Unpublished report to Vincent Wildlife Trust
Year :	1982
Title :	Eutrophication of waters. Monitoring assessment and control
Author :	OECD
Series :	OECD, Paris
Year :	1988
Title :	The reproductive biology of freshwater mussels in Ireland, with observations on their distribution and demography
Author :	Ross, E.D.
Series :	Unpublished Ph.D. thesis, National University of Ireland, Galway
Year :	1991
Title :	The spatial organization of otters (<i>Lutra lutra</i>) in Shetland
Author :	Kruuk, H.; Moorhouse, A.
Series :	Journal of Zoology, 224: 41-57
Year :	1996
Title :	Studies on the biology and ecology of <i>Margaritifera</i> in Ireland
Author :	Moorkens, E.
Series :	Unpublished Ph.D. thesis, University of Dublin, Trinity College
Year :	1996
Title :	The distribution and ecology of the freshwater pearl mussel, <i>Margaritifera margaritifera</i> L. 1758, in County Donegal, Ireland and implications for its conservation
Author :	Beasley, C.R.
Series :	Unpublished Ph.D. thesis, The Queen's University of Belfast
Year :	2000
Title :	Colour in Irish lakes
Author :	Free, G.; Allott, N.; Mills, P.; Kennelly, C.; Day, S.
Series :	Verhandlungen Internationale Vereinigung für theoretische und angewandte Limnologie, 27: 2620-2623
Year :	2002
Title :	Deterioration of Atlantic soft water macrophyte communities by acidification, eutrophication and alkalisation
Author :	Arts, G.H.P.
Series :	Aquatic Botany, 73: 373-393
Year :	2006
Title :	Otters - ecology, behaviour and conservation
Author :	Kruuk, H.
Series :	Oxford University Press
Year :	2006
Title :	The status of host fish populations and fish species richness in European freshwater pearl mussel (<i>Margaritifera margaritifera</i>) streams
Author :	Geist, J.; Porkka, M.; Kuehn, R.
Series :	Aquatic Conservation: Marine and Freshwater Ecosystems, 16: 251-266

Year :	2006
Title :	A reference-based typology and ecological assessment system for Irish lakes. Preliminary investigations. Final report. Project 2000-FS-1-M1 Ecological assessment of lakes pilot study to establish monitoring methodologies EU (WFD)
Author :	Free, G.; Little, R.; Tierney, D.; Donnelly, K.; Coroni, R.
Series :	Environmental Protection Agency, Wexford
Year :	2009
Title :	The identification, characterization and conservation value of isoetid lakes in Ireland
Author :	Free, G.; Bowman, J.; McGarrigle, M.; Little, R.; Coroni, R.; Donnelly, K.; Tierney, D.; Trodd, W.
Series :	Aquatic Conservation: Marine and Freshwater Ecosystems, 19(3): 264-273
Year :	2010
Title :	Otter tracking study of Roaringwater Bay
Author :	De Jongh, A.; O'Neill, L.
Series :	Unpublished draft report to NPWS
Year :	2010
Title :	Water Quality in Ireland 2007-2009
Author :	McGarrigle, M.; Lucey, J.; Ó Cinnéide, M.
Series :	Environmental Protection Agency, Wexford
Year :	2012
Title :	Survey of juvenile salmonid stocks for glochidial encystment in nine border catchments. Paul Johnston Associates
Author :	Johnston, P.M.
Series :	Unpublished report for Interreg IV project: Practical Implementation of Freshwater Pearl Mussel Measures
Year :	2014
Title :	Assessing near-bed velocity in a recruiting population of the endangered freshwater pearl mussel (<i>Margaritifera margaritifera</i>) in Ireland
Author :	Moorkens, E.; Killeen, I.
Series :	Aquatic Conservation: Marine and Freshwater Ecosystems, 24(6): 853-862
Year :	2015
Title :	Water Quality in Ireland 2010-2012
Author :	Bradley, C.; Byrne, C.; Craig, M.; Free, G.; Gallagher, T.; Kennedy, B.; Little, R.; Lucey, J.; Mannix, A.; McCreesh, P.; McDermott, G.; McGarrigle, M.; Ní Longphuirt, S.; O'Boyle, S.; Plant, C.; Tierney, D.; Trodd, W.; Webster, P.; Wilkes, R.; Wynne, C.
Series :	Environmental Protection Agency, Wexford
Year :	2017
Title :	Water Quality in Ireland 2010-2015
Author :	Fanning, A.; Craig, M.; Webster, P.; Bradley, C.; Tierney, D.; Wilkes, R.; Mannix, A.; Treacy, P.; Kelly, F.; Geoghegan, R.; Kent, T.; Mageean, M.
Series :	Environmental Protection Agency, Wexford
Year :	2019
Title :	The Status of Irish Salmon Stocks in 2018 with Catch Advice for 2019
Author :	Technical Expert Group on Salmon (TEGOS)
Series :	Report of the Technical Expert Group on Salmon (TEGOS) to Inland Fisheries Ireland (IFI)

Spatial data sources

Year :	2008
Title :	OSi 1:5000 IG vector dataset
GIS Operations :	WaterPolygons feature class clipped to the SAC boundary. Expert opinion used to identify Annex I habitats and to resolve any issues arising
Used For :	3110, 3130 (map 3)
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Year :	2019
Title :	NPWS rare and threatened species database
GIS Operations :	Dataset created from spatial references in database records. Expert opinion used as necessary to resolve any issues arising
Used For :	1029 (map 4)
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Year :	Revision 2012
Title :	Margaritifera Sensitive Areas data
GIS Operations :	Relevant catchment boundaries identified. Expert opinion used as necessary to resolve any issues arising
Used For :	1029 (map 4)
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Year :	2005
Title :	OSi Discovery series vector data
GIS Operations :	Creation of 10m buffer on terrestrial side of river banks data; creation of 20m buffer applied to canal centreline data. Creation of 20m buffer applied to river and stream centreline data; These datasets combined with derived OSi 1:5000 vector lake buffer data. Overlapping regions investigated and resolved; resulting dataset clipped to SAC boundary. Expert opinion used as necessary to resolve any issues arising
Used For :	1355 (map 5)
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Year :	2010
Title :	OSi 1:5000 IG vector dataset
GIS Operations :	Creation of 80m buffer on aquatic side of lake data; creation of 10m buffer on terrestrial side of lake data. These datasets combined with derived OSi Discovery Series river and canal datasets. Overlapping regions investigated and resolved; resulting dataset clipped to SAC boundary. Expert opinion used as necessary to resolve any issues arising. Creation of 250m buffer on aquatic side of the lake boundary to highlight potential commuting points
Used For :	1355 (map 5)
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Year :	2019
Title :	NPWS rare and threatened species database
GIS Operations :	Dataset created from spatial references in database records. Expert opinion used as necessary to resolve any issues arising
Used For :	1833 (map 6)

3110 Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae)

To restore the favourable conservation condition of Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae) in Leannan River SAC, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Habitat area	Hectares	Area stable or increasing, subject to natural processes	Lake habitat 3110 is considered to occur in Lough Gartan in Leannan River SAC. Patches may also co-occur with lake habitat 3130 in Loughs Akibbon and Fern. Habitat 3110 and/or 3130 may occur in Lough Nacally. Two measures of extent should be used: 1. the area of the lake itself and; 2. the extent of the vegetation communities/zones that typify the habitat. Further information relating to all attributes is provided in the lake habitats supporting document for the purposes of site-specific conservation objectives and Article 17 reporting (O Connor, 2015). See also the conservation objectives for lake habitat 3130 and for <i>Najas flexilis</i> (slender naiad) in this volume, and the Leannan River SAC conservation objectives supporting document for <i>Najas flexilis</i>
Habitat distribution	Occurrence	No decline, subject to natural processes	As noted above, lake habitat 3110 occurs in Lough Gartan in Leannan River SAC, and may co-occur with lake habitat 3130 in Loughs Akibbon and Fern. See map 3
Vegetation composition: typical species	Occurrence	Typical species present, in good condition, and demonstrating typical abundances and distribution	For lists of typical plant species, see the Article 17 habitat assessment for lake habitat 3110 (NPWS, 2013) and the lake habitats supporting document (O Connor, 2015)
Vegetation composition: characteristic zonation	Occurrence	All characteristic zones should be present, correctly distributed and in good condition	Further work is necessary to describe the characteristic zonation and other spatial patterns in lake habitat 3110 (see O Connor, 2015). Information on vegetation zonation may be available from Environmental Protection Agency (EPA) surveys and other sources
Vegetation distribution: maximum depth	Metres	Maintain/restore maximum depth of vegetation, subject to natural processes	The maximum depth of vegetation is likely to be specific to the lake shoreline in question. Further work is necessary to develop indicative targets for lake habitat 3110. Maximum depth should be large in 3110 lakes; however, pressures such as eutrophication, overgrazing, forestry and peat-cutting can lead to reduced vegetation depth. Maximum vegetation depth was shallow in Lough Fern in August 2017 (C. Roden, pers. comm.)
Hydrological regime: water level fluctuations	Metres	Maintain appropriate hydrological regime necessary to support the habitat	Fluctuations in lake water level are typical in Ireland, but can be amplified by activities such as abstraction, drainage and overgrazing. Increased water level fluctuations can increase wave action, up-root vegetation, increase turbidity, alter the substratum and lead to release of nutrients from the sediment. The hydrological regime of the lakes must be maintained so that the area, distribution and depth of the lake habitat and its constituent/characteristic vegetation zones and communities are not reduced

