ISSN 2009-4086

National Parks and Wildlife Service

Conservation Objectives Series

Lough Owel SAC 000688

An Roinn
Cultúir, Oidhreachta agus Gaeltachta

Department of
Culture, Heritage and the Gaeltacht

National Parks and Wildlife Service,
Department of Culture, Heritage and the Gaeltacht,

7 Ely Place, Dublin 2, Ireland.

Web: www.npws.ie
E-mail: nature.conservation@ahg.gov.ie

Citation:

NPWS (2018) Conservation Objectives: Lough Owel SAC 000688. Version 1. National Parks and Wildlife Service, Department of Culture, Heritage and the Gaeltacht.

Series Editor: Rebecca Jeffrey
ISSN 2009-4086

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***

000688	Lough Owel SAC
1092	White-clawed Crayfish *Austropotamobius pallipes*
3140	Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp.
7140	Transition mires and quaking bogs
7230	Alkaline fens

Please note that this SAC overlaps with Lough Owel SPA (004047). See map 2. The conservation objectives for this site should be used in conjunction with those for the overlapping site as appropriate.

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

NPWS Documents

Year :	1984
Title :	The vegetation of Irish lakes
Author :	Heuff, H.
Series :	Unpublished report to NPWS
Year :	1998
Title :	Conservation management of the white-clawed crayfish, *Austropotamobius pallipes*
Author :	Reynolds, J.D.
Series :	Irish Wildlife Manual No. 1
Year :	2009
Title :	Monitoring of white-clawed crayfish *Austropotamobius pallipes* in Irish lakes in 2007
Author :	O'Connor, W.; Hayes, G.; O'Keeffe, C.; Lynn, D.
Series :	Irish Wildlife Manual No. 37
Year :	2010
Title :	A technical manual for monitoring white-clawed crayfish (*Austropotamobius pallipes*) in Irish lakes
Author :	Reynolds, J.; O'Connor, W.; O'Keeffe, C.; Lynn, D.
Series :	Irish Wildlife Manual No.45
Year :	2012
Title :	Ireland Red List No. 8: Bryophytes
Author :	Lockhart, N.; Hodgetts, N.; Holyoak, D.
Series :	Ireland Red List series, NPWS
Year :	2013
Title :	A survey of the benthic macrophytes of three hard-water lakes: Lough Bunny, Lough Carra and Lough Owel
Author :	Roden, C.; Murphy, P.
Series :	Irish Wildlife Manual No. 70
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 :	Conservation status assessments for three fen habitat types - 7230, 7210 and 7140
Author :	Kimberley, S.
Series :	Unpublished report to NPWS
Year :	2014
Title :	Guidelines for a national survey and conservation assessment of upland vegetation and habitats in Ireland, Version 2.0
Author :	Perrin, P.M.; Barron, S.J.; Roche, J.R.; O'Hanrahan, B.
Series :	Irish Wildlife Manual No. 79
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 :	2016
Title :	Ireland Red List No. 10: Vascular Plants
Author :	Wyse Jackson, M.; FitzPatrick, Ú.; Cole, E.; Jebb, M.; McFerran, D.; Sheehy Skeffington, M.; Wright, M.
Series :	Ireland Red Lists series, NPWS

Other References

Year :	1893
Title :	Notes on Irish Characeae
Author :	Groves, H.; Groves, J.
Series :	The Irish Naturalist, 2(6): 163-164
Year :	1895
Title :	The distribution of the Characeae in Ireland
Author :	Groves, H.; Groves, J.
Series :	The Irish Naturalist, 4: 7-11, 37-41
Year :	1982
Title :	Eutrophication of waters. Monitoring assessment and control
Author :	OECD
Series :	OECD, Paris
Year :	1982
Title :	The changing status of Characeae in four marl lakes in the Irish Midlands
Author :	John, D.M.; Champ, W.S.T.; Moore, J.A.
Series :	Journal of Life Sciences of the Royal Dublin Society, 4(1): 47-71
Year :	1988
Title :	Crayfish extinctions and crayfish plague in central Ireland
Author :	Reynolds, J.D.
Series :	Biological Conservation, 45(4): 279-285
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 :	2004
Title :	Common Standards Monitoring guidance for lowland wetland habitats
Author :	JNCC
Series :	Joint Nature Conservation Committee, Peterborough
Year :	2005
Title :	The distribution of the white-clawed crayfish *Austropotamobius pallipes* in Ireland
Author :	Demers, A.; Lucey, J.; McGarrigle, M.L.; Reynolds, J.D.
Series :	Biology and Environment: Proceedings of the Royal Irish Academy, 105B: 62-69
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 :	EPA, Wexford

Year :	2008
Title :	Water Quality in Ireland 2004-2006
Author :	Clabby, K.J.; Bradley, C.; Craig, M.; Daly, D.; Lucey, J.; McGarrigle, M.; O'Boyle, S.; Tierney, D.; Bowman, J.
Series :	EPA, Wexford
Year :	2009
Title :	Hydrogeological investigation into elevated ammonia concentrations in Lough Owel, Co. Westmeath, Republic of Ireland
Author :	Groves, P.A.
Series :	Unpublished M.Sc. Thesis, Cardiff University
Year :	2009
Title :	The marl lakes of the British Isles
Author :	Pentecost, A.
Series :	Freshwater Reviews, 2(1): 167-197
Year :	2010
Title :	Water Quality in Ireland 2007-2009
Author :	McGarrigle, M.; Lucey, J.; Ó Cinnéide, M.
Series :	EPA, Wexford
Year :	2010
Title :	Karstification and groundwater - Surface water interactions in the Meath-Westmeath Lakeland region
Author :	Quinlan, C.
Series :	Unpublished Ph.D. Thesis, Trinity College Dublin
Year :	2011
Title :	Review and revision of empirical critical loads and dose-response relationships. Proceedings of an expert workshop, Noordwijkerhout, 23-25 June 2010
Author :	Bobbink, R.; Hettelingh, J.P.
Series :	RIVM report 680359002, Coordination Centre for Effects, National Institute for Public Health and the Environment (RIVM)
Year :	2011
Title :	A hydrogeological study of elevated ammonia levels in Lough Owel
Author :	Groves, P.A.
Series :	Irish Groundwater Newsletter, 49: 22-24
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 :	EPA, Wexford
Year :	2016
Title :	Localising and assessing groundwater discharge to lakes using natural environmental tracers
Author :	Wilson, J.; Rocha, C.
Series :	Irish Groundwater Newsletter, 53: 15-18
Year :	in prep.
Title :	Monitoring of hard-water lakes in Ireland using charophytes and other macrophytes
Author :	Roden, C.; Murphy, P.
Series :	Unpublished report to NPWS

