LAKE KEEL/ LOUGH KEEL

Section 1

Regenera Water Sports Pilot Site Vulnerability Assessment

Pilot Site	Lake Keel/ Lough Keel, Achill Island, Co. Mayo
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Grant Agreement	101134336
Grant Acronym	Regenera
Full name	Sustainable and Regenerative Management of Physical Activity and Practice of Sport in Water Areas and Surrounds
Work Package	2
Deliverable	2

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This Vulnerability Assessment is a tool for informing adaptation, planning and enabling resource managers to evaluate the impacts of water sports on a water body. This assessment is designed to support sound decision-making by identifying which ecosystems or species are significantly affected by current and proposed activities. This assessment will help understand why an ecosystem or species may be vulnerable. Vulnerability has three principal components: sensitivity, exposure, and adaptive capacity.

Consider the following while conducting your assessment:

- Screening – do you feel that an ecological study may be necessary?
- Scoping - which impacts in the blue space need to be assessed?
- Baseline study – has a baseline study of the geographic, biological, socio-economic and cultural context already been conducted?
- Impact prediction - what are possible impacts, positive and negative of conducting this analysis, if any?
- Mitigation - how can these negative impacts be mitigated?

Objectives of Vulnerability Assessment:

3. To evaluate the potential vulnerabilities and impacts of water sports and other human activities on blue spaces within the Regenera Water Sport framework.
4. Evaluate exposure to known vulnerabilities and assign severity levels to those vulnerabilities. Recommend remediation or mitigation if and whenever needed.

Scope of Vulnerability Assessment:

To include activities such as boating (sailing, rowing etc), swimming, fishing, jet skis, hiking and walking trails within blue spaces and surrounds.

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Goal of vulnerability assessment:
Is to provide the necessary knowledge to partners and stakeholders within the Regenera project to take appropriate actions against threats to the casestudy blue space environments.

Biosecurity

Invasive, non-native flora and fauna can have damaging effects on ecosystems of blue spaces. Anyone using waterways can inadvertently spread species from one water body to another.

Please note following while conducting your assessment.

Check - all clothing and equipment thoroughly for any visible material (mud, leaves, animal matter). Closely inspect seams/seals on waders and boots.

Clean - hose down or pressure wash all equipment on site. If there are no facilities, carefully bag all equipment until such facilities are available. Washings must be left on site or disposed of carefully. Do not allow washings to enter other watercourses.

Dry - Hang boots, nets etc in an airy space as air drying is the best method of disinfection. Some non-natives can survive up to 2 weeks on damp surfaces and 2 days on dry surfaces. Ensure items have been drying for 48 hours before using them on the next water way.

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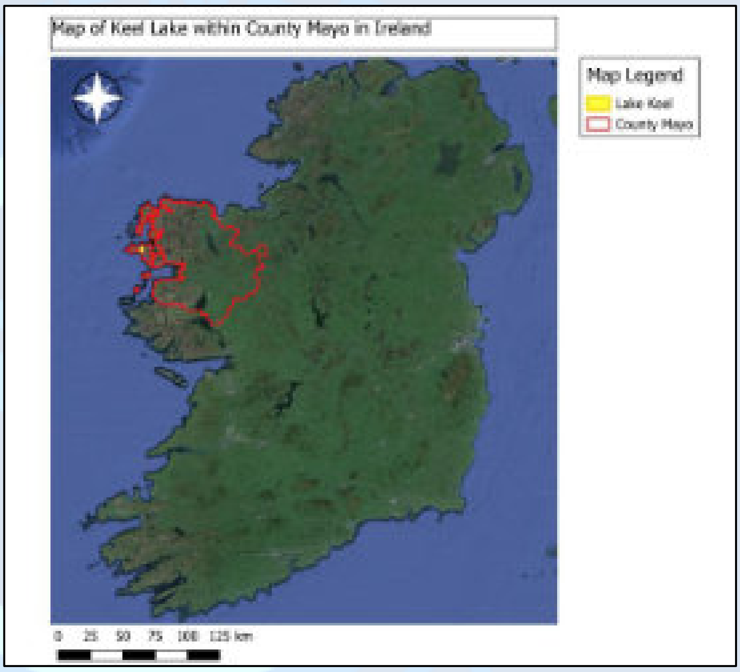
1.0 Site Description

1.1 Lake name

Lake Keel/Lough Keel

1.2 Location

Details	Map (Embed Image)
Grid Reference: F 64785 05582 **GPS Coordinates:** 53.981952, -10.062160 **Relevant Town(s):** Keel and Dooagh **County:** Mayo **District:** Westport-Belmullet Municipal District The regional road R319, is located south of Lake Keel and connects the Lake to nearby settlements. Keel town is the closest settlement to Lake Keel, and it is located approximately 0.9km west of Lake Keel. Dooagh town centre is the second closest town to Lake Keel, it is located west of the lake with a distance of 3.48km between the lake and Dooagh town centre.	

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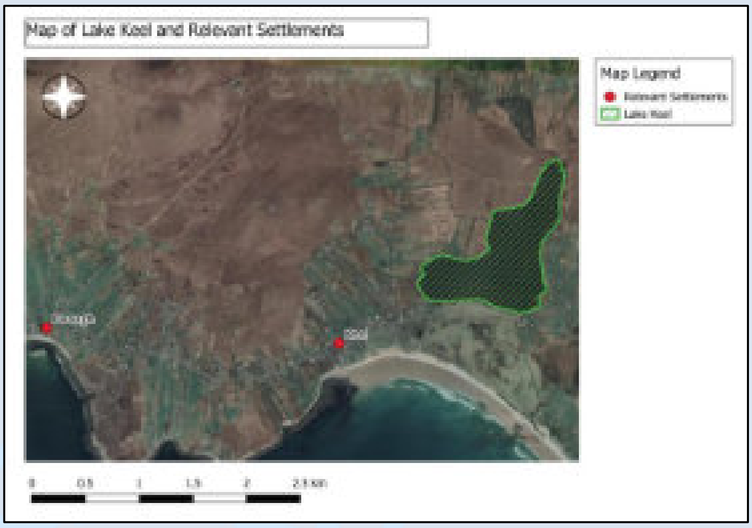

1.5 Size and Depth

1.3.1 Size

Give actual size in HA, measured from Ordnance Survey or official country-specific map or estimate size as below:

Large	Medium	Small
2 ha or greater	0.5-2 ha	Under 0.2 ha
More than 30m depth	max 30 m depth	Lessthan 6m depth

Size of Keel Lake: Large
Area of Keel Lake: 85.15ha

1.3.2 Depth

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The depth of the lake is estimated to be up to 1 meter within 20 meters from the shore. Beyond 20 meters from the shore, the depth increases to greater than 3 meters.

1.6 Surrounding environment - flora, fauna, and geographical feature

1. **Desk Survey**

Species Group	***Species Name (Common and Scientific)***	***Terrestrial/Aquatic***
Alga	Ankistrodesmus	Aquatic
Alga	Batrachospermum	Aquatic
Alga	Botryococcus	Aquatic
Alga	Cosmarium	Aquatic
Alga	Crucigenia	Aquatic
Alga	Cryptomonas	Aquatic
Alga	Dictyosphaerium	Aquatic
Alga	Dinobryon	Aquatic
Alga	Franceia ovalis	Aquatic
Alga	Gymnodinium	Aquatic
Alga	Kirchneriella	Aquatic
Alga	Monoraphidium	Aquatic
Alga	Nephrocytium	Aquatic
Alga	Pediastrum	Aquatic
Alga	Scenedesmus	Aquatic
Alga	Sohaerocystis	Aquatic