Lake substratum quality	Various	Maintain appropriate substratum type, extent and chemistry to support the vegetation	Research is required to further characterise the substratum types (particle size and origin) and substratum quality (notably pH, calcium, iron and nutrient concentrations) favoured by each of the five Annex I lake habitats in Ireland. It is likely that lake habitat 3110 is associated with a range of nutrient-poor substrates, from stones, cobble and gravel, through sands, silt, clay and peat. Substratum particle size is likely to vary with depth and along the shoreline within a single lake. The blackened vegetation at depth in Lough Fern in 2017 is indicative of disturbance of the lake substratum. Other data on lake substrata may be available from EPA surveys
Water quality: transparency	Metres	Restore appropriate Secchi transparency. There should be no decline in Secchi depth/transparency	Transparency relates to light penetration and, hence, to the depth of colonisation of vegetation. It can be affected by phytoplankton blooms, water colour and turbidity. Specific targets have yet to be established for lake habitat 3110 (O Connor, 2015). Habitat 3110 is associated with very clear water. The OECD fixed boundary system set transparency targets for oligotrophic lakes of $\geq 6\text{m}$ annual mean Secchi disk depth, and $\geq 3\text{m}$ annual minimum Secchi disk depth. Free et al. (2009) found high isoetid abundance in lakes with Secchi depths of more than 3m. Free et al. (2006) recorded Secchi depths of 1.5m and 1.6m in Loughs Gartan and Fern, respectively. Roden et al. (in prep.) noted very dark water colour in Lough Fern in August 2017
Water quality: nutrients	$\mu\text{g/l P}$; mg/l N	Maintain/restore the concentration of nutrients in the water column to sufficiently low levels to support the habitat and its typical species	As a nutrient-poor habitat, oligotrophic and Water Framework Directive (WFD) 'high' status targets apply. Where a lake has nutrient concentrations that are lower than these targets, there should be no decline within class, i.e. no upward trend in nutrient concentrations. For lake habitat 3110, annual average total phosphorus (TP) concentration should be $\leq 10\mu\text{g/l TP}$, average annual total ammonia concentration should be $\leq 0.040\text{mg/l N}$ and annual 95th percentile for total ammonia should be $\leq 0.090\text{mg/l N}$. See also The European Communities Environmental Objectives (Surface Waters) Regulations 2009. Lough Gartan passed the WFD TP target in 2012-2015, but failed in 2007-2009 and 2010-2012 with Good status (McGarrigle et al., 2010; Bradley et al., 2015; Fanning et al., 2017). Loughs Fern and Akibbon have failed the TP target since 2007
Water quality: phytoplankton biomass	$\mu\text{g/l chlorophyll } a$	Maintain/restore appropriate water quality to support the habitat, including high chlorophyll <i>a</i> status	Oligotrophic and WFD 'high' status targets apply to lake habitat 3110. Where a lake has a chlorophyll <i>a</i> concentration that is lower than this target, there should be no decline within class, i.e. no upward trend in phytoplankton biomass. The average growing season (March-October) chlorophyll <i>a</i> concentration must be $< 5.8\mu\text{g/l}$. The annual average chlorophyll <i>a</i> concentration should be $< 2.5\mu\text{g/l}$ and the annual peak chlorophyll <i>a</i> concentration should be $\leq 8.0\mu\text{g/l}$. See also The European Communities Environmental Objectives (Surface Waters) Regulations 2009. Lough Gartan and Lough Akibbon have consistently passed the target; however, Lough Fern has failed with Good status since 2010 (McGarrigle et al., 2010; Bradley et al., 2015; Fanning et al., 2017)
Water quality: phytoplankton composition	EPA phytoplankton composition metric	Maintain/restore appropriate water quality to support the habitat, including high phytoplankton composition status	The EPA has developed a phytoplankton composition metric for nutrient enrichment of Irish lakes. As for other water quality indicators, lake habitat 3110 requires WFD high status. Phytoplankton composition is not sampled at Lough Gartan. Its status at Lough Fern was Good in the 2007-2009, 2010-2012 and 2013-2015 cycles (McGarrigle et al., 2010; Bradley et al., 2015; Fanning et al., 2017)

Water quality: attached algal biomass	Algal cover	Maintain trace/absent attached algal biomass (<5% cover)	Nutrient enrichment can favour epiphytic and epipelagic algae that can out-compete the submerged vegetation. The cover abundance of attached algae in lake habitat 3110 should, therefore, be trace/absent (<5% cover)
Water quality: macrophyte status	EPA macrophyte metric (The Free Index)	Maintain/restore high macrophyte status	Nutrient enrichment can favour more competitive submerged macrophyte species that out-compete the typical and characteristic species for the lake habitat. The EPA monitors macrophyte status for WFD purposes using the 'Free Index'. The target for lake habitat 3110 is high status or an Ecological Quality Ratio (EQR) for lake macrophytes of ≥ 0.90 , as defined in Schedule Five of the European Communities Environmental Objectives (Surface Waters) Regulations 2009. Macrophyte status has been high in Lough Gartan since 2007, but Loughs Fern and Akibbon have consistently failed (McGarrigle et al., 2010; Bradley et al., 2015; Fanning et al., 2017)
Acidification status	pH units; mg/l	Maintain appropriate water and sediment pH, alkalinity and cation concentrations to support the habitat, subject to natural processes	Acidification can impact on species abundance and composition in soft water lake habitats. In Europe, acidification of isoetid lakes can lead to loss of isoetids and dominance by submerged bog mosses (<i>Sphagnum</i> spp.) and bulbous rush (<i>Juncus bulbosus</i>) (Arts, 2002). The specific requirements of lake habitat 3110, in terms of water and sediment pH, alkalinity and cation concentration, have not been determined. For lakes with habitat 3110, and adopting a precautionary approach based on Arts (2002), minimum pH should not be <5.5 pH units. Maximum pH should be <9.0 pH units, in line with the surface water standards established for soft waters (where water hardness is ≤ 100 mg/l calcium carbonate). See Schedule Five of the European Communities Environmental Objectives (Surface Waters) Regulations 2009. Lough Gartan, and Loughs Akibbon and Fern have passed the WFD metric since 2007 (McGarrigle et al., 2010; Bradley et al., 2015; Fanning et al., 2017)
Water colour	mg/l PtCo	Maintain/restore appropriate water colour to support the habitat	Increased water colour and turbidity decrease light penetration and can reduce the area of available habitat for lake macrophytes, particularly at the lower euphotic depths. The primary source of increased water colour in Ireland is disturbance to peatland. No habitat-specific or national standards for water colour currently exist. Studies have shown median colour concentrations in Irish lakes of 38mg/l PtCo (Free et al., 2000) and 33mg/l PtCo (Free et al., 2006). It is likely that the water colour in all Irish lake habitats would naturally be <50mg/l PtCo. Water colour can be very low (<20mg/l PtCo or even <10mg/l PtCo) in lakes with habitat 3110 where the peatland in the lake's catchment is intact. Free et al. (2006) reported colour of 59mg/l PtCo in Lough Gartan and 46mg/l PtCo in Lough Fern. Roden et al. (in prep.) recorded very darkly coloured water in Lough Fern in August 2017
Dissolved organic carbon (DOC)	mg/l	Maintain/restore appropriate organic carbon levels to support the habitat	Dissolved (and particulate) organic carbon (OC) in the water column is linked to water colour and acidification (organic acids). Increasing DOC in water has been documented across the Northern Hemisphere, including afforested peatland catchments in Ireland. Damage and degradation of peatland, leading to decomposition of peat is likely to be the predominant source of OC in Ireland. OC in water promotes decomposition by fungi and bacteria that, in turn, releases dissolved nutrients. The increased biomass of decomposers can also impact directly on the characteristic lake communities through shading, competition, etc.

Turbidity	Nephelometric turbidity units/ mg/l SS/ other appropriate unit	Maintain/restore appropriate turbidity to support the habitat	Turbidity can significantly affect the quantity and quality of light reaching rooted and attached vegetation and can, therefore, impact on lake habitats. The settlement of higher loads of inorganic or organic material on lake vegetation communities may also have impacts on sensitive, delicate species. Turbidity can increase as a result of re-suspension of material within the lake, higher loads entering the lake, or eutrophication. Turbidity measurement and interpretation is challenging. As a result, it is likely to be difficult to set habitat-specific targets for turbidity in lakes
Fringing habitat: area and condition	Hectares	Maintain the area and condition of fringing habitats necessary to support the natural structure and functioning of habitat 3110	Most lake shorelines have fringing habitats of reedswamp, other swamp, fen, marsh or wet woodland that intergrade with and support the structure and functions of the lake habitat. In Leannan River SAC, fringing habitats could include freshwater marsh, fen or other peatland, woodland and grassland. Fringing habitats are dependent on the lake, particularly its water levels, and support wetland communities and species of conservation concern. Many of the fringing wetland habitats support higher invertebrate and plant species richness than the lake habitats themselves

Conservation Objectives for : Leannan River SAC [002176]