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 habitat and to resolve any issues arising
Used For :	3140 (map 3)
Year :	2013
Title :	Roden and Murphy. A survey of the benthic macrophytes of three hard-water lakes: Lough Bunny, Lough Carra and Lough Owel
GIS Operations :	Shapefile clipped to SAC boundary. Vegetation unit names classified. Expert opinion used as necessary to resolve any issues arising
Used For :	Lake vegetation units (map 4)
Year :	2017
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 :	1092 (map 5)

3140 Hard oligo-mesotrophic waters with benthic vegetation of Chara spp.

To maintain the favourable conservation condition of Hard oligo-mesotrophic waters with benthic vegetation of *Chara* spp. in Lough Owel 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	Lough Owel is one of the most important and best studied hard water lakes (3140) in Ireland (Groves and Groves, 1893, 1895; John et al., 1982; Heuff, 1984; Pentecost, 2009; Roden and Murphy, 2013). It was in favourable conservation condition in 2011 (Roden and Murphy, 2013). 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. The vegetation of Lough Owel was mapped by John et al. (1982) and Roden and Murphy (2013). 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 3140 occurs in Lough Owel in the SAC. See map 3
Typical species	Occurrence	Typical species present, in good condition, and demonstrating typical abundances and distribution	For lists of 3140 typical species (cyanobacteria, algae, higher plants and water beetles), see the Article 17 habitat assessment for lake habitat 3140 (NPWS, 2013) and the lake habitats supporting document (O Connor, 2015). John et al. (1982) provide a comprehensive species list for Lough Owel. Roden and Murphy (2013) detail the typical species of Lough Owel, which include 11 charophyte species and the species of the krustenstein. Angiosperms are scarce in Lough Owel, but include Canadian waterweed (*Elodea canadensis*), shoreweed (*Littorella uniflora*), alternate water-milfoil (*Myriophyllum alterniflorum*) and the pondweeds *Potamogeton friesii* and *P. praelongus* (Roden and Murphy, 2013)
Vegetation composition: characteristic zonation	Occurrence	All characteristic zones should be present, correctly distributed and in good condition	The characteristic zonation of lake habitat 3140, generally, and Lough Owel, specifically, is described in Roden and Murphy (2013). The major vegetation units recorded at Lough Owel were krustenstein, *Chara curta* stands, *C. rudis* stands, *C. globularis* beds and *C. denudata* stands (Roden and Murphy, 2013). See map 4. John et al. (1982) also mapped the vegetation of Lough Owel and provided detailed zonation diagrams. The horizontal distribution of macrophyte communities was very similar in the two surveys (Roden and Murphy, 2013)
Vegetation distribution: maximum depth	Metres	Maintain maximum depth of vegetation, subject to natural processes	Maximum vegetation depth is expected to be deep in clear, hard water lakes, and extremely clear marl lakes can have charophyte vegetation to more than 9m (e.g. Lough Rea has charophytes to 10-11m, Coolorta >9m) (Roden and Murphy, in prep.). In this SAC, the maximum depth of vegetation at Lough Owel was 7.0m in 1972, 7.3m in 1975 and 5.5m in 1980-81 (John et al., 1982), 7m in 1977 (Heuff, 1984) and 7.7m in 2011 (Roden and Murphy, 2013). The target for Lough Owel is at least 7m and, ideally, more than 8m (Roden and Murphy, 2013)

Hydrological regime: water level fluctuations	Metres	Maintain/restore appropriate hydrological regime necessary to support the habitat	The hydrological regime of lakes with habitat 3140 is driven by groundwater. Increased water level fluctuations can increase wave action and turbidity, up-root vegetation, alter the substratum and lead to nutrient release from sediment. The hydrological regime must be maintained/restored to maintain the habitat's conservation condition, including area, distribution and depth of the lake habitat and its constituent/characteristic vegetation zones and communities. Owel is groundwater fed, has no surface water inlet and no functioning outflow. Wilson and Rocha (2016) and Groves (2009) report on groundwater discharges to Owel, notably on the eastern shore. Roden and Murphy (2013) found possible springs along the southern shore. John et al. (1982) state arterial drainage 1951-69 reduced the lake size. Fluctuations in lake water level are amplified at Owel by abstractions to provide 66% of Westmeath's drinking water and feed the Royal Canal (Quinlan, 2010). Water levels were very low in 2017
Lake substratum quality	Various	Maintain appropriate substratum type, extent and chemistry to support the vegetation	The hard water lake habitat (3140) is associated with a range of base-rich substratum types, from marl and limestone bedrock, through rocks, cobbles, gravel, muds and even peat. Further research into substratum quality (notably calcium, iron and nutrient concentrations) in the hard water lake habitat would be beneficial. A range of substratum types has been recorded at Lough Owel: boulders, cobble, sand, silt, mud, marl and peat; however, sandy marl is dominant (Roden and Murphy, 2013)
Water quality: transparency	Metres	Maintain/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. A target of >6m has been set for hard water lakes (3140) (Roden and Murphy, in prep.). The OECD fixed boundary system set transparency targets for oligotrophic lakes of ≥6m annual mean Secchi disk depth and ≥3m annual minimum Secchi disk depth. Hard water lakes typically have high transparency, particularly in the very clear and typical marl forms (Roden and Murphy, in prep.). Secchi depth at Lough Owel was 4-5.5m in 2011 (Roden and Murphy, 2013), a decrease from the 1973-1978 values of 7.0-8.9m (John et al., 1982). See John et al. (1982) for further information
Water quality: nutrients	µg/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	Lake habitat 3140 is typically associated with high water quality, as demonstrated by naturally low dissolved nutrients. The target for Lough Owel is Water Framework Directive (WFD) High Status or oligotrophic (OECD, 1982). Annual average total phosphorus (TP) concentration should be ≤10µg/l TP, average annual total ammonia concentration should be ≤0.04mg/l N and annual 95th percentile for total ammonia should be ≤0.09mg/l N. Where nutrient concentrations are lower than the targets, there should be no upward trend in concentrations. See also The European Communities Environmental Objectives (Surface Waters) Regulations 2009. Lough Owel failed the target, having good nutrient status in 2007-09 and 2010-12, and TP exceeded the 10µg/l target in 2004-06 and 2007-09 (Clabby et al., 2008; McGarrigle et al., 2010; Bradley et al., 2015). High ammonia has been reported for Lough Owel (Groves, 2009, 2011)