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Flowering Plant	Alternate Watermilfoil *(Myriophyllum alterniflorum*	Aquatic
Flowering Plant	Amphibious Bistort *(Persicaria amphibia*)	Aquatic
Flowering Plant	Branched Bur-reed *(Sparganium erectum)*	Aquatic
Flowering Plant	Broad-leaved Pondweed *(Potamogeton natans)*	Aquatic
Flowering Plant	Bulbous Rush *(Juncus bulbosus)*	Aquatic
Flowering Plant	Callitriche	Aquatic
Flowering Plant	Canadian Waterweed *(Elodea canadensis)*	Aquatic
Flowering Plant	Common Club-rush *(Schoenoplectus lacustris)*	Aquatic
Flowering Plant	Common Reed *(Phragmites australis)*	Aquatic
Flowering Plant	Common Spike-rush *(Eleocharis palustris)*	Aquatic
Flowering Plant	Curled Pondweed *(Potamogeton crispus)*	Aquatic
Flowering Plant	Lesser Pondweed *(Potamogeton pusillus)*	Aquatic
Flowering Plant	Lesser Spearwort *(Ranunculus flammula)*	Aquatic
Flowering Plant	Nuttall's Waterweed *(Elodea nuttallii)*	Aquatic
Flowering Plant	Perfoliate Pondweed *(Potamogeton perfoliatus)*	Aquatic
Flowering Plant	Pondweed *(Potamogeton)*	Aquatic
Flowering Plant	Shoreweed *(Littorella uniflora)*	Aquatic
Flowering Plant	Slender-leaved Pondweed *(Potamogeton filiformis)*	Aquatic
Flowering Plant	Small Pondweed *(Potamogeton berchtoldii)*	Aquatic

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Flowering Plant	Soft-rush *(Juncuseffusus)*	Terrestrial
Flowering Plant	Sparganium	Aquatic
Flowering Plant	Spiked Water-milfoil *(Myriophyllum spicatum)*	Aquatic
Flowering Plant	White Water-lily *(Nymphaea alba)*	Aquatic
Horsetail	Water Horsetail *(Equisetum fluviatile)*	Aquatic
Liverwort	Chiloscyphus polyanthos	Terrestrial
Liverwort	Liverworts *(Marchantiopsida)*	Terrestrial
Moss	Greater Water-moss *(Fontinalis antipyretica)*	Aquatic
Quillwort	Isoetes lacustris	Aquatic
Stonewort	Chara	Aquatic
Stonewort	Nitella	Aquatic

2. Field Survey

Species Group	Species Name	Aquatic/Terrestrial
Flowering Plant	Common Dandelion (*Taraxacum officinale*)	Terrestrial
Flowering Plant	Ribwort Plantain (*Plantago lanceolata*)	Terrestrial
Flowering Plant	Perennial Ryegrass (*Lolium perennial*)	Terrestrial
Flowering Plant	Common Field Daisy (*Lolium perenne*)	Terrestrial
Flowering Plant	White Clover (*Trifolium repens*)	Terrestrial
Flowering Plant	Marsh Pennywort (*Hydrocotyle vulgaris*)	Aquatic

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Flowering Plant	Broad-leaved Meadow-grass (*Poa chaixii*)	Terrestrial
Flowering Plant	Thyme Speedwell (*Veronica serpyllifolia*)	Terrestrial
Flowering Plant	Spear Thistle (*Cirsium vulgare*)	Terrestrial
Flowering Plant	Common Nettle (*Urtica dioica*)	Terrestrial
Flowering Plant	Wavy Bittercress (*Cardamine flexuosa*)	Terrestrial
Flowering Plant	Self-heal (*Prunella vulgaris*)	Terrestrial
Flowering Plant	Common Eyebright (*Euphrasia officinalis*)	Terrestrial
Flowering Plant	Water Mint (*Mentha aquatica*)	Terrestrial
Flowering Plant	Jointed Rush (*Juncusarticulates*)	Terrestrial
Flowering Plant	Common Sorrel (*Rumex acetosa*)	Terrestrial
Flowering Plant	Gorse (*Ulex*)	Terrestrial
Flowering Plant	Sheep's Fescue (*Festuca Ovina*)	Terrestrial
Flowering Plant	Yorkshire Fog (*Holcus lanatus)*	Terrestrial
Flowering Plant	Creeping Thyme (*Thymus serpyllum*)	Terrestrial
Flowering Plant	Silver Weed (*Potentilla anserina*)	Terrestrial
Flowering Plant	Field Madder (*Sherardia arvensis*)	Terrestrial
Flowering Plant	Fools Watercress (*Apium nodiflorum*)	Aquatic
Flowering Plant	Marsh Marigold (*Caltha palustris*)	Aquatic
Flowering Plant	Common Spikerush (*Eleocharis Palustris*)	Terrestrial
Flowering Plant	Soft Rush (*Juncus Effusus*)	Terrestrial
Flowering Plant	Yellow Iris (*Iris pseudacorus*)	Terrestrial
Flowering Plant	Birds Foot Trefoil (*Lotus corniculatus*)	Terrestrial

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Flowering Plant	Meadowsweet (*Filipendula ulmaria*)	Terrestrial
Flowering Plant	Purple Loosetrife (*Lythrum salicaria*)	Terrestrial
Flowering Plant	Bramble (*Bramble Fruticosis*)	Terrestrial
Flowering Plant	Montbretia (*Crocosmia*)	Terrestrial
Flowering Plant	Common Foxglove (*Digitalis purpurea*)	Terrestrial
Flowering Plant	Giant Rhubarb (*Gunnera tinctoria*)	Terrestrial
Flowering Plant	Meadow Buttercup (*Ranunculus acris*)	Terrestrial
Flowering Plant	Himalayan Balsam (*Impatiens glandulifera*)	Terrestrial
Flowering Plant	Bent grass (*Agrostis*)	Terrestrial
Flowering Plant	Sweet Vernal Grass (*Anthoxanthum odoratum*)	Terrestrial
Flowering Plant	Common Burdock (*Arctium minus*)	Terrestrial
Flowering Plant	Wild Chamomile (*Matricaria discoidea*)	Terrestrial
Flowering Plant	Amphibious Bistort (*Persicaria amphibia*)	Aquatic
Flowering Plant	Fuchsia (*Fuchsia magellanica*)	Terrestrial
Flowering Plant	Marsh Ragwort (*Jacobaea aquatica*)	Aquatic
Flowering Plant	Common Heather (*Calluna Vulgaris*)	Terrestrial
Flowering Plant	Bog Asphodel *(Narthecium ossifragum*)	Terrestrial
Flowering Plant	Purple Moorgrass *(Molinia caerulea)*	Terrestrial
Flowering Plant	Bog-Myrtle (*Myrica gale*)	Terrestrial
Flowering Plant	Chordgrass spp. (*Spartina spp.*)	Aquatic
Flowering Plant	Shoreweed *(Littorella uniflora)*	Aquatic

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Flowering Plant	Callitriche	Aquatic
Flowering Plant	Marsh-cinqefoil (*Comarum palustre*)	Aquatic
Flowering Plant	Cotton Deer-grass (*Trichophorum alpinum*)	Terrestrial
Flowering Plant	White-Beaked Sedge (*Rhynchospora alba*)	Terrestrial
Flowering Plant	Lesser Spearwort (*Ranunculus flammula*)	Aquatic
Flowering Plant	Devil’s Bit Scabious (*Succisa pratensis*)	Terrestrial
Flowering Plant	Marsh trefoil (*Menyanthes trifoliata*)	Aquatic
Moss	Sphagnum spp.	Terrestrial
Moss	Greater Water-moss *(Fontinalis antipyretica)*	Aquatic

3. Invasive Species

Species Group	**Species Name**	**Terrestrial/Aquatic**
Flowering Plant	Himalayan Balsam (Impatiens glandulifera)	Terrestrial
Flowering Plant	Giant Rhubarb (Gunera tinctoria)	Terrestrial
Flowering Plant	Nuttall's Waterweed *(Elodea nuttallii)*	Aquatic
Flowering Plant	Canadian Waterweed (Elodea canadensis)	Aquatic

Which describes the land best next to the water body table?