3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or *Isoeto-Nanojuncetea*

To restore the favourable conservation condition of Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletea uniflorae* and/or of the *Isoeto-Nanojuncetea* in Leannan River SAC, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Habitat area	Hectares	Area stable or increasing, subject to natural processes	Lake habitat 3130 is considered to occur in Loughs Akibbon and Fern in Leannan River SAC. Habitat 3110 and/or 3130 may occur in Lough Nacally. The habitat in both Lough Akibbon and Lough Fern was found to be in Unfavourable-Inadequate (Poor) conservation condition in 2017/18 (Roden et al., in prep.). See the Leannan River SAC conservation objectives supporting document for <i>Najas flexilis</i> (slender naiad) for further site-specific details. Two measures of extent should be used: 1. the area of the lake itself and; 2. the extent of the vegetation communities/zones that typify the habitat. Further information relating to all attributes is provided in the lake habitats supporting document for the purposes of site-specific conservation objectives and Article 17 reporting (O Connor, 2015)
Habitat distribution	Occurrence	No decline, subject to natural processes	As noted above, lake habitat 3130 is considered to occur in Loughs Akibbon and Fern in Leannan River SAC (see map 3)
Vegetation composition: typical species	Occurrence	Typical species present, in good condition, and demonstrating typical abundances and distribution	For lists of typical plant species, see the Article 17 habitat assessment for lake habitat 3130 (NPWS, 2013) and the lake habitats supporting document (O Connor, 2015). See also the <i>Najas flexilis</i> supporting document
Vegetation composition: characteristic zonation	Occurrence	All characteristic zones should be present, correctly distributed and in good condition	An on-going study aims to describe the characteristic zonation and other spatial patterns in lake habitat 3130 (Roden et al., in prep.). See also the <i>Najas flexilis</i> supporting document. From 2017/18 surveys (C. Roden, pers. comm.): Lough Akibbon- sheltered shores have beds of <i>Schoenoplectus lacustris</i> and <i>Equisetum fluviatile</i> with nearby water lilies, more exposed shores have <i>Littorella uniflora</i> with <i>Isoetes lacustris</i> below 1m, <i>Chara virgata</i> occurs below 1m in the south-west giving way to a <i>Najas/Nitella/Callitriche</i> community; Lough Fern- reedbeds occur at the south, most of the shore is rocky with <i>Littorella</i> and <i>Chara aspera</i> , below 1m <i>Nitella</i> sp. dominates with <i>Elodea canadensis</i> , <i>Potamogeton</i> spp. and occasional <i>Najas flexilis</i> , much of the deeper vegetation was blackened and decaying
Vegetation distribution: maximum depth	Metres	Maintain/restore maximum depth of vegetation, subject to natural processes	The maximum depth of vegetation is likely to be specific to the lake shoreline in question. An on-going study may develop indicative targets for lake habitat 3130 (Roden et al., in prep.). Maximum depth should be large in lakes within undisturbed peatland and uplands; however, pressures on peatland such as overgrazing may have reduced vegetation depth. Vegetation covers nearly the entire lake bed of shallow Lough Akibbon (C. Roden, pers. comm.). Lough Fern is also shallow (maximum depth of 2.5m) and vegetation has potential to colonise the entire lake bed; however, euphotic depth was c.2m in August 2017 (C. Roden, pers. comm.)

Hydrological regime: water level fluctuations	Metres	Maintain appropriate natural hydrological regime necessary to support the habitat	Fluctuations in lake water level are typical in Ireland, but can be amplified by activities such as abstraction, drainage and overgrazing. Increased water level fluctuations can increase wave action, up-root vegetation, increase turbidity, alter the substratum and lead to release of nutrients from the sediment. The hydrological regime of the lakes must be maintained so that the area, distribution and depth of the lake habitat and its constituent/characteristic vegetation zones and communities are not reduced
Lake substratum quality	Various	Maintain/restore appropriate substratum type, extent and chemistry to support the vegetation	Research is required to further characterise the substratum types (particle size and origin) and substratum quality (notably pH, calcium, iron and nutrient concentrations) favoured by each of the five Annex I lake habitats in Ireland. It is likely that lake habitat 3130 is associated with a range of substrate types that are more productive/base-rich relative to the substratum of lake habitat 3110. Substratum particle size is likely to vary with depth and along the shoreline within a single lake. See the <i>Najas flexilis</i> supporting document. The blackened vegetation at depth in Lough Fern in 2017 is indicative of disturbance of the lake substratum. Other data on lake substrata may be available from Environmental Protection Agency (EPA) surveys
Water quality: transparency	Metres	Restore appropriate Secchi transparency. There should be no decline in Secchi depth/transparency	Transparency relates to light penetration and, hence, to the depth of colonisation of vegetation. It can be affected by phytoplankton blooms, water colour and turbidity. The on-going study may develop specific targets for lake habitat 3130 (Roden et al., in prep.). Habitat 3130 is associated with clear water, as evidenced by the growth of the character species <i>Najas flexilis</i> (slender naiad) at depths of up to 10m. There is likely to be some variation in Secchi depth across lakes with habitat 3130 and site-specific conditions should also be considered. The OECD fixed boundary system set transparency targets for oligotrophic lakes of $\geq 6\text{m}$ annual mean Secchi disk depth, and $\geq 3\text{m}$ annual minimum Secchi disk depth. Free et al. (2006) recorded a Secchi depth of 1.6m in Lough Fern. Roden et al. (in prep.) noted very dark water colour in Lough Fern in August 2017
Water quality: nutrients	$\mu\text{g/l P}$; mg/l N	Restore the concentration of nutrients in the water column to sufficiently low levels to support the habitat and its typical species	3130 is associated with high water quality, with naturally low dissolved nutrients. It is naturally more productive than 3110, probably reflecting higher concentrations of nutrients such as calcium, rather than P alone. 3130 may reach favourable condition slightly above the oligotrophic boundary for nutrients, but in the absence of habitat-specific targets, the targets are WFD 'High Status' or oligotrophic (OECD, 1982). The "good-moderate" boundary is too enriched to support the habitat. Annual average TP concentration should be $\leq 10\mu\text{g/l}$ TP, average annual total ammonia concentration should be $\leq 0.040\text{mg/l N}$ and annual 95th percentile for total ammonia should be $\leq 0.090\text{mg/l N}$. See also The European Communities Environmental Objectives (Surface Waters) Regulations 2009. Lough Akibbon failed the TP target, having Good status since 2007, while Lough Fern failed with Good status in 2007-09 and Moderate in 2010-12 and 2013-15 (McGarrigle et al., 2010; Bradley et al., 2015; Fanning et al., 2017)

Water quality: phytoplankton biomass	µg/l chlorophyll <i>a</i>	Restore appropriate water quality to support the habitat, including high chlorophyll <i>a</i> status	3130 is associated with high water quality, and naturally low algal growth. As for nutrients, the targets are Water Framework Directive (WFD) 'High Status' or oligotrophic (OECD, 1982). The "good-moderate" boundary is too enriched to support the habitat. The average growing season (March-October) chlorophyll <i>a</i> concentration must be <5.8µg/l. The annual average chlorophyll <i>a</i> concentration should be <2.5µg/l and the annual peak chlorophyll <i>a</i> concentration should be ≤8.0µg/l. Where a lake has a chlorophyll <i>a</i> concentration that is lower than this target, there should be no decline within class, i.e. no upward trend in phytoplankton biomass. See also The European Communities Environmental Objectives (Surface Waters) Regulations 2009. Lough Akibbon passed the target, having High chlorophyll <i>a</i> status since 2007, but Lough Fern failed with Good status in 2010-12 and 2013-15 (McGarrigle et al., 2010; Bradley et al., 2015; Fanning et al., 2017)
Water quality: phytoplankton composition	EPA phytoplankton composition metric	Restore appropriate water quality to support the habitat, including high phytoplankton composition status	The EPA has developed a phytoplankton composition metric for nutrient enrichment of Irish lakes. As for other water quality indicators, lake habitat 3130 requires WFD high status. Phytoplankton composition status at Lough Fern was Good in the 2007-2009, 2010-2012 and 2013-2015 cycles (McGarrigle et al., 2010; Bradley et al., 2015; Fanning et al., 2017)
Water quality: attached algal biomass	Algal cover	Maintain/restore trace/absent attached algal biomass (<5% cover)	Nutrient enrichment can favour epiphytic and epipelic algae that can out-compete the submerged vegetation. The cover abundance of attached algae in lake habitat 3130 should, therefore, be trace/absent (<5% cover). In 2017, the vegetation at depth in Lough Fern was very blackened and partly decayed. It appeared to largely have been made up of <i>Nitella</i> sp., but may have included filamentous algae (Roden et al., in prep.)
Water quality: macrophyte status	EPA macrophyte metric (The Free Index)	Restore high macrophyte status	Nutrient enrichment can favour more competitive submerged macrophyte species that out-compete the typical and characteristic species for the lake habitat. The EPA monitors macrophyte status for WFD purposes using the 'Free Index'. The target for lake habitat 3130 is high status or an Ecological Quality Ratio (EQR) for lake macrophytes of ≥0.90, as defined in Schedule Five of the European Communities Environmental Objectives (Surface Waters) Regulations 2009. The lakes have consistently failed the high status target for macrophytes since 2007, Lough Akibbon was Moderate in 2007-2009 and 2010-2012, and Good in 2013-2015, Lough Fern was Poor in the three cycles (McGarrigle et al., 2010; Bradley et al., 2015; Fanning et al., 2017)
Acidification status	pH units; mg/l	Maintain appropriate water and sediment pH, alkalinity and cation concentrations to support the habitat, subject to natural processes	Acidification can impact on species abundance and composition in lake habitat 3130. The specific requirements of habitat 3130, in terms of water and sediment pH, alkalinity and cation concentration, have not been determined. In line with targets for <i>Najas flexilis</i> , median pH values should be greater than 7 pH units. Water and sediment alkalinity and concentrations of cations (notably calcium) should be appropriate to the habitat. The target for WFD Acidification/Alkalisations status is high. Maximum pH should be <9.0 pH units, in line with the surface water standards. See Schedule Five of the European Communities Environmental Objectives (Surface Waters) Regulations 2009. Both Loughs Akibbon and Fern passed the WFD metric in 2007-09, 2010-12 and 2013-15 (McGarrigle et al., 2010; Bradley et al., 2015; Fanning et al., 2017)