Water quality: phytoplankton biomass	µg/l Chlorophyll *a*	Maintain/restore appropriate water quality to support the habitat, including high chlorophyll *a* status	Lake habitat 3140 is associated with high water quality, as demonstrated by naturally low algal growth. As for nutrients, the default target is WFD High Status or oligotrophic (OECD, 1982). Average growing season (March-October) chlorophyll *a* concentration must be <5.8µg/l. Annual average chlorophyll *a* concentration should be <2.5µg/l and the annual peak should be <8.0µg/l. Where chlorophyll *a* concentrations are lower than the targets, there should be no upward trend in phytoplankton biomass. See also The European Communities Environmental Objectives (Surface Waters) Regulations 2009. Lough Owel failed the targets in 2004-06 and 2007-09, but had high status in 2010-12 (Clabby et al., 2008; McGarrigle et al., 2010; Bradley et al., 2015). Average maximum chlorophyll *a* in Lough Owel has exceeded the OECD target of ≤8.0µg/l in most years from 1973 to 2009 (John et al., 1982; McGarrigle et al., 2010)
Water quality: phytoplankton composition	EPA phytoplankton composition metric	Maintain/restore appropriate water quality to support the habitat, including high phytoplankton composition status	The Environmental Protection Agency (EPA) has developed a phytoplankton composition metric for nutrient enrichment of Irish lakes. As for other water quality indicators, the default target for lake habitat 3140 is WFD high status. Lough Owel had good phytoplankton composition status in 2010-12 (Bradley et al., 2015)
Water quality: attached algal biomass	Algal cover	Maintain 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 hard water lakes (3140) should, therefore, be trace/absent (<5% cover)
Water quality: macrophyte status	EPA macrophyte metric (The Free Index)	Maintain high macrophyte status	Nutrient enrichment can favour more competitive submerged macrophyte species that out-compete the typical and characteristic species for hard water lakes (3140). The EPA monitors macrophyte status for WFD purposes using the 'Free Index'. The target for lake habitat 3140 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 was high in Lough Owel in 2007-09 and 2010-12 (McGarrigle et al., 2010; Bradley et al., 2015)
Acidification status	pH units; mg/l	Maintain appropriate water and sediment pH, alkalinity and cation concentrations to support the habitat, subject to natural processes	The specific requirements of lake habitat 3140, in terms of water and sediment pH, alkalinity and cation concentration, have not been fully determined. Acidification is not considered a threat to lake habitat 3140; however, eutrophication can lead to at least temporary increases in pH to toxic levels (>9/9.5 pH units). 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
Water colour	mg/l PtCo	Maintain appropriate water colour to support the habitat	Increased colour decreases light penetration and reduces the area of macrophyte habitat, particularly at the lower euphotic depths. Higher colour also appears to favour angiosperms over charophytes in hard water lakes (Roden and Murphy, in prep.). The primary source of increased colour in Ireland is peatland disturbance. No habitat-specific or national standards for water colour 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). Lake habitat 3140 is typically associated with very clear waters and expected colour would be <10mg/l PtCo or, more likely, <5mg/l PtCo. Free et al. (2006) recorded colour of 1mg/l PtCo in Lough Owel

Dissolved organic carbon (DOC)	mg/l	Maintain 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 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. John et al. (1982) noted small increases in turbidity at Lough Owel
Fringing habitat: area and condition	Hectares	Maintain the area and condition of fringing habitats necessary to support the natural structure and functioning of habitat 3140	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. Equally, 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. Fringing fen habitats can be particularly important around hard water lakes, notably the Annex I habitats alkaline fen, *Cladium* fen and petrifying springs (habitat codes 7230, 7210 and 7220 respectively). Transition mire and quaking bogs (7140) grading into alkaline fen (7230) are found at the north-west and south-west of Lough Owel. See also the conservation objectives for habitats 7140 and 7230 in this volume

7140 Transition mires and quaking bogs

To maintain the favourable conservation condition of Transition mires and quaking bogs in Lough Owel 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	Transition mires and quaking bogs has not been mapped in detail for Lough Owel SAC and thus the total area of the qualifying habitat in the SAC is unknown. The habitat dominates two main areas of wetland vegetation in the SAC, at the north-west (Bunbrosna) and the south-west (Tullaghan) ends of Lough Owel. These areas comprise a mosaic of different vegetation types of varying degrees of wetness with the transition mire and quaking bog vegetation grading into alkaline fen (7230), wet grassland and wet woodland (NPWS internal files)
Habitat distribution	Occurrence	No decline, subject to natural processes	See the notes on Habitat area above
Ecosystem function: soil nutrients	Soil pH and appropriate nutrient levels at a representative number of monitoring stops	Maintain soil pH and nutrient status within natural ranges	Relevant nutrients and their natural ranges are yet to be defined. However, nitrogen deposition is noted as being relevant to this habitat in NPWS (2013). See also Bobbink and Hettelingh (2011)
Ecosystem function: peat formation	Percentage cover of peat-forming vegetation and water table levels	Maintain active peat formation, where appropriate	In order for peat to form, water levels need to be slightly below or above the soil surface for c.90% of the time
Ecosystem function: hydrology - water levels	Centimetres; duration of water levels	Maintain, or where necessary restore, appropriate water levels necessary to support the natural structure and functioning of the habitat	Maintenance of a permanently high water level, remaining close to the peat surface all year, with water level fluctuations within natural ranges, is required for this wetland habitat. See Kimberley (2013)
Ecosystem function: hydrology - flow patterns	Flow direction	Maintain, or where necessary restore, appropriate topography and water movement regime necessary to support the natural structure and functioning of the habitat	Maintenance, both within and surrounding the habitat, of topography and flow patterns within natural ranges is essential in order to ensure the hydrological integrity of this wetland habitat
Ecosystem function: water quality	Water chemistry measures	Maintain, or where necessary restore, appropriate water quality to support the natural structure and functioning of the habitat	The surface water conditions necessary to maintain transition mires range from acidic to slightly base-rich. The vegetation typically has intimate mixtures of species considered to be acidophile and others considered calciphile. In other cases, these intermediate properties may reflect the actual process of succession, as peat accumulates in groundwater-fed fen or open water to produce rainwater-fed bog isolated from groundwater influence
Community diversity	Abundance of variety of vegetation communities	Maintain variety of vegetation communities, subject to natural processes	The entire diversity of transition mire vegetation communities present in the SAC is currently unknown. Information on vegetation communities associated with this habitat in the uplands is presented in Perrin et al. (2014)
Vegetation composition: typical vascular plants and bryophytes	Percentage cover at a representative number of 2m x 2m monitoring stops	Maintain adequate cover of typical vascular plant and bryophyte species	For lists of typical plant species, see the Article 17 conservation status assessment for transition mires and quaking bogs (NPWS, 2013) and the fen habitats supporting document (Kimberley, 2013). See also Perrin et al. (2014) and JNCC (2004). In this SAC, typical species recorded in the habitat include bottle sedge (*Carex rostrata*), lesser tussock-sedge (*C. diandra*), common cottongrass (*Eriophorum angustifolium*), purple moor-grass (*Molinia caerulea*) and the brown mosses *Calliergonella cuspidata* and *Scorpidium revolvens* (NPWS internal files)