	Present	**Moderate**	**Abundant**
Bog/Moorland			✓
Forest	✓		
Grassland			✓
Crops-tillage/			

other			
Urban			
Other (describe)			

1. Desk Survey

Species Group	*Species Name*
Annelid	Californian Blackworm (*Lumbriculus variegatus*)
Bacterium	Anabaena
Bacterium	Aphanizomenon flos-aquae
Bird	Barnacle Goose (*Branta leucopsis*)
Bird	Common Goldeneye (*Bucephala clangula*)
Bird	Common Greenshank (*Tringa nebularia*)
Bird	Common Redshank (*Tringa totanus*)
Bird	Eurasian Curlew (*Numenius arquata*)
Bird	Eurasian Teal (*Anas crecca*)
Bird	Eurasian Wigeon (*Anas penelope*)
Bird	Great Black-backed Gull (*Larus marinus*)
Bird	Grey Heron (*Ardea cinerea*)
Bird	Herring Gull (*Larus argentatus*)
Bird	Mallard (*Anas platyrhynchos*)
Bird	Mew Gull (*Larus canus*)

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Bird	Mute Swan (*Cygnus olor*)
Bird	Tufted Duck (*Aythya fuligula*)
Bird	Whooper Swan (*Cygnus cygnus*)
Bony fish (Actinopterygii)	Brown/Sea Trout (*Salmo trutta*)
Bony fish (Actinopterygii)	European Eel (*Anguilla anguilla*)
Diatom	Asterionella formosa
Diatom	Stephanodiscus
Diatom	Synedra
Insect - true fly (Diptera)	Ablabesmyia monilis
Insect - true fly (Diptera)	Ablabesmyia phatta
Insect - true fly (Diptera)	Cladopelma viridulum
Insect - true fly (Diptera)	Cladotanytarsus atridorsum
Insect - true fly (Diptera)	Cladotanytarsus lepidocalcar
Insect - true fly (Diptera)	Cricotopus trifasciatus
Insect - true fly (Diptera)	Endochironomus albipennis
Insect - true fly (Diptera)	Endochironomus tendens
Insect - true fly (Diptera)	Heterotanytarsus apicalis
Insect - true fly (Diptera)	Macropelopia nebulosa
Insect - true fly (Diptera)	Orthocladius consobrinus
Insect - true fly (Diptera)	Parachironomus arcuatus
Insect - true fly (Diptera)	Parachironomus frequens
Insect - true fly (Diptera)	Parachironomus mauricii
Insect - true fly (Diptera)	Parachironomus Pe2
Insect - true fly (Diptera)	Paracladopelma laminatum

Insect - true fly (Diptera)	Parakiefferiella bathophila
Insect - true fly (Diptera)	Potthastia longimana
Insect - true fly (Diptera)	Procladius signatus
Insect - true fly (Diptera)	Prodiamesa olivacea
Insect - true fly (Diptera)	Psectrocladius sordidellus
Insect - true fly (Diptera)	Synorthocladius semivirens
Sponge (Porifera)	Porifera

2. Field Survey

Species Group	**Species Name**
Bird	European Robin (*Erithacus rubecula*)
Bird	Eurasian Wren (*Eurasian wren*)
Bird	Greater Black-backed Gull (*Larus marinus*)
Bird	Lesser Black-backed Gull (*Larus fuscus)*
Bird	Pied Wagtail (*Motacilla alba*)
Bird	European Starling (*Sturnus vulgaris)*
Bird	Mallard (*Anas platyrhynchos*)
Bird	Hooded Crow (*Corvus cornix*)
Bird	Magpie (*Pica pica*)
Bird	Grey Heron (*Ardea cinerea*)
Insects	Common Green Grasshopper (*Omocestus vesiculas)*
Insecta	Common Orb-weaver (*Araneus Quadratus*)
Insecta	Green Leafhopper (*Cicadella viridis*)

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Insecta	Red Ant (*Myrmica Rubra*)
Insecta	Emperor Dragonfly (*Anax imperator*)
Insecta	Cranefly spp. (*Tipuloidea*)
Insecta	Cabbage Butterfly (*Pieris rapae*)
Insecta	Red Admiral (*Vanessa Atalanta*)
Insecta	White-Tailed Bumblebee (*Bombus lucorum*)
Insecta	Water Boatmen (*Corixidae*)
Insecta	Green Leafhopper (*Cicadella viridis*)
Insecta	Common Spittlebug (*Philaenus spumarius*)
Insecta	*Hygrotus inaequalis*
Insecta	Mayfly Larva spp.
Insecta	Stonefly Larva spp.
Insecta	Beetle Larva spp.
Insecta	Freshwater Shrimp *(Gammarus Pulex)*
Gastropoda	Black Slug (*Arion ater*)
Mollusca	Jenkins'Spire Snail (*Potamopyrgus antipodarum*)
Mammalia	Irish Hare (*Lepus timidus hibernicus*)

3. Invasive Species

Species Group	Species Name	Terrestrial/Aquatic
Insecta	Freshwater Shrimp *(Gammarus Pulex)*	Aquatic
Mollusca	Jenkins' Spire Snail (*Potamopyrgus antipodarum*)	Aquatic

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Riparian Zone Survey	Vegetation identified from the field survey within the riparian zone of Lake Keel includes marsh pennywort, wavy bittercress, selfheal, common eyebright, water mint, jointed rush, soft rush, common burdock, yellow iris, bog myrtle, marsh cinquefoil. These species improve the soil stability of the shore and reduce erosion and absorb pollutants such as carbon dioxide as well as prevents the diffusion of pollutants into water. Speciesof a high abundance along the shore included fools' watercress, jointed rush, marsh pennywort and yellow iris. Specieswith a low abundance included common eyebright and marsh cinquefoil. The presence of vegetative species within the riparian zone slows down the process of erosion and protects the shoreline of Lake Keel. The eastern shoreline of the lake was inaccessible due to private ownership and waterways.
Aquatic plant survey	Submerged species recorded at the site during the field survey included marsh pennywort and greater water moss. Emerging plants identified at Lake Keel included marsh marigold, lesser spearwort, water mint, spiked rush, callitriche, and cordgrass spp. Floating plants recorded at the site included marsh trefoil and amphibious bistort. From the field survey conducted, marsh pennywort was one of the most abundant species found along the shoreline. Beyond 3 meters from the lake boundary was not surveyed due to depth and reduced visibility.

1.4.3. Is shoreline vegetation abundant yes / no (circle most applicable)

1.4.4. Are aquatic plant types abundant yes / no (circle most applicable)

1.4.5 Geographical features of note within a 20km vicinity of the water body

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Slievemore Peak is 671 meters high, consists of mountainous sloped land and is located 2.2km north of Lake Keel. There is a number of run-off streams from this peak that enter the Lake. Lake Keel is located within the Blacksod-Broadhaven catchment area. There are three rivers and two run-off streams that flow downstream into Lake Keel. Water exits Lake Keel via a single river that travels under the R319, which allows water to flow into the North Atlantic Ocean through Keel beach which is located approximately 1km south of the lake. Wild Nephin National Park is situated 15.9km east of Lake Keel and is connected to the lake via the N59 and R319 roads.

1.4.6 Water Quality

According to the EPA, water quality within Lake Keel is classified as moderate. Total phosphorous levels, chlorophyll levels, and nutrient condition status were considered good by the EPA in 2007 to 2009. The status of ammonia and oxygen levels were high, and the general physio-chemical status was considered good. A chemical analysis was produced in order to analyse the water from Lake Keel, results showed that the amount of ammonium, nitrates and nitrites were appropriate for human-use. No algal blooms were recorded at the site however there was an abundance of algae present within the lake, and the pH of the lake was recorded to be 7.5 which is standard for freshwater lakes.

Levels of E. coli were tested, and it was found that per 100ml, the most probable number of E.coli present was 45. Coliforms were also tested within Lake Keel and the most probable number per 100ml of water for coliforms was concluded to be greater than 201. High numbers of coliforms and e. Coli can be a risk to human and animal health as well as encourage eutrophication within the lake. It also suggests that there may be agricultural run-off or untreated wastewater entering the lake. While the water at the Lake Keel is considered to be of a moderate quality and no evidence of heavy pollution was found, the EPA has identified that Lake Keel is at risk according to the water framework directive. (EPA, 2013

1.4.7 Local Human Population

According to the Central Statistics Office (CSO), the total population of the closest settlements to Lake Keel, Dooagh town and Keel town was recorded to be 567. Achill Island is divided into electoral divisions and surrounding Lake Keel are the Slievemore Division and the Achill Division which have a combined population of 1,766.