Water colour	mg/l PtCo	Maintain/restore appropriate water colour to support the habitat	Increased water colour and turbidity decrease light penetration and can reduce the area of available habitat for lake macrophytes, particularly at the lower euphotic depths. The primary source of increased water colour in Ireland is disturbance to peatland. No habitat-specific or national standards for water colour currently exist. Studies have shown median colour concentrations in Irish lakes of 38mg/l PtCo (Free et al., 2000) and 33mg/l PtCo (Free et al., 2006). It is likely that the water colour in all Irish lake habitats would naturally be <50mg/l PtCo. Water colour is generally <30mg/l PtCo or, more naturally, <20mg/l PtCo in lakes with habitat 3130, where the peatland in the lake's catchment is intact. Free et al. (2006) reported colour of 46mg/l PtCo in Lough Fern. Roden et al. (in prep.) recorded very darkly coloured water in Lough Fern in August 2017
Dissolved organic carbon (DOC)	mg/l	Maintain/restore appropriate organic carbon levels to support the habitat	Dissolved (and particulate) organic carbon (OC) in the water column is linked to water colour and acidification (organic acids). Increasing DOC in water has been documented across the Northern Hemisphere, including afforested peatland catchments in Ireland. Damage and degradation of peatland, leading to decomposition of peat is likely to be the predominant source of OC in Ireland. OC in water promotes decomposition by fungi and bacteria that, in turn, releases dissolved nutrients. The increased biomass of decomposers can also impact directly on the characteristic lake communities through shading, competition, etc. Roden et al. (in prep.) recorded very darkly coloured water in Lough Fern in August 2017
Turbidity	Nephelometric turbidity units/ mg/l SS/ other appropriate units	Maintain/restore appropriate turbidity to support the habitat	Turbidity can significantly affect the quantity and quality of light reaching rooted and attached vegetation and can, therefore, impact on lake habitats. The settlement of higher loads of inorganic or organic material on lake vegetation communities may also have impacts on sensitive, delicate species. Turbidity can increase as a result of re-suspension of material within the lake, higher loads entering the lake, or eutrophication. Turbidity measurement and interpretation is challenging. As a result, it is likely to be difficult to set habitat-specific targets for turbidity in lakes
Fringing habitat: area and condition	Hectares	Maintain the area and condition of fringing habitats necessary to support the natural structure and functioning of habitat 3130	Most lake shorelines have fringing habitats of reedswamp, other swamp, fen, marsh or wet woodland that intergrade with and support the structure and functions of the lake habitat. In Leannan River SAC, fringing habitats could include freshwater marsh, fen or other peatland, woodland and grassland. Fringing habitats are dependent on the lake, particularly its water levels, and support wetland communities and species of conservation concern. Many of the fringing wetland habitats support higher invertebrate and plant species richness than the lake habitats themselves

Conservation Objectives for : Leannan River SAC [002176]

1029 Freshwater Pearl Mussel *Margaritifera margaritifera*

To restore the favourable conservation condition of Freshwater Pearl Mussel (*Margaritifera margaritifera*) in Leannan River SAC, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Distribution	Kilometres	Maintain distribution at 12.8km. See map 4	The conservation objective applies to the Leannan population. Mussels are widespread in the main channel from Gartan Bridge to Lough Fern (Moorkens, 1995, 1996, 2009, 2012, 2015; Ross, 1988; Beasley, 1996; NPWS, 2010). Downstream of Fern, mussels were known to Tully Bridge in the 1990s, but the river is now canalised, silted, slow-flowing and unsuitable (Moorkens, 2007). Mussels are patchily distributed but abundant between Lough Gartan and Barrack Bridge (Moorkens, 1995, 1996, 2007, 2009, 2012, 2015; Beasley, 1996). Downstream of Barrack Bridge numbers decline rapidly to common and frequent (Moorkens, 2015). Mussels are frequent at best from Dromore Bridge to Kilmacrenan. Some of the best remaining habitat is from Kilmacrenan Gorge to the Lurgy, but mussels decline rapidly downstream (Moorkens, 2015). The target is for the species to be sufficiently widespread to maintain itself on a long-term basis as a viable component of the Leannan system. See NPWS (2010) for further information
Population size	Number of adult mussels	Restore population to at least 75,000 adult mussels	Moorkens (1995, 1996) found a good population of mussels in the Leannan. Beasley (1996) counted 1,141 mussels at 6 sites (density varied significantly). Moorkens (2009) recorded a significant decline 1990s-2009, caused by intensification of land use and regular pearl fishing, and gave a population estimate of 50,000-100,000. Moorkens (2009) counted 415 in sweep transects at 4 sections in the upper Leannan and estimated the highest density as c.1000 mussels/100m of channel. Moorkens (2012) estimated 15,000-17,000 in the c.1.5km downstream of Gartan Bridge and 30,000-50,000 between Gartan and Barrack Bridge, concluding the 50,000-100,000 population estimate was still applicable. Habitat is below carrying capacity throughout. NPWS (2013, 2019) estimated that the Leannan population is declining at -3% to -10%/yr. The target is for the species to be sufficiently abundant to maintain itself on a long-term basis as a viable component of the Leannan system
Population structure: recruitment	Percentage per size class	Restore to at least 20% of population no more than 65mm in length; and at least 5% of population no more than 30mm in length	Mussels ≤65mm are considered 'young mussels' and are found buried in the substratum and/or beneath adult mussels. Mussels ≤30mm are 'juvenile mussels' and are always buried in the substratum. See the European Communities Environmental Objectives (Freshwater Pearl Mussel) Regulations 2009 and I.S. EN 16859:2017. The Leannan is an ageing population. Moorkens (1995, 1996) recorded mussels from 5-yr-old juveniles to aged adults. Beasley (1996) also found a juvenile mussel of 26-30mm. The Leannan failed the targets and no mussels ≤30mm were found in 2007, 2009, 2011 and 2015 (Moorkens, 2007, 2009, 2012, 2015; NPWS, 2010). In 2011, 2% was ≤65mm (smallest mussel 51mm), but no mussels ≤65mm were found in 2007, 2009 or 2015. The Leannan population is unsustainable owing to lack of survival of juvenile mussels. The target is for sufficient juvenile recruitment to allow the species to maintain itself on a long-term basis as a viable component of the Leannan system

Population structure: adult mortality	Percentage	No more than 5% decline from previous number of live adults counted; dead shells less than 1% of the adult population and scattered in distribution	5% is the cut-off between the combined errors associated with natural fluctuations and sampling methods and evidence of true population decline. 1% dead shells is indicative of natural losses. The Leannan population declined by c.38% between the 1990s and 2009 (Moorkens, 2015). It failed the targets in 2009 (up to 33% dead shells in samples) (Moorkens, 2009; NPWS, 2010). It failed the live adult target in 2015 (overall decline, local increases suggestive of movement in floods and/or other stress events), but passed for dead shells (Moorkens, 2015). Moorkens (2015) predicted, with continued poor condition, the population would decrease by 40% by 2020, reducing it to scattered individuals, and become extinct shortly thereafter. The Leannan population is unsustainable owing to lack of juvenile mussel survival and elevated adult mortality. The target is for sufficient survival of adults to allow the species to maintain itself on a long-term basis as a viable component of the Leannan system
Suitable habitat: extent	Kilometres	Restore suitable habitat in more than 12.8km in the Leannan system (see map 4) and any additional stretches necessary for salmonid spawning	The mussel habitat extends from Gartan Bridge to Lough Fern (Moorkens, 1995, 1996, 2009, 2012, 2015; Ross, 1988; Beasley, 1996; NPWS, 2010). The two best areas of habitat are between Lough Gartan and Barrack Bridge, and Kilmacrenan Gorge and the Lurgy confluence (Moorkens, 2015). Scouring has damaged the habitat downstream of Barrack Bridge, and it has been dredged/canalised between Dromore Bridge and Kilmacrenan (Moorkens, 2015). The habitat downstream of Lough Fern appears to have become unsuitable as a result of hydromorphological changes (canalisation, siltation and slow flow) (Moorkens, 2007). Mussel habitat is severely impacted by hydromorphological changes, sedimentation and nutrient enrichment (Moorkens, 2007, 2009, 2012, 2015; NPWS, 2010). Juvenile habitat is in very poor condition (Moorkens, 2015). The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Leannan system
Suitable habitat: condition	Kilometres	Restore condition of suitable habitat	The habitat is a combination of the area of 1) habitat adult and juvenile mussels can occupy; 2) spawning and nursery habitats host fish can occupy. Fish nursery and mussel habitat typically overlap. Fish spawning habitat is generally adjacent to mussel habitat, but may lie upstream of the generalised mussel distribution. Only spawning areas that regularly contribute juvenile fish to adult mussel habitat should be considered. Mussel and fish habitat availability is determined by flow and substratum and is highly sensitive to hydromorphological, sedimentation and enrichment pressures from throughout the catchment. See I.S. EN 16859:2017. Mussel habitat is widespread in the Leannan but is severely impacted by hydromorphological changes, sedimentation and nutrient enrichment and cannot support sufficient juvenile survival. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Leannan system