Vegetation composition: native negative indicator species	Percentage cover at a representative number of 2m x 2m monitoring stops	Native negative indicator species at insignificant levels	Negative indicators include species not characteristic of the habitat and species indicative of undesirable impacts such as overgrazing, undergrazing, nutrient enrichment, agricultural improvement or impacts on hydrology. Native negative indicator species that could suggest drying out include ling (*Calluna vulgaris*) and birch (*Betula pubescens*)
Vegetation composition: non-native species	Percentage cover at, and in local vicinity of, a representative number of 2m x 2m monitoring stops	Cover of non-native species less than 1%	Attribute and target based on Perrin et al. (2014). Non-native species can be invasive and have deleterious effects on native vegetation. A low target is set as non-native species can spread rapidly and are most easily dealt with when still at lower abundances
Physical structure: drainage	Percentage area in local vicinity of a representative number of monitoring stops	Area showing signs of drainage from heavy trampling, tracking or ditches less than 10%	Attribute and target based on Perrin et al. (2014). Drainage can result in loss of characteristic species and transition to drier habitats
Physical structure: disturbed bare ground	Percentage cover at, and in local vicinity of, a representative number of 2m x 2m monitoring stops	Cover of disturbed bare ground not more than 10%	Attribute and target based on Perrin et al. (2014). Disturbance can include hoof marks, wallows, human footprints, vehicle and machinery tracks. Excessive disturbance can result in loss of characteristic species and presage erosion for peatlands
Indicators of local distinctiveness	Occurrence and population size	No decline in distribution or population sizes of rare, threatened or scarce species associated with the habitat; maintain features of local distinctiveness, subject to natural processes	This includes species listed in the Flora (Protection) Order, 2015 and/or the red data lists (Lockhart et al., 2012; Wyse Jackson et al., 2016). The Near Threatened fibrous-tussock sedge (*Carex appropinquata*) (Wyse Jackson et al., 2016) occurs in association with the habitat in the SAC (NPWS internal files). The Near Threatened round-leaved wintergreen (*Pyrola rotundifolia*) (Wyse Jackson et al., 2016) occurs in the SAC (NPWS internal files), but cannot be specifically assigned to this habitat

7230 Alkaline fens

To maintain the favourable conservation condition of Alkaline fens in Lough Owel SAC, which is defined by the following list of attributes and targets:

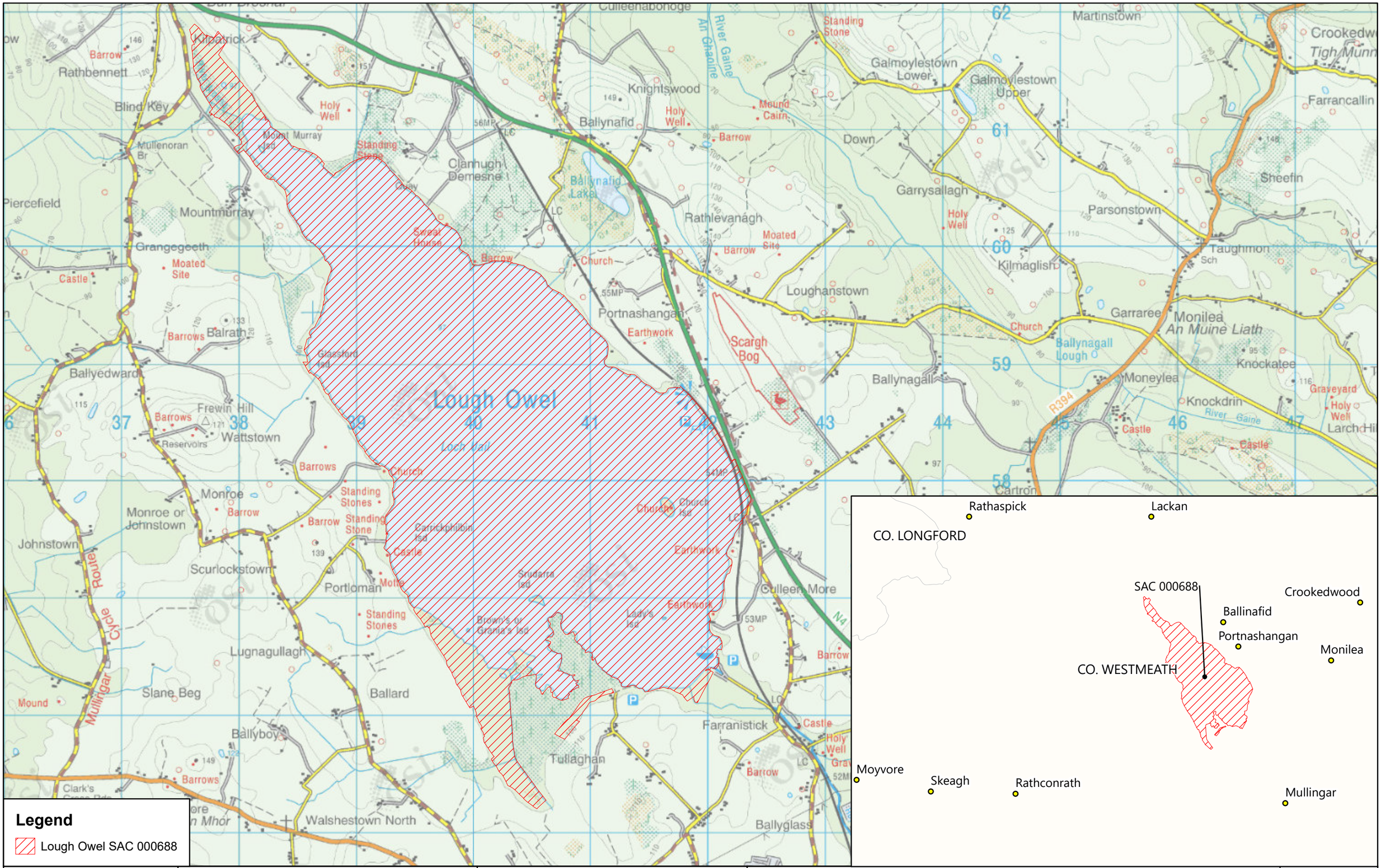
Attribute	Measure	Target	Notes
Habitat area	Hectares	Area stable or increasing, subject to natural processes	Alkaline fen has not been mapped in detail for Lough Owel SAC and thus the total area of the qualifying habitat in the SAC is unknown. However, it is known that the areas of alkaline fens (7240) in the SAC are small and occur in close association with transition mire and quaking bogs (7140) in two main areas at the north-west (Bunbrosna) and the south-west (Tullaghan) ends of Lough Owel. Though small in area, the habitat in the SAC is considered a representative example of fen associated with an alkaline lake and possibly springs (NPWS internal files)
Habitat distribution	Occurrence	No decline, subject to natural processes	See the notes for Habitat area above
Ecosystem function: soil nutrients	Soil pH and appropriate nutrient levels at a representative number of monitoring stops	Maintain soil pH and nutrient status within natural ranges	Relevant nutrients and their natural ranges are yet to be defined. However, nitrogen deposition is noted as being relevant to this habitat in NPWS (2013). See also Bobbink and Hettelingh (2011)
Ecosystem function: peat formation	Percentage cover of peat-forming vegetation and water table levels	Maintain active peat formation, where appropriate	In order for peat to form, water levels need to be slightly below or above the soil surface for c.90% of the time
Ecosystem function: hydrology - groundwater levels	Water levels (centimetres); duration of levels; hydraulic gradients	Maintain, or where necessary restore, appropriate natural hydrological regimes necessary to support the natural structure and functioning of the habitat	Fen habitats require high groundwater levels (i.e. water levels at or above the ground surface) for a large proportion of the calendar year (i.e. duration of mean groundwater level). Fen groundwater levels are controlled by regional groundwater levels in the contributing catchment area (which sustain the hydraulic gradients of the fen groundwater table). Regional abstraction of groundwater may affect fen groundwater levels
Ecosystem function: hydrology - surface water flow	Drain density and form	Maintain, or where necessary restore, as close as possible to natural or semi-natural drainage conditions	Drainage, either within or surrounding the fen habitat, can result in the drawdown of the alkaline fen groundwater table. The depth, geometry and density of drainage (hydromorphology) will indicate the scale and impact on fen hydrology. Drainage can result in loss of characteristic species and transition to drier habitats
Ecosystem function: water quality	Water chemistry measures	Maintain, or where necessary restore, appropriate water quality, particularly pH and nutrient levels, to support the natural structure and functioning of the habitat	Fens receive natural levels of nutrients (e.g. iron, magnesium and calcium) from water sources. However, they are generally poor in nitrogen and phosphorus, with the latter tending to be the limiting nutrient under natural conditions. Water supply should also be relatively calcium-rich
Community diversity	Abundance of variety of vegetation communities	Maintain variety of vegetation communities, subject to natural processes	The entire diversity of alkaline fen vegetation communities present in the SAC is currently unknown. Information on the vegetation communities associated with alkaline fens in the uplands is presented in Perrin et al. (2014)
Vegetation composition: brown mosses	Percentage cover at a representative number of 2m x 2m monitoring stops	Maintain adequate cover of typical brown moss species	Typical brown moss species include *Bryum pseudotriquetrum, Calliergonella cuspidata, Calliergon giganteum, Campylium stellatum, Cratoneuron filicinum, Ctenidium molluscum, Fissidens adianthoides, Palustriella commutata, Scorpidium cossonii, S. revolvens* and *S. scorpioides*. A variety of brown mosses occur in the habitat in the SAC (NPWS internal files)