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1.4.8. List Designated Sites

SAC Sites within 15km of Lake Keel:		
Site Code	**Site Name**	**Approx. Distance (km)**
000470	Mullet/Blacksod Bay Complex SAC	9.4km
002998	West Connacht Coast SAC	8.2km
000495	Duvillaun Islands SAC	11.1km
001497	Doogort Machair/Lough Doo SAC	4.5km
001955	Croaghaun/Slievemore SAC	0.7km
000485	Corraun Plateau SAC	11.9km
002268	Achill Head SAC	0.6km
001513	Keel Machair/Menaun Cliffs SAC	<0.1km

SPA Sites within 15km of Lake Keel:		
Site Code	**Site Name**	**Approx. Distance (km)**
004177	Bills Rocks SPA	13.9km
004227	Mullet Peninsula SPA	12.5km
004037	Blacksod Bay/Broad Haven SPA	9.7km
004111	Duvillaun Islands SPA	11.3km
004235	Doogort Machair SPA	5.0km

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NHA Sites within 15km of Lake Keel:		
Site Code	**Site Name**	**Approx. Distance (km)**
001567	Tullaghan Bay and Bog NHA	12.3km
002381	Doogort East Bog NHA	2.4km
002403	Sraheens Bog NHA	7.5km

2.0 Identify Vulnerabilities

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Different issues that may arise from the use of the lake for recreational activities and tourism include pollution, erosion, introduction of invasive species, habitat loss and fragmentation. Water sports such as kitesurfing, kayaking, and surfing can cause wave-action erosion to the shoreline, which would cause habitat loss and could physically disturb wildlife currently inhabiting the lake. Water activities can also cause noise pollution due to engines and increased human activity which would disturb nesting birds and decrease the habitat quality of both the lake and the surrounding habitats. If boats and jet skis are used on the lake, there would be a risk of fuel spillages and leaks which could harm species residing on the lake as well as cause mortality of both flora and fauna species. Continuous use of boats, jet skis and other water vehicles on the lake could increase emissions of harmful air pollutants such as carbon dioxide into the atmosphere.

Water activities and land activities such as hiking and walking could cause the spread of invasive species. Boats, kayaks and other equipment used in water could carry invasive species from one area to another. Tourists and locals partaking in activities around the lake could spread invasive species by transporting invasive species via clothing, cars and shoes. Human activity also causes the trampling of vegetative species which causes habitat fragmentation and erosion which may reduce species populations and imbalance sensitive ecosystems. The transportation of water vehicles and water vessels can also cause trampling, erosion and habitat quality decline. Fishing activity on Lough Keel could lead to overfishing of fish species residing within the lake and could decrease food availability for bird species.

2.1 Identify Vulnerabilities Table

Risk Score 1-5
5 being the highest risk and 1 being the lowest

Ecological impact	Species	Hazard	What will be harmed	Control measure	Risk score

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Species sensitivity-Flora	All listed aquatic vegetative species, Bog Asphodel, Devil's Bit Scabious.	Inputs of domestic waste, oil and fuel spillages, physical destruction via trampling.	Species diversity, ecosystem interactions, natural processes such as photosynthesis	No fuel or oils should be allowed within a buffer zone from the lake; public education via signage could be implemented.	2
Species sensitivity-Fauna	All listed bird species present, European Eel (Anguilla anguilla).	Increased human activity, improper waste disposal, increased noise pollution from water sports, fuel and oil spills, overfishing.	Nesting sites, bird behaviour, ecosystem interaction, food webs, habitat quality, species diversity	Buffer zones could be established from shorelines and potential nesting sites; information boards could be installed for public awareness; bins could be installed; restrictions on fishing could be implemented.	3
Habitat Disruption	All listed bird species present, all vegetative species present.	Trampling of vegetation, removal of vegetation, erosion of shoreline due to waves created by water sports, anchoring on the lakebed.	Ecosystem relations, habitats, food webs.	Areas could be restricted from public access; signage could be installed for public education.	2
Physical Habitat damage	All listed bird species present, all listed terrestrial and aquatic	Launching and docking kayaks and boats, anchoring boats, trampling of vegetation due	Species diversity, the lake shoreline, nesting sites, breeding	Accessible areas could be established for docking and launching; the public could be educated by	3

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	vegetative species present.	to walking and hiking, parking and driving vehicles.	and foraging grounds for both insects and bird species listed.	raising awareness and installing signs; Vehicles should be encouraged to park away from the shore; Eco-friendly modes of transport could be encouraged.	
Noise pollution	All bird species listed as present, the Irish Hare	Motorboats, water sports such as kitesurfing, human communications and traffic.	Breeding, nesting and feeding sites. Natural behaviours and processes.	Restricted times could be established for loud activities i.e. outside of nesting/breeding seasons; education could be provided for the public and signs could be installed for public awareness.	3
Collision risk	All bird species listed as present, the Irish Hare.	Direct collisions from boats and kites with birds, road vehicles and traffic.	Species diversity of both flora and fauna, ecosystems, animal welfare.	Established speed limits for boats and terrestrial vehicles could be implemented in the area and restricted areas for boats; the public could be educated by raising awareness and installing signage.	2

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Invasive species spread	All flowering plant species listed.	Increased spread due to human activity and tourism.	Ecosystems, food webs, species diversity, native species.	Sports equipment and boats should be disinfected appropriately; signage could be installed for public awareness; known areas with invasives could be blocked off from public access; water sport companies could be educated.	3
Chemical Pollution	All listed bird species, all listed aquatic plant species, Brown Trout, European Eel.	Fuel and oil spills, chemical equipment disinfectants, human waste, chemical sunscreen, carbon emissions from vehicles and equipment.	Flora and Fauna biodiversity, Habitat quality, water quality, ecosystems, species diversity.	Fuels and oils could be handled off-site and should be handled correctly, eco-safe products could be used where possible, human waste should be properly disposed of and treated, eco-friendly modes of transport could be encouraged.	4
Sedimentat-ion	All listed aquatic vegetative species, all listed aquatic invertebrate species	Increased sediment input from anthropogenic activities such as construction, erosion of shoreline due to human activity and water sport.	Aquatic flora and fauna biodiversity, water quality and habitat quality	Erosion control measures could be implemented such as buffer strips or planting native vegetation along the shore. Construction activities and land-use could be limited and	2

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				restricted.	
Water pollution	All listed bird species, fish species and aquatic vegetative species.	Water run-off from agricultural areas, domestic waste, increased human activities such as boating and swimming.	Ecosystems, habitat quality, aesthetic values, water quality.	Buffer zones from rivers and lakes could be established; eco-friendly boating practices could be encouraged and used; agricultural run-off should be regulated; leave no trace guidelines could be encouraged and followed by users of the Lake Keel.	3
Fishing Pressures	European Eel, all listed bird species	Overfishing, Water pollution.	Food webs, ecosystems, habitat quality, food availability, disturbance of breeding sites	Fishing quotas and no fishing zones could be established; Catch and release could be practiced; Fishing seasons could be restricted.	2
Aesthetic and recreational pressure	All listed aquatic and terrestrial vegetative species, listed bird species, listed aquatic and terrestrial invertebrate species.	Water pollution, human waste input, erosion due to increased human activity i.e. trampling, kitesurfing, driving, habitat fragmentation due to human activity.	Water quality, habitat quality, natural beauty of the lake, flora and fauna biodiversity.	Leave no trace guidelines should be followed; Waste should be properly disposed of.	2

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Climate change exacerbation	All species listed	Emissions from boats and terrestrial vehicles such as camper vans and cars, expansion of urban areas, land clearing for human use.	Carbon levels, decreased oxygen availability, increased temperatures, water levels may fluctuate, habitat quality is negatively impacted.	Leave no trace guidelines should be followed; eco-safe products could be used where possible; plant native vegetation could be planted; buffer zones could be established around the bog and shoreline.	1

2.2 Environmental vulnerability

Along the lake shore is a specially designated site, Keel Machair/Menaun Cliffs SAC. A few protected species reside within the area, species that have been recorded within the site includes a variety of bird species such as the mute swan, the greater black-backed gull, the lesser black-backed gull, the mew gull, whooper swan, barnacle goose, common goldeneye, common greenshank, common redshank, Eurasian curlew, Eurasian teal, Eurasian wigeon, grey heron, herring gull, tufted duck, European robin, Eurasian wren, pied wagtail, hooded crow, common magpie, European starling and mallard which are all protected under the EU Birds Directive and Wildlife Act. Locals have reported nesting swans on the northern side of Lake Keel and a whooper swan feather was found along the shoreline. There is a previous record of barnacle geese and whooper swans present within the lake, both bird species are migratory species to Ireland and visit during the winter. The site may be vital for the survival of such species.