Water quality: macroinvertebrate and phytobenthos (diatoms)	Ecological quality ratio (EQR)	Restore water quality- macroinvertebrates: EQR greater than 0.90 (Q4-5, Q5); phytobenthos: EQR greater than 0.93	The EQR targets correspond to high ecological status for these two Water Framework Directive biological quality elements. They represent high water quality with very low nutrient concentrations (oligotrophic conditions). Reaching these targets does not, however, guarantee achieving the targets for the other attributes. In 2009, the habitat in the Leannan system failed the macroinvertebrate target, but passed the diatom target; however, confidence in the diatom result was low owing to early sampling (Ní Chatháin, 2009; Williams, 2009; NPWS, 2010). See also The European Communities Environmental Objectives (Surface Waters) Regulations 2009. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Leannan system
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Substratum quality: filamentous algae (macroalgae); macrophytes (rooted higher plants)	Percentage	Restore substratum quality- filamentous algae: absent or trace (less than 5%); macrophytes: absent or trace (less than 5%)	The Leannan failed the macrophyte target, but passed the filamentous algal target in 2009 when high rainfall/flows may have limited macroalgal development (NPWS, 2010). Williams (2009) recorded high macrophyte cover at 3 Leannan sites. It failed both targets in 2011 and 2015 (Moorkens, 2012, 2015). Moorkens (2012) noted an expansion in <i>Myriophyllum</i> cover (up to 30% in some quadrats). Macroalgal cover was 10-75% in transects in 2011. In 2015, algal cover was 10-70% (severe in places) and macrophyte 0-30% in transects, heavy floc cover (decaying algae, other organic matter) was frequent, and in the Lurgy, filamentous algae occurred throughout and were abundant downstream of Kilmacrenan (Moorkens, 2015). Sufficient recruitment of juvenile mussels is being prevented by the poor condition of the river substratum. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Leannan system
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Substratum quality: sediment	Occurrence	Restore substratum quality- stable cobble and gravel substrate with very little fine material; no artificially elevated levels of fine sediment	The Leannan failed the target for the Sub-basin Management Plan, with severe sedimentation in parts of the mussel habitat (Moorkens, 2009; NPWS, 2010). Williams (2009) also recorded significant silt plumes at some sites. Sedimentation of the mussel habitat appears to have provided a rooting medium for macrophytes in the Leannan. It failed the target in 2011 and 2015, and silt plumes were recorded (Moorkens, 2012, 2015). Heavy floc cover (decaying algae, other organic matter) was recorded throughout the Leannan in 2015 (Moorkens, 2015). Sufficient survival of juvenile mussels is being prevented by the poor condition of the river substratum. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Leannan system
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Substratum quality: oxygen availability	Redox potential	Restore to no more than 20% decline from water column to 5cm depth in substrate	Differences in redox potential between the water column and the substrate correlate with differences in oxygen levels. Juvenile mussels require full oxygenation while buried in gravel. In suitable habitat, there should be very little loss of redox potential between the water column and underlying gravels. See I.S. EN 16859:2017. The Leannan failed the redox target in 2009, 2011 and 2015. Average redox potential at 5cm was 32.4% (range 20.7-41.7%) in 2009, indicating areas with severe oxygen decline in the substratum (Moorkens, 2009; NPWS, 2010). Average redox in 2011 ranged from 23.8-30.6% (overall average 26.9%) across 11 sites. Average redox in 2015 was 22% from 126 readings (Gartan Bridge to downstream of the Lurgy), 18-26% across sites; <20% only near transects and in patches upstream of the Lurgy (Moorkens, 2015). The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Leannan system
Hydrological regime: flow variability	Metres per second	Restore appropriate hydrological regime	The availability of suitable pearl mussel habitat is largely determined by flow (geology is the other key factor). To restore the habitat for the species, flow variability over the annual cycle must be such that: 1) high flows can wash fine sediments from the substratum; 2) high flows are not artificially increased so as to cause excessive scour of mussel habitat; 3) low flows do not exacerbate the deposition of fine sediment or growth of algae/macrophytes and 4) low flows do not cause stress to mussels in terms of exposure, water temperatures, food availability or aspects of the reproductive cycle. Groundwater inflow to a river contributes to water-cycling. See also Moorkens and Killeen (2014) and I.S. EN 16859:2017. Hydrological change owing to drainage activities is contributing to the species' decline in the Leannan. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of Leannan system
Host fish	Number	Maintain sufficient juvenile salmonids to host glochidial larvae	Salmonid fish are host to the larval stage of the freshwater pearl mussel and essential to completion of the life cycle. 0+ and 1+ fish are typically used, both because of habitat overlaps and the development of immunity with age in fish. Fish presence is sufficient, as higher fish density and biomass is indicative of enriched conditions in mussel rivers. Geist et al. (2006) found that higher densities of host fish coincided with eutrophication, poor substrate quality for mussels and a lack of mussel recruitment, while significantly lower host fish density and biomass were associated with high juvenile mussel numbers. Fish movements must be such that 0+ fish remain in the mussel habitat until their 1+ summer. No fish stocking should occur within the mussel habitat, nor any works that may change the salmonid balance or residency time. No glochidia were found on young Leannan fish in 2009 or 2017, but were found on 2 trout in 2012 (Johnston, 2009, 2012; Johnston and Moorkens, 2018)

Fringing habitat: Hectares
area and condition

Maintain the area and
condition of fringing
habitats necessary to
support the population

Semi-natural and natural riparian habitats, including those along lake fringes, even where they do not form part of a natural floodplain, are an integral part of the structure and functioning of river systems. Open wetlands, such as wet heath and blanket bog, are particularly critical to the hydrological regime of mussel rivers. Fringing habitats assist in the settlement of fine suspended material, protect banks from erosion and contribute to nutrient cycling, as well as contributing to the aquatic food web (e.g. allochthonous matter from poor fens and flushes) and providing habitat (refuge and resources) for life-stages of fish, birds and aquatic invertebrates. Equally, fringing habitats are dependent on rivers/lakes, particularly their water levels, and support wetland communities and species of conservation concern. The target is for sufficient habitat in favourable condition to allow the species to maintain itself on a long-term basis as a viable component of the Leannan system

Conservation Objectives for : Leannan River SAC [002176]

1106 Salmon *Salmo salar*

To restore the favourable conservation condition of Atlantic Salmon (*Salmo salar*) in Leannan River SAC, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Distribution: extent of anadromy	Percentage of river accessible	100% of river channels down to second order accessible from estuary	Artificial barriers block salmon's upstream migration, thereby limiting species to lower stretches and restricting access to spawning areas
Adult spawning fish	Number	Conservation limit (CL) for each system consistently exceeded	A conservation limit is defined by the North Atlantic Salmon Conservation Organisation (NASCO) as "the spawning stock level that produces long-term average maximum sustainable yield as derived from the adult to adult stock and recruitment relationship". The target is based on the Technical Expert Group on Salmon's (TEGOS) annual model output of CL attainment levels. See Technical Expert Group on Salmon (2019) for further details. Stock estimates are either derived from direct counts of adults (rod catch, fish counter) or indirectly by fry abundance counts. Based on rod catch estimates, the Leannan River is currently below CL for both one-sea-winter (meeting 72% of CL) and multi-sea-winter salmon (meeting 17% of CL)
Salmon fry abundance	Number of fry/5 minutes electrofishing	Maintain or exceed 0+ fry mean catchment-wide abundance threshold value. Currently set at 17 salmon fry/5 minutes sampling	Target is threshold value for rivers currently exceeding their conservation limit (CL)
Out-migrating smolt abundance	Number	No significant decline	Smolt abundance can be negatively affected by a number of impacts such as estuarine pollution, predation and sea lice (<i>Lepeophtheirus salmonis</i>)
Number and distribution of redds	Number and occurrence	No decline in number and distribution of spawning redds due to anthropogenic causes	Salmon spawn in clean gravels
Water quality	EPA Q value	At least Q4 at all sites sampled by EPA	Q values based on triennial water quality surveys carried out by the Environmental Protection Agency (EPA)

Conservation Objectives for : Leannan River SAC [002176]

1355 Otter *Lutra lutra*

To maintain the favourable conservation condition of Otter (*Lutra lutra*) in Leannan River SAC, which is defined by the following list of attributes and targets:

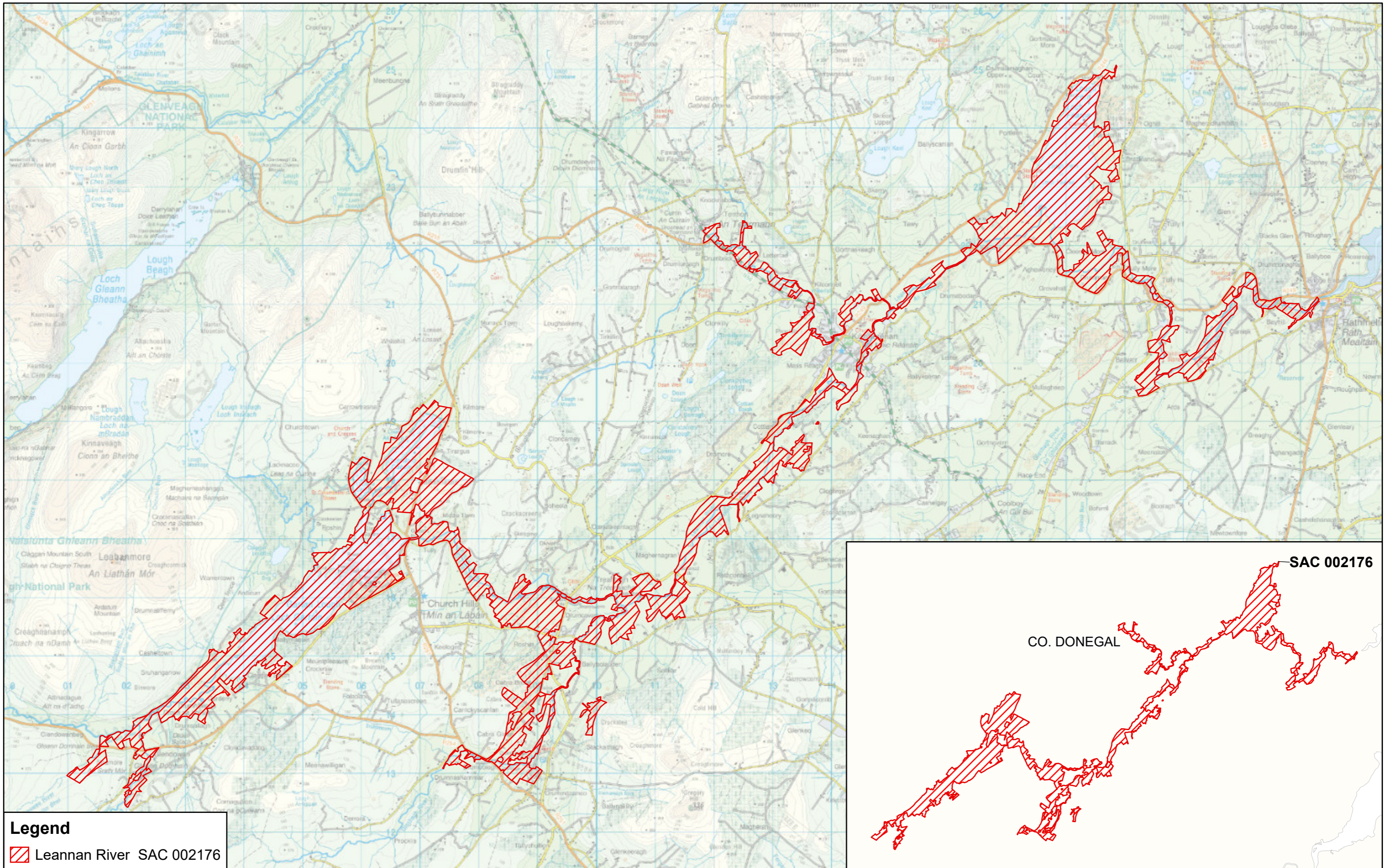
Attribute	Measure	Target	Notes
Distribution	Percentage positive survey sites	No significant decline	Measure based on standard otter survey technique. Favourable Conservation Status (FCS) target, based on 1980/81 survey findings, is 88% in SACs. Current range is estimated at 93.6% (Reid et al., 2013)
Extent of terrestrial habitat	Hectares	No significant decline. Area mapped and calculated as 138ha along river banks/ lake shoreline/around ponds	No field survey. Areas mapped to include 10m terrestrial buffer, identified as critical for otters (NPWS, 2007), along rivers and around water bodies
Extent of freshwater (river) habitat	Kilometres	No significant decline. Length mapped and calculated as 60km	No field survey. River length calculated on the basis that otters will utilise freshwater habitats from estuary to headwaters (Chapman and Chapman, 1982)
Extent of freshwater (lake) habitat	Hectares	No significant decline. Area mapped and calculated as 191ha	No field survey. Area mapped based on evidence that otters tend to forage within 80m of the shoreline (NPWS, 2007)
Couching sites and holts	Number	No significant decline	Otters need lying up areas throughout their territory where they are secure from disturbance (Kruuk and Moorhouse, 1991; Kruuk, 2006)
Fish biomass available	Kilograms	No significant decline	Broad diet that varies locally and seasonally, but dominated by fish, in particular salmonids, eels and sticklebacks in freshwater (Bailey and Rochford, 2006; Reid et al., 2013)
Barriers to connectivity	Number	No significant increase. For guidance, see map 5	Otters will regularly commute across stretches of open water up to 500m e.g. between the mainland and an island; between two islands; across an estuary (De Jongh and O'Neill, 2010). It is important that such commuting routes are not obstructed

Conservation Objectives for : Leannan River SAC [002176]


1833 Slender Naiad *Najas flexilis*

To restore the favourable conservation condition of Slender Naiad (*Najas flexilis*) in Leannan River SAC, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Population extent	Hectares; distribution	Maintain/restore the spatial extent of <i>Najas flexilis</i> within the lakes, subject to natural processes. See map 6 for known locations	Populations of <i>Najas flexilis</i> (slender naiad) occur in Lough Akibbon and Lough Fern in Leannan River SAC. See the Leannan River SAC conservation objectives supporting document for <i>Najas flexilis</i> for further details
Population depth	Metres	Maintain/restore the depth range of <i>Najas flexilis</i> within the lakes, subject to natural processes	See the <i>Najas flexilis</i> supporting document for further details
Population viability	Plant traits	Maintain/restore plant fitness, subject to natural processes	See the <i>Najas flexilis</i> supporting document for further details
Population abundance	Square metres	Maintain/restore the cover abundance of <i>Najas flexilis</i> , subject to natural processes	See the <i>Najas flexilis</i> supporting document for further details
Species distribution	Occurrence	Maintain current range subject to natural processes	See the <i>Najas flexilis</i> supporting document for further details
Habitat extent	Hectares	Maintain/restore habitat extent, subject to natural processes	See the <i>Najas flexilis</i> supporting document for further details
Hydrological regime: water level fluctuations	Metres	Maintain appropriate natural hydrological regime necessary to support the habitat for the species	See the <i>Najas flexilis</i> supporting document for further details
Lake substratum quality	Various	Maintain/restore appropriate substratum type, extent and chemistry to support the populations of the species	See the <i>Najas flexilis</i> supporting document for further details
Water quality	Various	Restore appropriate water quality to support the populations of the species	See the <i>Najas flexilis</i> supporting document for further details
Acidification status	pH units; mg/l	Maintain appropriate water and sediment pH, alkalinity and cation concentrations to support the populations of <i>Najas flexilis</i> , subject to natural processes	See the <i>Najas flexilis</i> supporting document for further details
Water colour	mg/l PtCo	Maintain/restore appropriate water colour to support the populations of <i>Najas flexilis</i>	See the <i>Najas flexilis</i> supporting document for further details
Associated species	Species composition and abundance	Maintain/restore appropriate associated species and vegetation communities to support the populations of <i>Najas flexilis</i>	See the <i>Najas flexilis</i> supporting document for further details
Fringing habitat: area and condition	Hectares	Maintain the area and condition of fringing habitats necessary to support the populations of <i>Najas flexilis</i>	See the <i>Najas flexilis</i> supporting document for further details



Legend
 Leannan River SAC 002176

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**MAP 1:
 LEANNAN RIVER SAC
 CONSERVATION OBJECTIVES
 SAC DESIGNATION**
 Map to be read in conjunction with the NPWS Conservation Objectives Document.

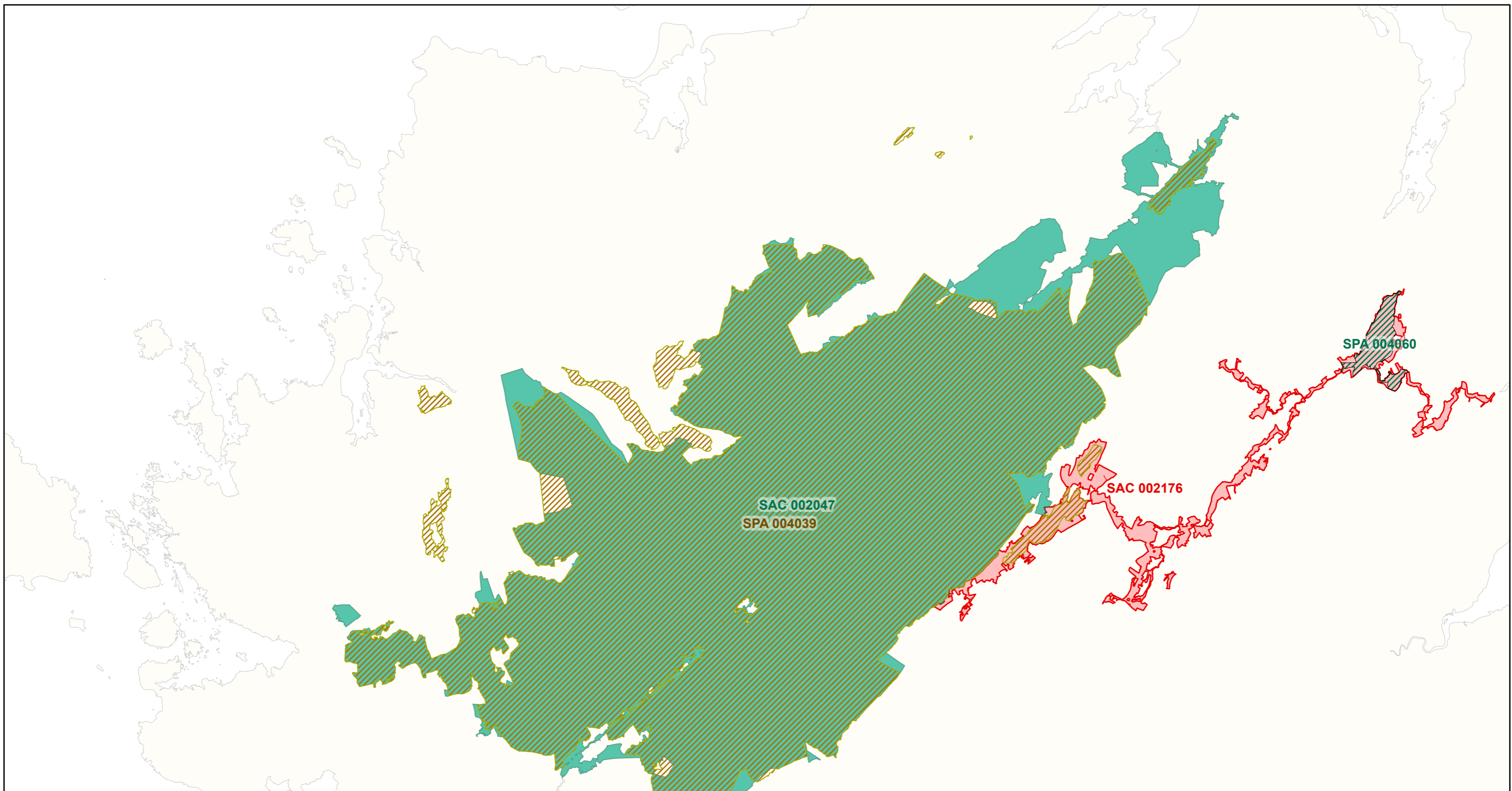
**SITE CODE:
 SAC 002176; version 3.01. CO. DONEGAL**

0 0.75 1.5 2.25 3 Kilometers

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**Map Version 1
 Date: May 2019**



Legend

- Leannan River SAC 002176
- Cloghernagore Bog and Glenveagh National Park SAC 002047
- Derryveagh And Glendowan Mountains SPA 004039
- Lough Fern SPA 004060
- OSi Discovery Series County Boundary

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**MAP 2:
LEANNAN RIVER SAC
CONSERVATION OBJECTIVES
ADJACENT AND AJOINING BOUNDARIES**

Map to be read in conjunction with the NPWS Conservation Objectives Document.