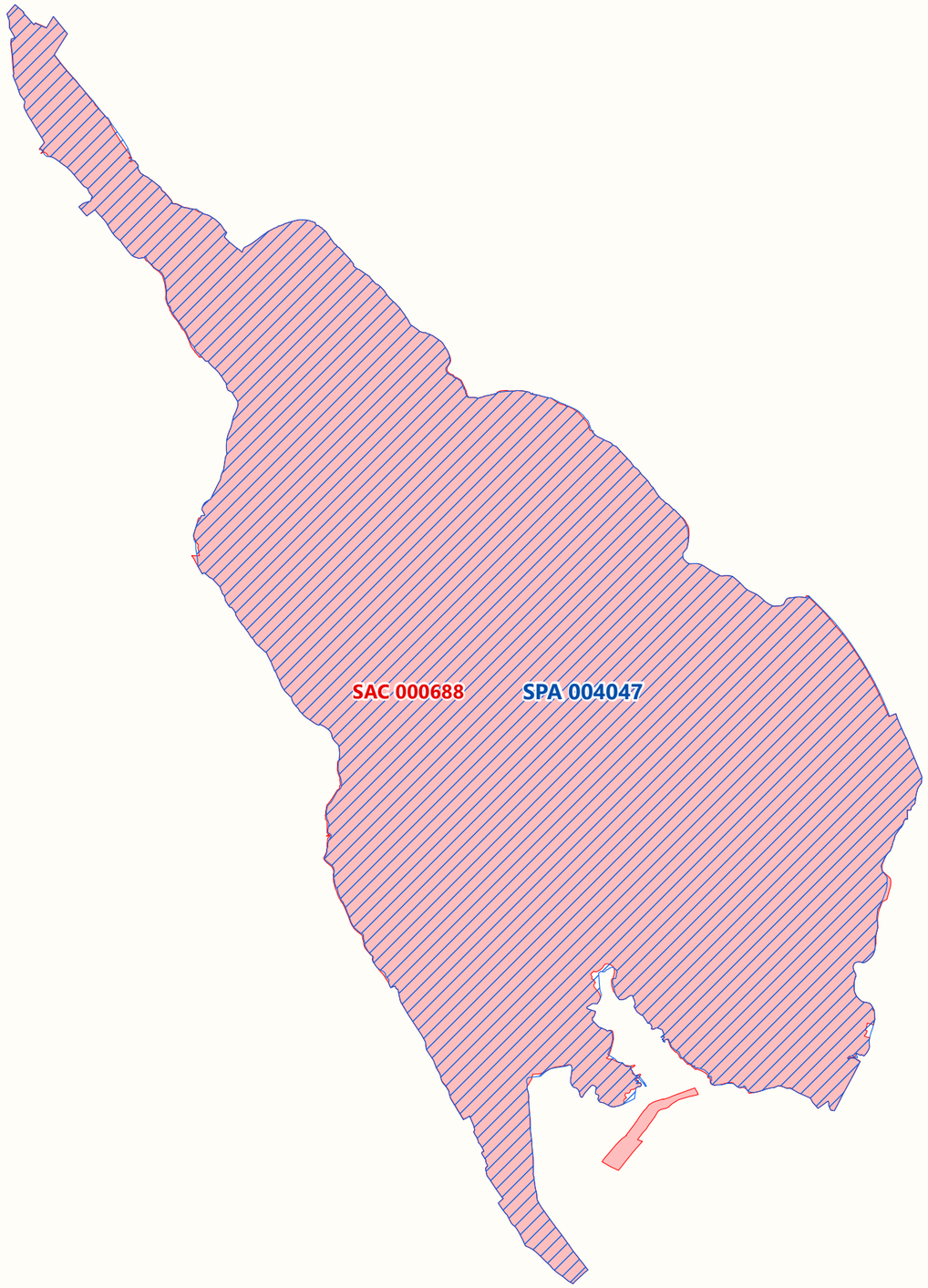
Vegetation composition: typical vascular plants	Percentage cover at a representative number of 2m x 2m monitoring stops	Maintain adequate cover of typical vascular plant species	For lists of typical plant species, see the Article 17 conservation status assessment for alkaline fens (NPWS, 2013) and the fen habitats supporting document (Kimberley, 2013). See also Perrin et al. (2014) and JNCC (2004). In this SAC, species recorded in the habitat include black bog-rush (*Schoenus nigricans*), long-stalked yellow sedge (*Carex lepidocarpa*), fen bedstraw (*Galium uliginosum*) and marsh fern (*Thelypteris palustris*) (NPWS internal files)
Vegetation composition: native negative indicator species	Percentage cover at a representative number of 2m x 2m monitoring stops	Cover of native negative indicator species at insignificant levels	Negative indicators include species not characteristic of the habitat and species indicative of undesirable impacts such as overgrazing, undergrazing, nutrient enrichment, agricultural improvement or impacts on hydrology. Native negative indicators may include graminoids such as reed canary-grass (*Phalaris arundinacea*) and reed sweet-grass (*Glyceria maxima*), tall herbs such as great willowherb (*Epilobium hirsutum*), bracken (*Pteridium aquilinum*), bramble (*Rubus fruticosus*) and common nettle (*Urtica dioica*), and bryophytes such as *Brachythecium rutabulum* and *Kindbergia praelonga*
Vegetation composition: non-native species	Percentage cover at, and in local vicinity of, a representative number of 2m x 2m monitoring stops	Cover of non-native species less than 1%	Attribute and target based on Perrin et al. (2014). Non-native species can be invasive and have deleterious effects on native vegetation. A low target is set as non-native species can spread rapidly and are most easily dealt with when still at lower abundances
Vegetation composition: native trees and shrubs	Percentage cover in local vicinity of a representative number of monitoring stops	Cover of scattered native trees and shrubs less than 10%	Attribute and target based on Perrin et al. (2014). Scrub and trees will tend to invade if fen conditions become drier
Vegetation composition: soft rush and common reed cover	Percentage cover in local vicinity of a representative number of monitoring stops	Total cover of soft rush (*Juncus effusus*) and common reed (*Phragmites australis*) less than 10%	Attribute and target based on Perrin et al. (2014)
Vegetation structure: litter	Percentage cover in local vicinity of a representative number of monitoring stops	Total cover of litter not more than 25%	Attribute and target based on JNCC (2004). More than 25% litter cover may indicate insufficient removal of biomass by grazing and/or undesirable water table levels
Physical structure: disturbed bare ground	Percentage cover at, and in local vicinity of, a representative number of 2m x 2m monitoring stops	Cover of disturbed bare ground not more than 10%	Attribute and target based on Perrin et al. (2014). While grazing may be appropriate in this habitat, excessive areas of disturbed bare ground may develop due to unsuitable grazing regimes. Disturbance can include hoof marks, wallows, human footprints, vehicle and machinery tracks. Excessive disturbance can result in loss of characteristic species and presage erosion for peatlands
Physical structure: tufa formations	Percentage cover in local vicinity of a representative number monitoring stops	Disturbed proportion of vegetation cover where tufa is present is less than 1%	Attribute and target based on Perrin et al. (2014)
Indicators of local distinctiveness	Occurrence and population size	No decline in distribution or population sizes of rare, threatened or scarce species associated with the habitat; maintain features of local distinctiveness, subject to natural processes	This includes species on the Flora (Protection) Order, 2015 and/or the red data lists (Lockhart et al., 2012; Wyse Jackson et al., 2016). The Near Threatened (Wyse Jackson et al., 2016) species fibrous tussock-sedge (*Carex appropinquata*) and marsh fern (*Thelypteris palustris*) occur in the habitat in the SAC (NPWS internal files). The Near Threatened round-leaved wintergreen (*Pyrola rotundifolia*) occurs in the SAC (NPWS internal files), but cannot be specifically assigned to this habitat