Other protected species inhabiting the site included the Irish Hare which is protected under the Wildlife (Amendment) Act 2000 and the Habitats Directive (92/43/EEC). Important processes such as migration for bird species, photosynthesis for aquatic vegetative species and reproductive cycles for both flora and fauna species can be interrupted by water sports and human activity which can reduce the number of ecosystem interactions and services. If prey or predator populations

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were to decline in the area, the ecosystem would be negatively impacted and populations would either go extinct or migrate, decreasing the local and national biodiversity.

Invasive species

Invasive species are present at the site, invasive species that would be of particular concern include giant rhubarb and Himalayan balsam. Both species are vegetative invasive alien species that could be spread due to increased tourism and increased land use. The seeds of these species could be transported and spread due to direct contact with humans, vehicles and animals. If these invasive alien species spread, it is likely that other species that are native or support existing ecosystems, will decline which would lead to other impacts such as a decline in local biodiversity, decreased aesthetic value and imbalanced ecosystems. It is possible that alien species can be spread or introduced due to human activity. Aquatic invasive vegetative species also include Nuttall's waterweed and Canadian waterweed which can spread due to fragmentation of the original plant. These species can be spread or introduced to new areas when fragments or parts of the plant is broken off by human activity and is transported either by equipment and vehicles used by humans or by the flow of water. Seeds can also be spread via human activity which would lead to the introduction of the invasive species in ecosystems. Currently, no regulations or restrictions are established at present regarding invasive species in the area. Jenkin's Spire snail as well as the freshwater shrimp, *Gammarus Pulex,* are present and established at the lake. Such species may be outcompeting native species and could be spread to other areas from the lake due to human activity. There is currently no management plan in place for such species.

In future, to prevent the spread of invasive alien species, areas could be restricted from public access and equipment for water sports and terrestrial sports on site should be washed and disinfected according to the National Biodiversity Data Centre guidelines.

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Erosion

It is likely that the shoreline of the lake is being eroded by waves created by both wind and water sports. Vegetation within the riparian zone of the lake can act as a barrier against waves generated by human activity. Boats, kayaks and canoes are hauled and docked along the southern side of the shore which disturbs the soil, erodes the shoreline and causessedimentation within the lake. Erosion and sedimentation are more likely to be occurring on the southern side of the lake as human activity is higher at the southern side than the northern side of the lake.

Water Quality

Current Considerations

At present, the lakebed is disturbed by swimming and docking and launching boats, canoes and kayaks.Due to the disturbed soil from both the shoreline and bed, the visibility of the lake is low, and turbidity may be impacted. There is potential for invasive speciesto spread due to human activity as fragments of aquatic plants can be spread and seedsof terrestrial plants can be transported via human activities. Fuel may be used for boats at lake, camper vans and cars park along the shoreline which could also leak fuel into the lake which would reduce water quality.

Future Considerations

In the future, invasive speciesmay be introduced to the lake due to lack of disinfected equipment and increasedhuman activity. With increased human activity, pollutants such as sunscreen, oil and fuels, domestic waste within the water will increase. In future, leave not trace guidelines should be encouraged and all equipment should be thoroughly disinfected to prevent water quality at Lake Keel from declining

Chemical Analysis.

A chemical analysis of the water at Lake Keel showed that metal levels in Lake Keel were not at toxic levels.The quality of the water based on the chemical analysis produced can be classified as moderate, as levels of iron and manganese were high and could be toxic to specieswithin the lake and cause bioaccumulation. High levels of ammonia can be toxic to fish speciesand can promote eutrophication within the

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lake. High levels ammonium can also lead to oxygen depletion and excessivealgal growth. The alkalinity of the lake was recorded to be 41.8mg/L which suggests moderate alkalinity within the lake, which can be beneficial for species of flora and fauna as natural and anthropogenic acidification in more likely to be prevented. Water conductivity of the lake was recorded to be 193 μS/cm at 20 degrees Celsius, a moderate concentration of dissolved ions that reflects a moderate water quality.

Water usage

The water is not currently used for cleaning purposes.

The water within Lake Keel is not currently used as a public water supply.

2.2 Human Impact

There is evidence of overcrowding at the site. Evidence of high foot-traffic was noted along the shoreline, particularly along the southern side of the site. Vegetation had been trampled and paths of bare soil and soil with little plant cover were created due to human activity. More bird species and invertebrate species were observed on the northern side of the lake where human activity was low. This could be due to the lack of noise pollution and lack of disturbance.

Occurrence of Litter table

	None	Present	Moderate	Abundant
Litter in the water		✓		
Litter in the vicinity		✓		

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Infrastructure

There is a lack of infrastructure present at the site. The road, R319, crosses over the river from which water leaves Lake Keel. Trailers owned by water sport companies that use the lake currently park along the shoreline. Pollution from chemicals in concrete present on the road R319 is possible due to run-off water, however it is unlikely to have a significant impact on species present within the lake. At present, there is no new infrastructure planned and pollution from chemicals in wood is unlikely.

Carbon Footprint

The water sport companies don't require fuels or oils for activities on the lake, however in order for both tourists and locals to access the lake, they must drive which increases carbon in the area. At present, buses and bikes would not be able to appropriately access the lake due to the uneven terrain. There are currently no footpaths present for pedestrians to access the lake.

2.4 Socio-economic considerations

Water sports at Lake Keel attract large groups of tourists to the area, especially during the summer. Organisations that currently use the lake regularly include Pure Magic Water sports, Surf le Tomás and the Achill Outdoor Education Centre. The lake is currently used for kayaking, surfing and kitesurfing by these organisations. The tourism that the water sports attract, also brings tourism for local businesses such as restaurants and hotels.

The lake is also used by locals for recreational activities. Local people like to partake in water sports along with tourists at the lake as well as fish and camp at the lake. It is a significant place for locals to enjoy aesthetic views and to partake in sports.

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No archaeological sites have been recorded in the vicinity of the lake or within the lake.

3.0 Exposure Assessment

3.1 Consider seasonal variations

During summer, the peak season for tourism at Lake Keel, noise pollution levels, light pollution levels and human disturbances increase which can have negative impacts for species at the lake. Many species such as the emperor dragonfly and the green leafhopper breed during the summer when temperatures are warm. If disturbed by human activity, natural processes and behaviours could change which would have significant negative impacts on ecosystems within Lake Keel and the surrounding vicinity, such as declining populations and declining biodiversity. For bird species in Ireland, nesting and breeding takes place from March to August. Increased human activity during the summer may disturb nesting birds as species spend more time and energy staying vigilant of humans. Human activity at the lake could also disturb the fish species that reside at the lake, particularly the brown trout as they feed on mayfly larva during the summer. Species have less opportunity to forage, breed, migrate and nest during the busy season due to human disturbances. Summer is also a season in which many flowering plant species produce flowers for reproduction, this increases the risk of invasive species spreading such as Himalayan balsam and giant rhubarb. If tourists increase foot-traffic around the shore of the lake, it is possible that invasive vegetation will spread and be introduced to other ecosystems. Vegetative species are also more likely to be trampled during the busy season as the number of people and vehicles on-site is increased.

During the off-season at Lake Keel, migratory species such as the whooper swan and barnacle goose migrate to Ireland to forage. They are less likely to be disturbed as human activity levels, noise pollution and light pollution decreases. There is a previous record of the European eel at the lake, this species is a critically endangered species that likes to inhabit freshwater habitats. They migrate during autumn, therefore decreased human activity would allow them to migrate to the ocean without being disturbed. Brown trout have also been recorded inhabiting the lake and spawn in freshwater habitats during autumn. Tourism is less likely to have an

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impact on these fish species during the off-season. Vegetative species are less likely to be trampled in compared to the peak-seasonduring summer as human activity decreases, the off-peak season allows any trampled species to recover and regenerate

3.2 Human Activities

Activities that have the potential to cause harm, water pollution, disturbance of vegetation, erosion

A variety of human activities take place at the lake, activities undertaken includes terrestrials and aquatic sports. Firstly, many locals and tourists walk around the shoreline of the lake and camp along the bank. Walking and camping can disturb vegetation and trample species which can cause habitat fragmentation and erosion. It can also cause the spread or introduction of invasive alien species which can cause native vegetative species to decline due to lack of shade, competition for space and lack of resources.