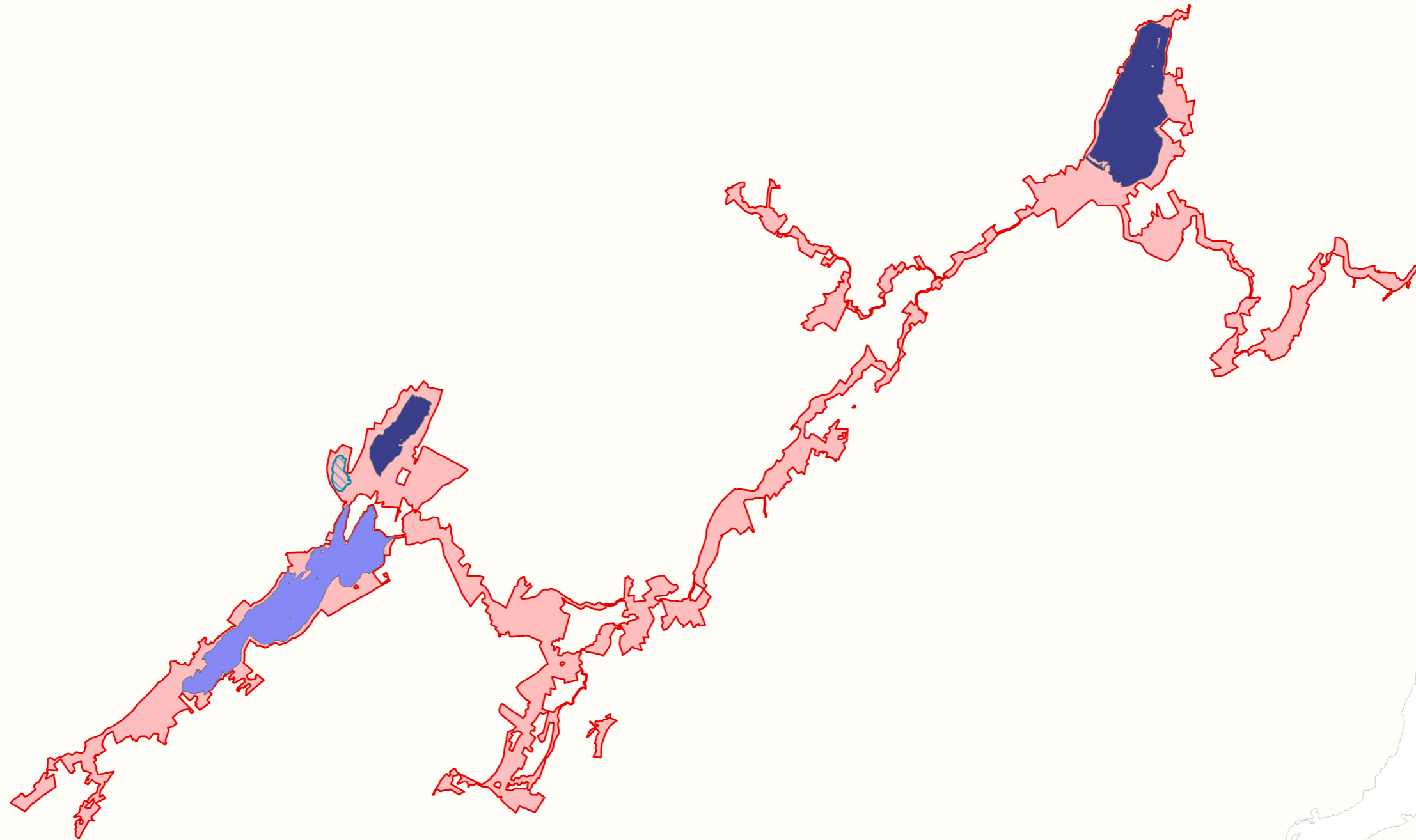
**SITE CODE:
SAC 002176; version 3.01, SAC 002047; version 3.0
SPA 004039; version 3.02, SPA 004060; version 3.02
CO. DONEGAL**

0 1.5 3 4.5 6 Kilometers

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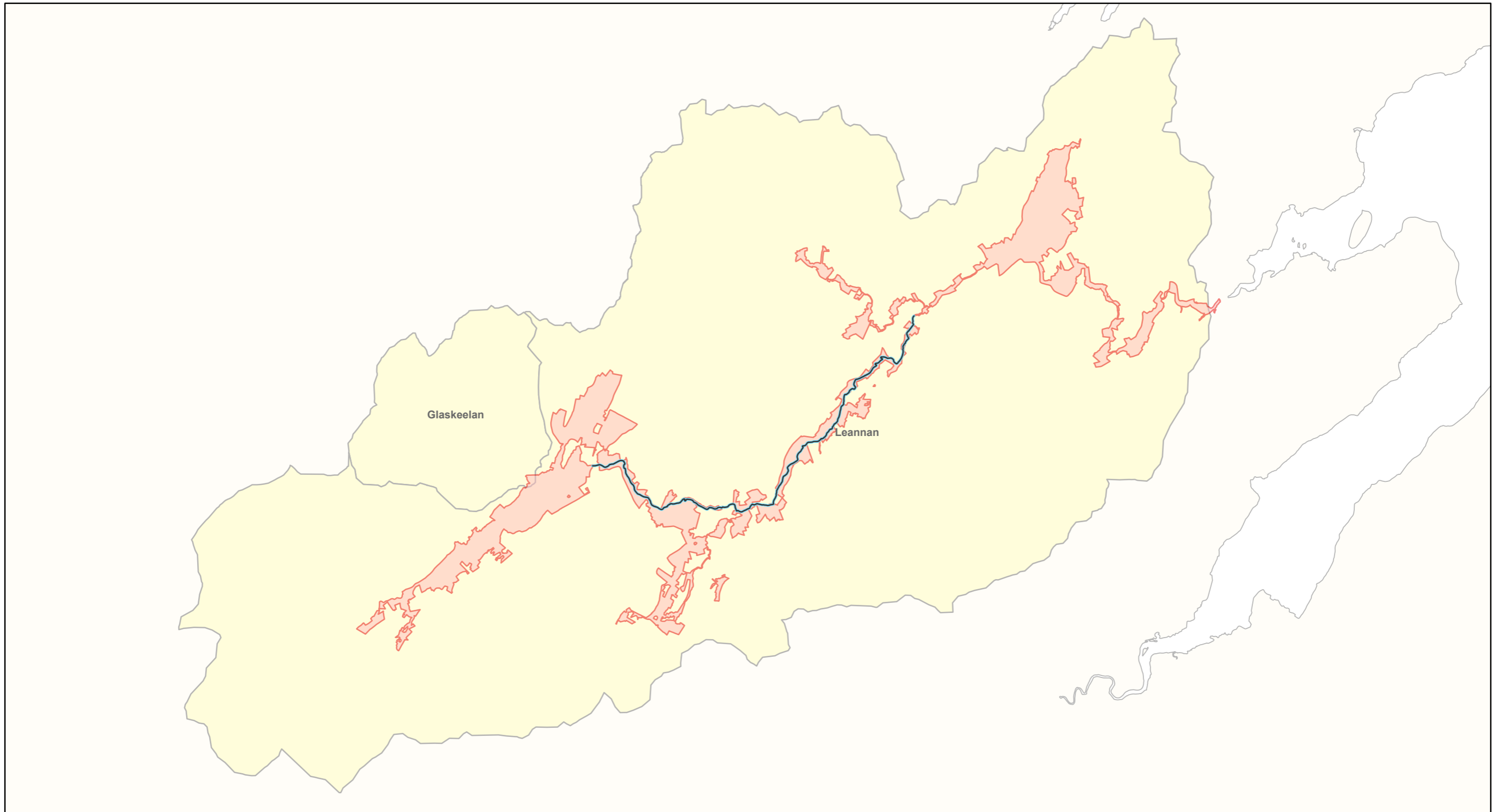
Níl sna teorainneacha ar na léarscáileanna ach nod garshuíomhach ginearálta. Féadfar athbhreithnithe a déanamh ar theorainneacha na gceantar comharthaithe. Suirbhéarachta Ordonáis na hÉireann Ceadúnas Uimh EN OSI-NMA-014. © Suirbhéarachta Ordonáis na hÉireann Riattas na hÉireann