1092 White-clawed Crayfish *Austropotamobius pallipes*

To maintain the favourable conservation condition of White-clawed Crayfish in Lough Owel SAC, which is defined by the following list of attributes and targets:

Attribute	Measure	Target	Notes
Distribution	Number of occupied 1km squares	No reduction from baseline. See map 5	There are few geo-referenced records of white-clawed crayfish (*Austropotamobius pallipes*) from Lough Owel, but the species is mentioned in reports as being widespread in the lake. Video evidence and other anecdotal reports would support this assessment. However, the species has also been subject to unexplained mortalities in the lake (Demers et al., 2005). There are records from N3861, N3958, N4157 and N4156, but it is likely that the species is present in all the 1km squares that contain shoreline habitat. See also Reynolds (1988) and O'Connor et al. (2009)
Population structure: recruitment	Occurrence of juveniles and females with eggs	Juveniles and/or females with eggs should be present in all occupied 1km squares, subject to natural processes and availability of suitable habitat	See Reynolds et al. (2010) for further details
Negative indicator species	Occurrence	No non-indigenous crayfish species	Non-indigenous crayfish species (NICS) are identified as a major direct threat to the white-clawed crayfish (*Austropotamobius pallipes*) and as a disease vector, in particular crayfish plague (*Aphanomyces astaci*), which is fatal to white-clawed crayfish. Ireland is currently free of NICS. See Reynolds (1998) for further details
Disease	Occurrence	No instances of disease	There have been outbreaks of crayfish plague (*Aphanomyces astaci*) in Ireland since 2015 and it is thought that human activity, especially the transport of disease vectors on contaminated equipment, has introduced and spread the disease. Strict biosecurity is required
Water quality	Water chemistry measures	Maintain appropriate water quality, particularly pH and nutrient levels, to support the natural structure and functioning of lake habitat 3140	There should be no decline in water quality as defined by the targets set for lake habitat 3140 in Lough Owel SAC (see the conservation objective for 3140 in this volume). White-clawed crayfish (*Austropotamobius pallipes*) is tolerant of a wide range of water conditions except for the poorest quality and most acid waters. The water quality targets for lake habitat 3140 are more stringent than white-clawed crayfish require so no specific target is set for the species
Habitat quality: heterogeneity	Occurrence of positive habitat features	No decline in heterogeneity or habitat quality	White-clawed crayfish (*Austropotamobius pallipes*) need high habitat heterogeneity. Larger crayfish must have stones to hide under, or an earthen bank in which to burrow. Hatchlings shelter in vegetation, gravel and among fine tree-roots. Smaller crayfish are typically found among weed and debris in shallow water. Larger juveniles in particular may also be found among cobbles and detritus such as leaf litter. These conditions and habitat features must be available on the whole length of occupied habitat