Activities such as canoeing, kayaking and boating can also spread invasive species from other areas, if the vesselsare transported from one body of water to another without being washed or disinfected, it is possible that invasive alien species such as the zebra mussel (*Dreissena polymorpha*) could be introduced. Boats, kayaks and canoes can also erode the lakes bank and damage vegetation as they are dragged along the ground to accessthe water. The use of boats and vehicles on site could also lead to fuel or oil spills which would pollute the water and potentially smother both flora and fauna species. Kitesurfing is a water sport that takes place at Lake Keel, the noise levels produced from kite surfing can disturb nesting birds and that activity disturbs the water which could disturb fish species inhabiting the lake. Fishing at the lake could impact fish populations depending on the season, fishing could also decrease food availability for other species such as gull species. The application of chemical sunscreen, skincare products and chemical cleaning solutions for equipment can cause water pollution as the harmful chemical enter the water directly or as run-off. Littering of domestic waste can also increase the nutrient connect of the lake which would cause nutrient pollution and could lead to eutrophication, resulting in decreased oxygen availability for both flora and fauna species inhabiting the lake.

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3.3 Intensity of water sports

The most popular sports at Lake keel appear to be kitesurfing and kayaking with three main outdoor organisations providing equipment and servicesto tourists and locals. The busiest season for water sports, according to locals, takes place from May to August. Water sports take place at the lake from approximately 9am to 5pm all throughout the week. From observations made during the on-site field survey, each outdoor organisation had a trailer of equipment along the southern shoreline of the lake. Canoeing and kayaking involved large groups of tourists and locals on the lake, these groups ranged from school tours, camps, and families. Companies offering canoeing and kayaking servicestended to take on groups for two-to-three-hour sessions, twice a day. Based on observations made at Lake Keel, kitesurfing takes place from 10am to 7pm with up to four participants at a time on the lake. Swimming also takes place at the lake but not as frequently as other water sports. Locals and tourists can swim at the lake, however it is not a popular choice as beaches nearby such as Keel beach and Keem Bay offer more space and resources for families and groups. Boats can also be used at the lake for fishing; no boats or fishermen were observed at the time of the survey. It was reported by locals that fishermen visit the lake often throughout the summer to catch brown trout.

3.4 Table for Vulnerability Assessment

Risk 1-5
1-low risk
5 -high risk

Activity	Jan	Feb	Mar	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Angling	3	2	1	1	1	1	1	1	2	3	3	3
Water sports	1	1	1	2	3	4	4	4	3	2	1	1
Shore-based activity walks hikes	1	1	2	2	3	4	4	4	2	2	2	2

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4.0 Sensitivity Assessment

4.1 Ecosystem sensitivity

At present, tourist activities and water sports at the lake may be affecting ecosystems in a variety of ways. Hiking and walking without control measures in place have the potential to spread invasive species which causes both flora and fauna native species populations to decline as it reduces food availability, increases competition between species and reduces resources such as shelter and space. Ecosystem services such as photosynthesis may be interrupted or lost as human activities can decrease both the size and quality of habitats and can cause a decline of species populations.

During peak season, more fauna species tend to be residing in the northern side of the lake where there is less human activity and disturbances. The level of human activity at Lake Keel could be interrupting food webs and natural interactions and processes between species as species may be spending energy on staying alert and vigilant. Activity along the shoreline is also eroding the shore which is increasing sediment input into the lake which could be smothering aquatic invertebrates and plants. Litter and pollutants were observed at the site, which could also cause decrease oxygen availability and could increase nutrient input in the lake. Waves created by water sports may contribute to vegetative reproductive processes as waves and activities such as rowing and swimming can break off vegetation and carry seeds, which allows reproductive cycles to proceed.

4.2 Species sensitivity

A variety of species may be being affected by water sports and the tourism it brings at Lake Keel. Human activities such as walking and hiking can trample vegetation leading to habitat fragmentation, which causes species populations to become isolated and results in a decline in genetic diversity. It also creates edge effects which result in species becoming exposed to elements such as increased wind and light which can cause migration and mortality. Such human activities also decrease habitat size which increases the competition for resources such as shelter and food between species. If invasive species present at the site are further spread due to human activity, water sports and tourism, the ecosystem will become imbalanced and other important vegetative species such as the yellow iris and rush species may be outcompeted which would also negatively impact the species that breed and forage from native vegetation.

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Bird species can be impacted by water activities and tourism due to the noise pollution. According to local reports, birds tended to nest on the northern side of the lake where human disturbances were less likely. Bird species that may be particularly sensitive include the migratory bird species, the Whooper swan and Barnacle Goose. These species migrate to Ireland during winter to forage. If these species are disturbed by noise generated by tourism during the winter, they may stop migrating to the area. Bird species that use the area all year-round can also be impacted during nesting and breeding season, especially during the summer as it is peak season for tourism. Nesting and breeding birds can be disturbed by human activity at the lake which would decrease species populations and genetic diversity.

Flora and fauna may also be trampled on as tourists walk into the lake and drag boats, kayaks and canoes into the water via the shoreline. There is a variety of important species of flora that can benefit pollinators such as bog asphodel and devil's bit scabious, if environmental conditions such as soil stability were to change due to human activity, species populations could decrease which would negatively impact food webs. It is important to note that due to the presence of devil's bit scabious, the site could be an important feeding ground for Marsh Fritillary (*Euphydryas aurinia*).

The European eel, a critically endangered species according to the IUCN Red List. It was last recorded at the lake in 1968, if it is still present at the lake, it may be impacted by sedimentation caused by human activity as the site may be a potential breeding site for the eels. Plastic litter left in the water and along the shoreline can smother animals both terrestrial and aquatic as they may get trapped inside the plastic. Domestic waste at the site could be causing oxygen depletion due to increased nutrient inputs which would cause the mortality of sensitive species.

4.3 Habitat sensitivity

Aquatic habitats are affected by water sports and tourism in various ways. At Lake Keel, domestic waste was observed around the shoreline and lake which reduces the aesthetic value of habitats, the quality of habitats and can increase nutrient intake into the freshwater lake. If nutrient levels keep increasing, eutrophication can occur which will result in algae dominating the lake, killing other living organisms due to oxygen depletion.

Swimming after the application of chemical sunscreens or other skin products also

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causeschemical pollution within the lake. Water sports that require engines risk oil and fuel spills into the lake or if spilled within surrounding habitats, chemical pollutants could enter the lake as run-off. The use of vehicles also emits carbon dioxide which can decrease the air quality of habitats which reduces habitat quality. Any pollutants on vehicles could be washed off into the lake due to surface run-off water.

Water sports such as kayaking, kitesurfing and jet skiing can generate waves which degrade the shoreline. Canoes and kayaks are dragged into the water from the sandy shore which causes the soil of the lake shoreline to become disturbed and deposited into the lake which causes sedimentation. Increased sedimentation and erosion can have an impact on the velocity and turbidity of the lake. Docking and launching water vessels, walking and hiking can also trample on important vegetation that provides nesting and breeding sites for bird and insect species. When vegetation is trampled on, habitat fragmentation occurs which reduces habitat size and quality.