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Date: May 2019**



Legend

- 3110 Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*)
- 3130 Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletalia uniflorae* and/or *Isoeto-Nanojuncetea*
- 3110/3130 Oligotrophic waters containing very few minerals of sandy plains (*Littorelletalia uniflorae*) / Oligotrophic to mesotrophic standing waters with vegetation of the *Littorelletalia uniflorae* and/or *Isoeto-Nanojuncetea*
- Leannan River SAC 002176
- OSi Discovery Series County Boundary



Legend

- Leannan River SAC 002176
- 1029 Freshwater Pearl Mussel - *Margaritifera margaritifera* Suitable habitat target
- 1029 Freshwater Pearl Mussel - *Margaritifera margaritifera* Distribution target
- 1029 Freshwater Pearl Mussel - *Margaritifera margaritifera* Catchment

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**MAP 4:
LEANNAN RIVER SAC
CONSERVATION OBJECTIVES
FRESHWATER PEARL MUSSEL**

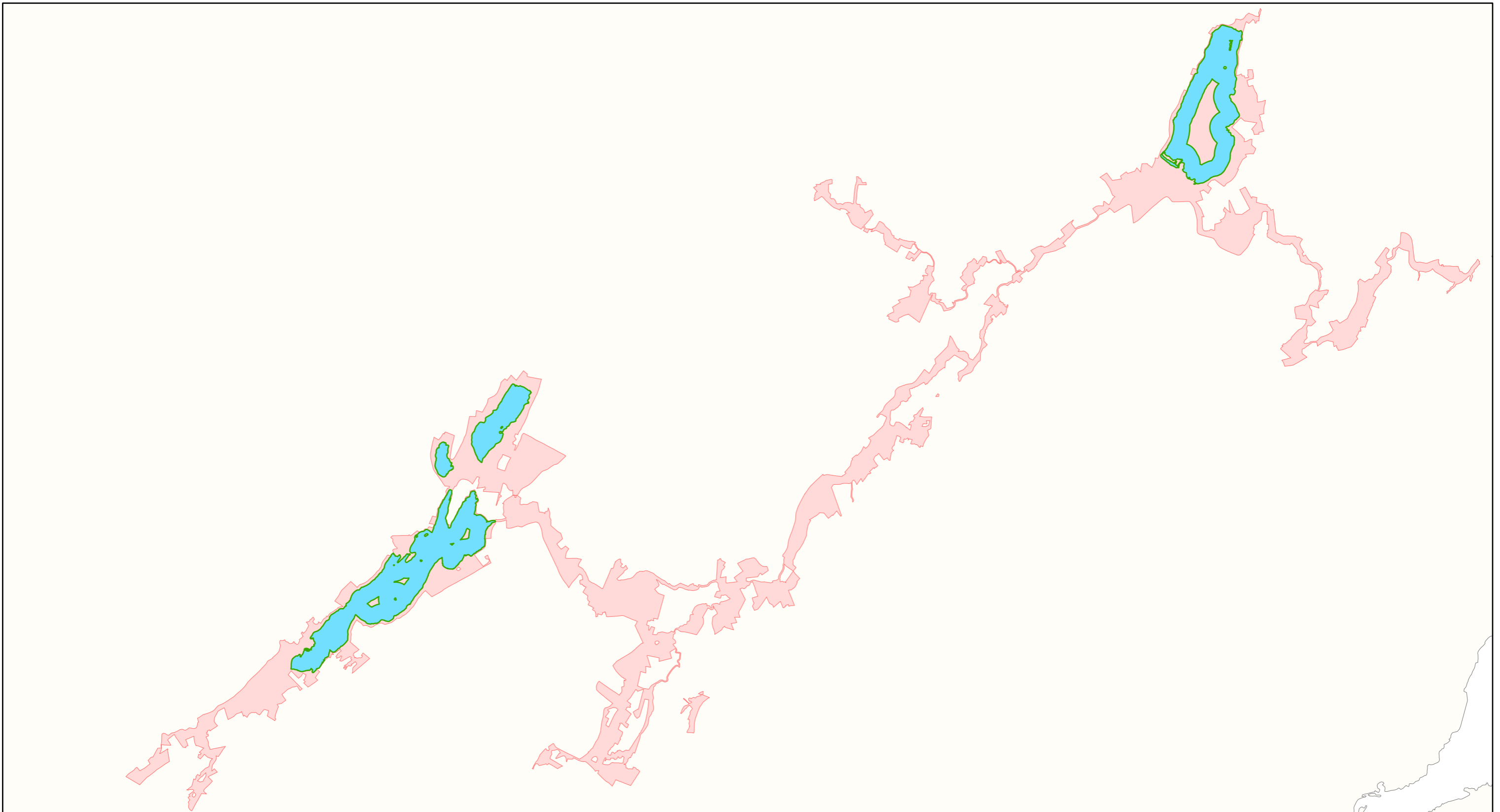
Map to be read in conjunction with the NPWS Conservation Objectives Document.

SITE CODE:
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Map Version 1
Date: May 2019



Legend

- 1355 Otter *Lutra lutra* Commuting
- Leannan River SAC 002176
- OSi Discovery Series County Boundary

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**MAP 5:
LEANNAN RIVER SAC
CONSERVATION OBJECTIVES
OTTER COMMUTING**

Map to be read in conjunction with the NPWS Conservation Objectives Document.

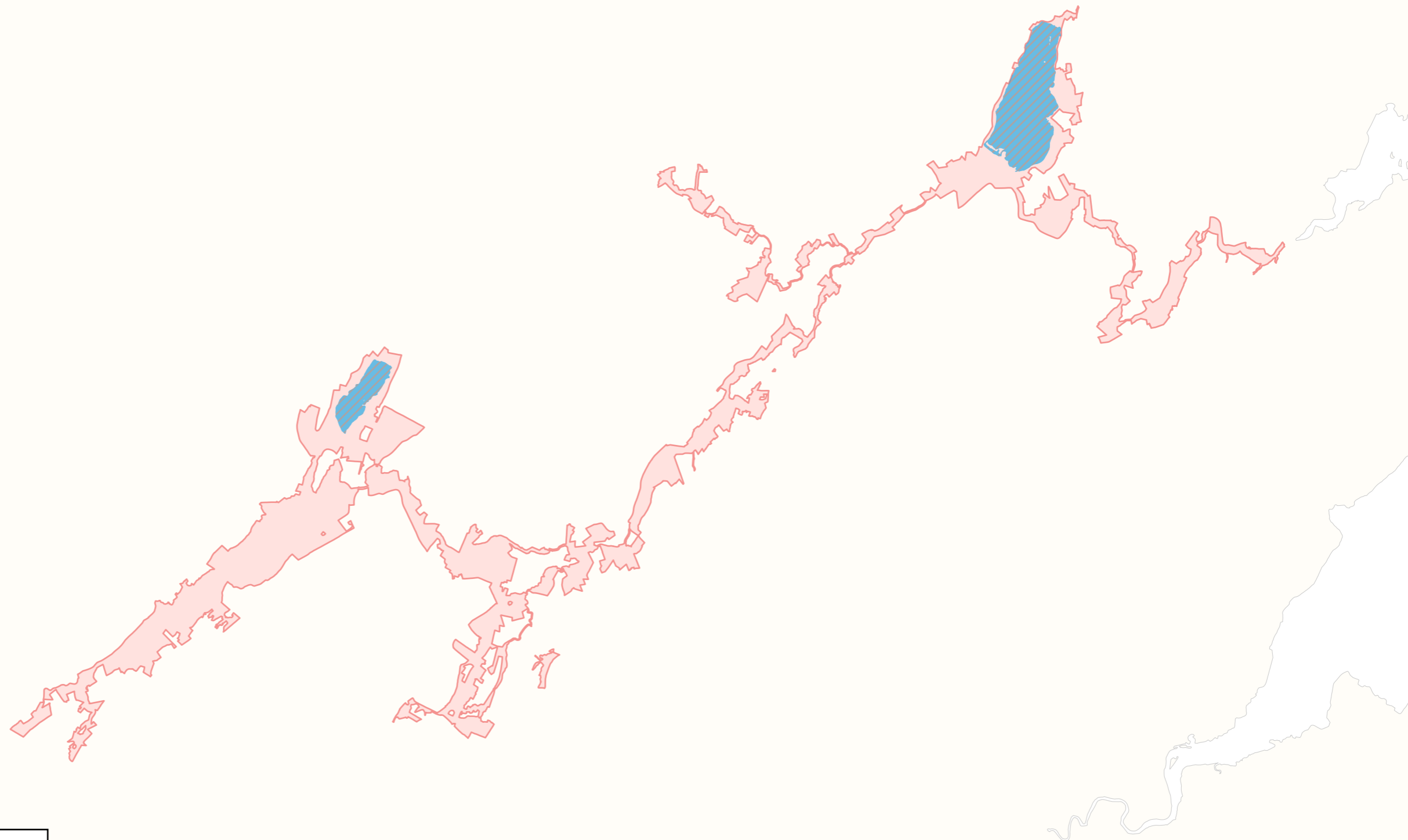
**SITE CODE:
SAC 002176; version 3.01. CO. DONEGAL**

0 0.65 1.3 1.95 2.6 3.25 km

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**Map Version 1
Date: May 2019**



Legend

- 1833 Slender Naiad *Najas flexilis*
- Leannan River SAC 002176
- OSi Discovery Series County Boundary

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**MAP 6:
LEANNAN RIVER SAC
CONSERVATION OBJECTIVES
SLENDER NAIAD**

Map to be read in conjunction with the NPWS Conservation Objectives Document.

**SITE CODE:
SAC 002176; version 3.01. CO. DONEGAL**

0 0.8 1.6 2.4 3.2 4 km

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**Map Version 1
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