Lough Owel
Lough Owel SAC 000688
Culleenabohoge
Kilpatrick
Rathbennett
Barrow
Blind Key
Holy Well
Mount Murray
Standing Stone
Mullenoran Br
Piercefield
Mountmurray
Grangegeeth
Moated Site
Castle
Barrows
Balrath
Ballyedward
Frewin Hill
Reservoirs
Wattstown
Monroe
Monroe or Johnstown
Johnstown
Standing Stones
Barrow
Standing Stone
Scurlockstown
Portloman
Motte
Lugnagullagh
Slane Beg
Mound
Ballard
Ballyboy
Clark's
Walshestown North
Clannagh Demesne
Knightswood
Ballynafid
Holy Well
Mound
Cairn
Barrow
Ballynafid Lake
Rathlevanagh
Moated Site
Barrow
Church
Sweat House
Barrow
Portnashangan
Earthwork
Scargh Bog
Loughanstown
Glassford Ind
Carrickphilbin Ind
Castle
Church
Church Ruins
Earthwork
Srudarra Ind
Brown's or Granla's Ind
Lady's Ind
Earthwork
Culleen More
Tullaghan
Farranistick
Castle
Holy Well
Barrow
Ballyglass
Standing Stone
Galmoylestown Lower
Galmoylestown Upper
Down
Garrysallagh
Holy Well
Parsonstown
Kilmaglish
Martinstown
Crookedwood
Tigh Munn
Farrancallin
Sheefin
Taughmon
Sch
Garraree
Monilea
An Muine Liath
Church
Ballynagall Lough
Ballynagall
Moneylea
Knockdrin
Knockatee
Graveyard
Holy Well
Castle
Castle
Cartron
R394
River Gaine
An Ghaoine
River Gaine
Route
Cycle
Mullingar
N4
Rathaspick
Lackan
CO. LONGFORD
SAC 000688
Crookedwood
Ballinafid
Portnashangan
Monilea
CO. WESTMEATH
Moyvore
Skeagh
Rathconrath
Mullingar
Legend
Lough Owel SAC 000688
An Roinn Cultúir, Oidhreachta agus Gaeltachta
Department of Culture, Heritage and the Gaeltacht
MAP 1:
LOUGH OWEL SAC
CONSERVATION OBJECTIVES
SAC DESIGNATION
Map to be read in conjunction with the NPWS Conservation Objectives Document.
SITE CODE:
SAC 000688; version 3.01. CO. WESTMEATH
0
0.5
1
1.5
2 km
The mapped boundaries are of an indicative and general nature only. Boundaries of designated areas are subject to revision.
Ordnance Survey of Ireland Licence No EN 0059216. © Ordnance Survey of Ireland Government of Ireland
Níl sna teorainneacha ar na léarscáileanna ach nod garshuiomhach ginearálta. Féadfar athbhreithnithe a déanamh ar theorainneacha na gceantar comharthaithe. Suirbhéarachta Ordonáis na hÉireann Ceadúnas Uimh EN 0059216. © Suirbhéarachta Ordonáis na hÉireann Rialtas na hÉireann
N
Map Version 1
Date: April 2018



Legend

- Lough Owel SAC 000688
- Lough Owel SPA 004047
- OSi Discovery Series County Boundary

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

MAP 2:
LOUGH OWEL SAC
CONSERVATION OBJECTIVES
OVERLAPPING DESIGNATION

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

SITE CODE:
SAC 000688; version 3.01. SPA 004047; version 3.
CO. WESTMEATH

0 0.5 1 1.5 2 km

N

Map Version 1
Date: April 2018

Legend

- Lough Owel SAC 000688
- OSi Discovery Series County Boundary
- 3140 Hard oligo-mesotrophic waters with benthic vegetation of Chara spp.

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

MAP 3:
LOUGH OWEL SAC
CONSERVATION OBJECTIVES
LAKE HABITAT

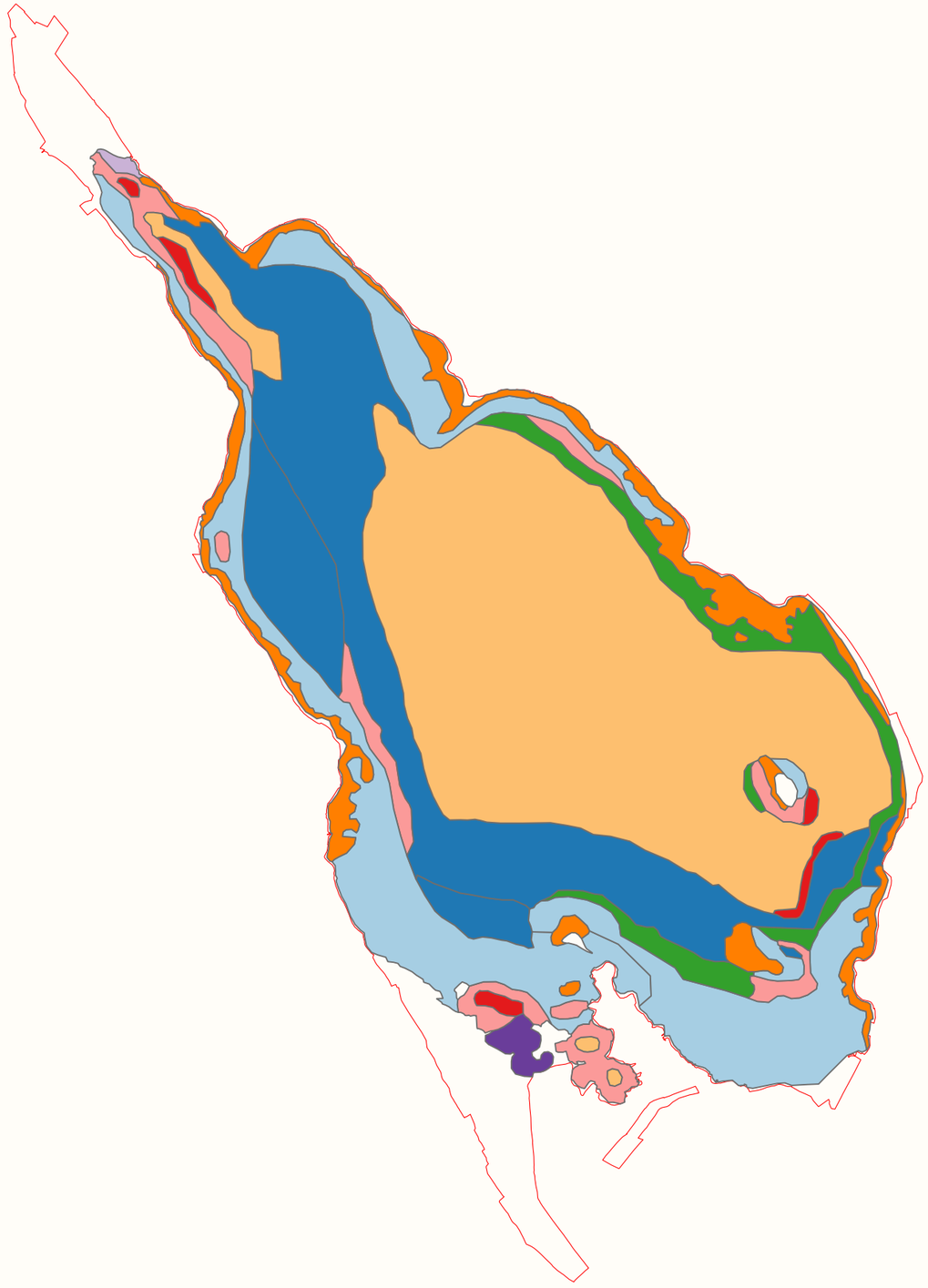
Map to be read in conjunction with the NPWS Conservation Objectives Document.