4.4 Species Sensitivity Table

	Species	**High impact**	**Medium impact**	**Low impact**
Water skiing	**Listed Bird Species**			✓
Fishing	**European eel, brown trout**		✓	
Swimming	**Listed Aquatic Invertebrates, Listed Aquatic Vegetation, Listed Bird Species.**			✓
Windsurfing	**Listed Bird Species**		✓	

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Boating - engine	**Listed Bird Species, Listed Fish species, Water Boatmen, Hygrotus inaequalis**	✓		
Boating - rowing	**Listed Aquatic Vegetative Species**			✓
Paddleboarding	**Listed Aquatic Vegetative Species**			✓
Canoeing	**Listed Aquatic Vegetative Species**			✓
Cycling	**Listed Terrestrial Vegetative Species, Irish Hare, Bird Species**			✓
Trail Running	**Listed Terrestrial Vegetative Species, Irish Hare, Listed Bird Species**			✓
Road Running	**Listed Terrestrial Vegetative Species, Irish**			✓

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	Hare, Bird Species			
Walking	**Listed Terrestrial Vegetative Species, Irish Hare, Bird Species**		✓	

4.5 Habitat Sensitivity Table

	Habitat	**High impact**	**Medium impact**	**Low impact**
Water skiing	Riparian Zone, Eutrophic Lake			✓
Fishing	Eutrophic Lake			✓
Swimming	Eutrophic Lake			✓
Windsurfing	Riparian Zone/Shoreline, Eutrophic Lake			✓
Boating - engine	Riparian Zone/Shoreline, Eutrophic Lake		✓	
Boating - rowing	Eutrophic Lake			✓
Paddleboarding	Eutrophic Lake			✓
Canoeing	Riparian Zone/Shoreline, Eutrophic Lake			✓
Cycling	Grasslands, Blanket Bog		✓	

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Trail Running	Grasslands, Blanket Bog			✓
Road Running	Grasslands, Blanket Bog		✓	
Walking	Grasslands, Blanket Bog		✓	

4.6 Proposed Future Developments

There are no proposed future developments proposed within the vicinity of the lake that would impact the vulnerability of habitats and speciesin the area.

All projects that have been proposed previously within the vicinity of the lake have been either rejected or accepted and started already. The most recent projects accepted on a conditional basis, include the construction of a domestic dwelling as well as improving the landscape and drainage system surrounding that dwelling. Another proposal accepted on a conditional basis includes the construction of a dwelling and a shed. Potential impacts that could arise from these projects includes sediment transported into the lake via wind and water due to construction, run-off could transport fuels, oils and other chemicals from machinery used during construction. Domestic waste could leach through the soil or be transported to the lake by wind and water if not managed correctly which would increase sediment and nutrient input within Lake Keel. Noise pollution and light pollution would also be generated from construction and land-use change which could impact bird and insect species. Both short term and cumulative effects from future proposed projects that involve construction are possible due to erosion and pollution. Short-term impacts on the environment at Lake Keel include disturbances to wildlife, emission of air pollutants, input of domestic waste and input of chemical pollutants due to spillages and leaks. Cumulative effects that could arise from projects include species migrations and extinctions, habitat quality degradation and habitat fragmentation.
(Mayo County Council, 2024; An Bord Pleanala, 2024

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4.0 Summarisation & Utilisation of Findings:

5.1 Adaptive Capacity of the Blue Space

There is a range of species that support natural processes and ecosystem interactions at the lake. Many habitats and species provide important ecosystem services such as carbon sequestering and tourism.
At present, the water quality of Lake Keel is of a moderate quality according to EPA. It is recommended that a study evaluating the water quality and environmental conditions at the lake should be done in future.

Lake Keel is connected to four rivers, three flow downstream into the lake and one flows out from the lake towards Keel beach. Two additional small streams were recorded on-site flowing into the lake. It is possible that species may be migrating to and from the freshwater lake and the sea which could enhance biodiversity and genetic diversity at the lake.

Climate Resilience

The lake isn't particularly resilient to climate change as it is a eutrophic lake that is sensitive to temperatures and precipitation. The blanket bog located north of the lake can act as a buffer for climate change as it regulates carbon, reduces the risk of pollutants entering the water due to run-off and it can regulate temperatures.

Management Practices

At present, the area is protected due to the established SAC, Keel Machair/Menaun Cliffs, which locals are aware of and try to avoid nesting areas. However, there is a lack of management and conservation practices in relation to environmental regulations and rules at Lake Keel.

Community Engagement

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Local community groups showed an acknowledgement of the protected area as well as potentially nesting birds and activity groups try to avoid disturbing and harming species. The lake is not managed by local communities or groups.

5.2 Impacts

Short term impacts

Issues identified at the site that may be caused by water sports included physical litter of domestic waste such as plastics and food which can cause increased nutrient levels within the lake and reduced the aesthetic value and habitat quality. Chemical pollutants from skincare products, vehicles and water sport equipment are likely to be entering the lake either directly from the source or as run-off. Waves generated by water sports can also displace species as the velocity of the water increases and waves erode the shoreline which can also damage species both aquatic and terrestrial. Human activity along the shoreline can result in sedimentation as launching and docking, as well as walking can damage vegetation. This reduces soil stability along the shore and causes sedimentation to occur within the lake, lowers the velocity of the lake, displaces species and increases turbidity which can reduce light availability for aquatic plants. Noise pollution generated by water sports can disturb birds and other fauna species which interrupts natural process such as reproductive cycles of species. Water sport activity on the lake can cause direct mortality of species both flora and fauna via collisions on the water.

Long Term Impacts

Cumulative impacts at the lake includes habitat degradation due to pollution cause by water sports and tourism. Fuels, oils, and other chemical pollutants that would arise from human activity within the lake, can harm wildlife at the lake as if ingested. They can be toxic for species and can result in mortality and loss of species. Such pollutants could bioaccumulate within food webs at the lake and would decrease the habitat quality for many species. If nutrients from domestic waste continue to enter the waste via pollutants from tourism, nutrient levels

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will increase to a level where algal blooms will occur and dominate the lake. This would result in oxygen depletion, causing the mortality of many aquatic species of both flora and fauna. Waves created by water sports would continuously erode the shoreline which would lead to shortage of shelter and space for species both flora and fauna. Tourists and locals walking around the lake can also create boundaries within habitats i.e. paths, trails, this results in less resources available for species and species may be exposed to harmful environmental conditions. Increased human activity would result in increased competition between species for resources, leading to decreasing biodiversity and genetic diversity among species. Land and water sports can also cause the spread and introduction of invasive alien species which would also contribute to increased competition for resources among species. Consistent noise pollution and disturbance could also result in species migrating to other areas which would decrease local biodiversity, genetic diversity and could result in declining species populations.

5.3 Mitigation

1.	The SAC, Keel Machair/Menaun Cliffs, has been established to protect flora and fauna species in the area as well as the habitats they inhabit. There are no established zones of protection or restricted areas with the exception of the established SAC. Noise and light levels are currently not monitored or regulated. Currently, there are no regulations or restrictions regarding water quality. In future, regulations regarding noise and light pollution levels could be established to mitigate impacts on species inhabiting the lake. To protect nesting birds, a buffering zone could be established along the northern and western shoreline of the lake.
2.	The shoreline of Lake Keel at present has not been managed or protected, the shoreline was used moderately by water sport companies and campers. The surrounding area of the lake is used as commonage for sheep grazing, the eastern side of the lake was inaccessible due to restrictions placed by private landowners. It is possible the northern side

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	of the lake where the blanket bog resided was fenced off for conservation purposes as a gate prevented public access,however the bog is accessible from Slievemore Road. To protect vulnerable areas such as the blanket bog, signage or barriers could be established to conserve the area and prevent human disturbances.
3.	No facilities are available for waste disposal at Lake Keel and no signage is present for public education. Water sports companies present at the lake currently don't use fuels or oils except for cars and vans on land. To mitigate potential impacts of domestic waste and chemical pollutants, signage could be installed to inform the public of leave no trace guidelines and nesting birds in the area. Bins could also be installed to prevent domestic waste from entering the water.
4	There is currently no invasive species management plan that covers the presence of giant rhubarb and Himalayan balsam at Lake Keel. Measures to prevent the spread of invasivesare not currently in place. In future, to prevent the spread of invasives at Lake Keel, signage could be installed to educate the public, water sport companies could disinfect equipment with appropriate solutions such as Virkon, and a management plan to eradicate invasive alien species could be established.

5.4 Non-Technical Summary

Lake Keel is a freshwater lake that is currently used for a range of water sports, mainly kitesurfing, canoeing and kayaking. The water quality of the lake has been assessedas moderate by the EPA,there is a risk of eutrophication occurring at the lake due to increased nutrient levels as domestic waste enters the lake due to human activity. The shoreline and surrounding land of the lake is used for hiking, camping and trailing. It is likely that tourism and water sports are negatively impacting the lakes habitats and species. Human activity has impacted the lake via noise pollution, physical damage to vegetation and disturbance of wildlife. It is also possible that human activity has caused spread or introduction of invasive species in the area.