SITE CODE:
SAC 000688; version 3.01. CO. WESTMEATH

0 0.5 1 1.5 2 km

N

Map Version 1
Date: April 2018



Legend

- Lough Owel SAC 000688
- OSi Discovery Series County Boundary

Vegetation Unit Name

- *Chara curta* Unit
- *Chara denudata* Unit
- *Chara globularis* Unit
- *Chara rudis* Unit
- Aquatic angiosperm Units
- Bare Substratum
- Krustenstein Unit
- Open
- Spring / Doline Unit

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

MAP 4:
LOUGH OWEL SAC
CONSERVATION OBJECTIVES
LAKE VEGETATION UNITS

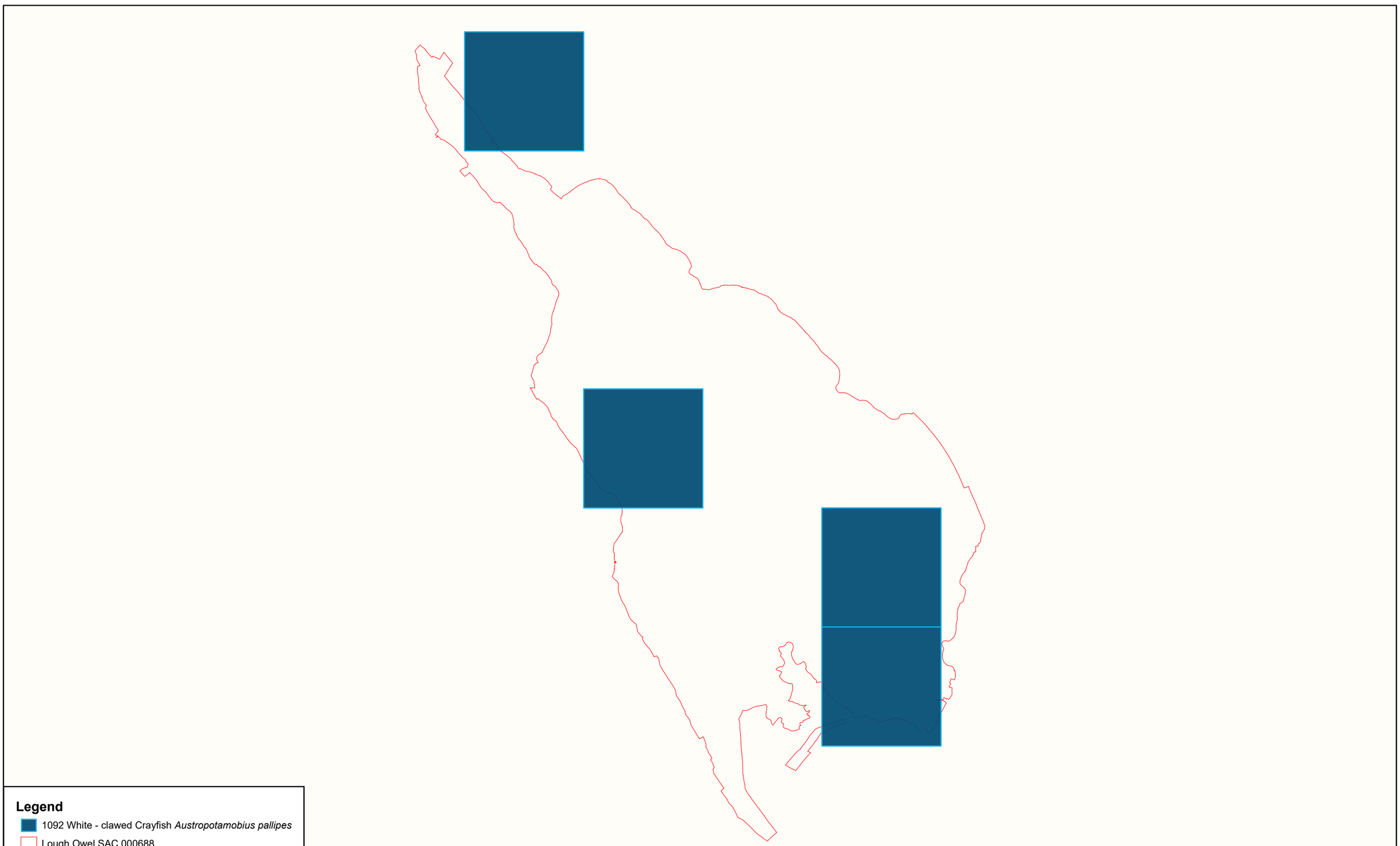
Map to be read in conjunction with the NPWS Conservation Objectives Document.

SITE CODE:
SAC 000688; version 3. CO. WESTMEATH

0 0.5 1 1.5 2 km

N

Map Version 1
Date: March 2018



Legend

- 1092 White - clawed Crayfish *Austropotamobius pallipes*
- Lough Owel SAC 000688
- OSi Discovery Series County Boundary

An Roinn
Cultúir, Oidhreachta agus Gaeltachta

Department of
Culture, Heritage and the Gaeltacht

MAP 5:
LOUGH OWEL SAC
CONSERVATION OBJECTIVES
WHITE CLAWED CRAYFISH

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

SITE CODE:
SAC 000688; version 3.01. CO. WESTMEATH

0 0.5 1 1.5 2 km

N

Map Version 1
Date: April 2018