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Sensitive species to consider include listed bird species such as the whooper swan which may be disturbed when feeding over the winter or the pied wagtail which nests during the summer, the busiest season for tourism at Lake Keel. Species of flora can also be sensitive to trampling via walking or launching and docking kayaks and boats. If such species are continuously damaged by human activity, species populations that support ecosystems within Lake Keel could decline which would cause extinctions or migrations of species in the area. Trampling can also lead to habitat fragmentation which results in habitats becoming smaller, habitat quality declining and increased competition for resources between flora and fauna species. Habitats that may be sensitive to human-induced pollution and processes such as erosion include the surrounding grasslands, the blanket bog and the eutrophic lake. Human activity at the lake can cause sedimentation, air pollution, chemical pollution, erosion, increased turbidity, increased nutrient input which would all negatively impact habitats within the area.

the

Layman's Report

Key actions that would mitigate the impacts of tourism and water sport at Lake Keel include educating the public. The public could be educated via public talks about conservation and wildlife at Lake Keel, providing educational information to water sport companies and installing signage at the lake boundary to inform the public and raise awareness. Leave no trace guidelines could also be promoted in the area via signage. Buffer zones and restricted areas could be established to protect nesting, breeding and feeding sites could be established to prevent human disturbances. Restrictions could be placed on noise pollution generated by tourism and water sport; this could be done by limiting water sports to certain times during the year.

A management plan for invasive species could be established in the area, particularly for invasive aquatic vegetative species as well as the giant rhubarb and Himalayan balsam, and water sport equipment should be appropriately disinfected in accordance with National Biodiversity Data Centre guidelines. To further prevent the spread of invasive species, areas could be blocked off from public access and signage could be installed to warn the public of invasive species present. To prevent litter and other domestic waste being put into the lake, bins could be installed around the area. In order to mitigate damage caused by vehicles on site,

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cars could be encouraged to park away from the shoreline and eco-friendly transport modes could be promoted in the area. Dedicated surveys regarding birds, mammals, reptiles, aquatic and terrestrial plants should be conducted in the future to gain an understanding of the ecosystem within Lake Keel and implement the correct measures to protect the species and habitats that inhabit the lake and its surrounding environment.

Bibliography

An Bord Pleanala (2024). *Bord Order ABP-316024-23.*[online] Available at: https://www.pleanala.ie/anbordpleanala/media/abp/cases/orders/316/d316024.pdf?r=926857 [Accessed 2 May 2024].

EPA (2013). *Irish Lake Trophic Status and Ecological Status 2007-2009*.

Mayo County Council (2024). *Search For Planning- Mayo County Council*. [online] Mayo Coco. Available at: https://www.mayo.ie/planning/search [Accessed 23 Aug. 2024].

Section 2

Regenera Water Sports Pilot Site SWOT Analysis

Pilot Site	Lake Keel/ Lough Keel, Achill Island, Co. Mayo
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Partner Organisation	Leave No Trace Ireland
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Grant Agreement	101134336
Grant Acronym	Regenera
Full name	Sustainable and Regenerative Management of Physical Activity and Practice of Sport in Water Areas and Surrounds
Work Package	2
Deliverable	2.2
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Abstract

A SWOTanalysis is a tool used to evaluate the Strengths, Weaknesses,Opportunities, and Threats related to the natural environment and biodiversity.

Strengths (Internal Positive Factors):

- Resilient biodiversity
- Protected areas
- Community engagement
- Research and knowledge
- Supportive policies and legislation

Weaknesses (Internal Negative Factors):

- Habitat fragmentation

- Pollution
- Invasive species
- Limited funding
- Lack of public awareness

Opportunities (External Positive Factors):

- Ecotourism
- Technological advances
- Global conservation initiatives
- Environmental education
- Restoration projects

Threats (External Negative Factors):

- Climate change
- Urbanisation
- Overexploitation of resources
- Increasing pollution
- Potential policy changes weakening environmental protections

A SWOTanalysis helps in identifying these factors to develop effective conservation strategies, leveraging strengths and opportunities while addressing weaknesses and threats to ensure sustainable management and protection of biodiversity.

Strengths	***Weaknesses***
Public awareness	Requires significant resources to draw up mitigation plans & maintenance responses
Multidisciplinary team collaboration- ecologist, biologist stakeholders/	Shoreline erosion

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Site useful for	Disturbances
Community engagement with conservation projects....	Risk of ....
Area regulation/	Water pollution potential from fuel/sunscreens/litter
Maintenance of area will increase and /or protect biodiversity	Human traffic leading to habitat degradation by walkers
What area offers now	Operational complexity with multidisciplinary teams
High aesthetic area	Possible presence of invasive species- flora or fauna
Biodiversity potential/	Lack of local engagement on environmental issues
	Environmental issues already present??

Opportunities	***Threats***
Development of sustainable and environmentally friendly water sport practices	Difficulties in integrating multidisciplinary teams and cost of hiring suitable disciplines
Multidisciplinary teams working together ...	Sports can directly impact the natural ecosystems, habitats & water quality
Sustainable infrastructure	Long term ecological damage if management plans not implemented
Education	Increased stress on wildlife if not managed correctly
Innovative new projects	Decrease in water quality affecting humans, flora and fauna

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Expansion of eco-friendly infrastructure	Potential conflicts between conservation and recreation activities
Innovative project which will encourage other communities to follow suit	Loss of vulnerable plants and animals and how close is the area to losing some?
	The future of protected species no longer secured
	Lack of local business/community support Resistance to engaging in environmental issues
	Climate change

Pilot site analysis

Strengths	***Weaknesses***
Visually aesthetic area that attracts tourism and supports the economy.	Habitat Fragmentation and degradation due to human activities.
Contributes to local and national biodiversity.	Invasive alien species present with potential to spread due to human activities.
Native species inhabit the area such as the Irish Hare.	Wildlife is disturbed due to human activities.
Local communities are aware of nesting birds and discourage tourists from disturbing local wildlife.	Physical litter and domestic waste present due to lack of facilities.
Established protected area in accordance with the EU Habitats Directive.	Lack of public awareness and education regarding the environment and conservation.
Locals use the area for recreational activities such as fishing, walking and	Erosion of terrestrial habitats and the shoreline due to human traffic, use of

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swimming.	vehicles and boats and kayaks.
Land-use of grazing in the area could potentially be preventing gorse from becoming abundant.	Sedimentation within the lake due to human activity.
The area provides breeding, nesting and foraging sites for fauna.	No management plan in place to mitigate impacts of tourism. A management plan would require resources, local support and funding.
Endangered and protected species have been recorded at the site.	Noise pollution due to tourism.
Provides ecosystem services such as carbon sequestering and flood control.	Water quality could potentially be decreasing due to inputs of chemical pollutants such as sunscreen, fuels and oils.
Habitats that are vital for supporting Ireland's biodiversity are situated within the lake vicinity i.e. blanket bog.	Increased nutrient inputs due to domestic waste. Potential loss of important species that contribute to Ireland's species diversity such as migrating birds.

Opportunities	**Threats**
Eco-friendly infrastructure instalments to prevent litter and inputs of waste into the environment.	Acceleration of climate change.
Public education and awareness.	Change of land-use or increased land-use.
Community involvement to protect and manage the environment.	Overexploitation of the area for tourism.
Use of eco-friendly and sustainable practices i.e. catch and release.	Instalment of infrastructure and facilities

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Water sport companies could get involved in public education and promote sustainability.	Run-off water containing pollutants and human activity would decrease the water quality, reducing habitat quality and aesthetic values over time.
Establishment of regulations and practices such as biofuel use where possible to protect the environment.	Lack of public education and awareness.
Development of conservation and restoration projects.	Lack of regulations and management.
Potential for invasive species management plan.	Change of environmental policies and law could impact the protection of habitats and species in the area.
	Cumulative negative impacts on the environment due to human activity.
	Lack of support, funding and resources for management.
	Imbalanced ecosystems due to species loss, disturbances, and declining populations.
	The future of endemic species, the Irish Hare, could be negatively impacted if tourism disturbs the species.

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