Desk Top Assessment

Lough Key

Priority Area for Action

(AFA0118)

Version F02

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Western Region

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1 Introduction

1.1 Background to the Priority Area for Action

Lough Key Priority Area for Action (PAA) is located in North Roscommon between the towns of Boyle and Carrick-on-Shannon and is an area of approximately 80 km^2 (**Figure 1**). The PAA forms part of the wider 26B_Upper Shannon Catchment and 26B_3 Boyle_Sc_020 (**Figure 2**). The PAA is bordered to the north by the Lough Allen PAA and to the south by the Killukin/Shannon PAA. The PAA as selected for focused work during the 2nd cycle river basin management plan includes the 6 waterbodies- the river waterbodies- Boyle_040, Demesne_010 and Mocmoyne_010 and the lake waterbodies- Fin Boyle, Oakport and Key. It has been proposed by Roscommon County Council and LAWPRO to add the following 2 water bodies to the PAA in the 3rd cycle implementation of the River Basin Management Plan, therefore for completeness, the following water bodies are also included within this deskstudy, although fieldwork will not be undertaken until the 3rd cycle when the River Basin Management Plan covering 2022 to 2027 has been approved: Boyle_020 and Boyle_030. The addition of these water bodies allow for better characterisation of the water bodies at subcatchment scale.

The waters generally flow in a south eastern direction with the Mocmoyne_010 flowing into the Boyle_030. The Boyle_030 in turn flows into the Boyle_040. There are multiple tributaries of the Boyle_040 river. Ten of the twelve tributaries are inflows to Lough Key, one flows into Derrywanna Lough and Cornacarta Lough Respectively, and the other tributary flows into Oakport. Lough Key is located in the east of the sub-catchment. Fin Lough is in the south-east of the sub-catchment, flowing into Demesne_26_010 which in turn flows into Lough Key / Boyle_040. Oakport lake is also in the south-east, situated on the lower reaches of Boyle_040.

Both Lough Key and Boyle_040 are *At Risk* while the Fin Boyle, Oakport, Demesne_010 and Mocmoyne_010 are at *Review*. There is little data available on these four waterbodies as they are unassigned and not monitored by the EPA (**Figure 3**).

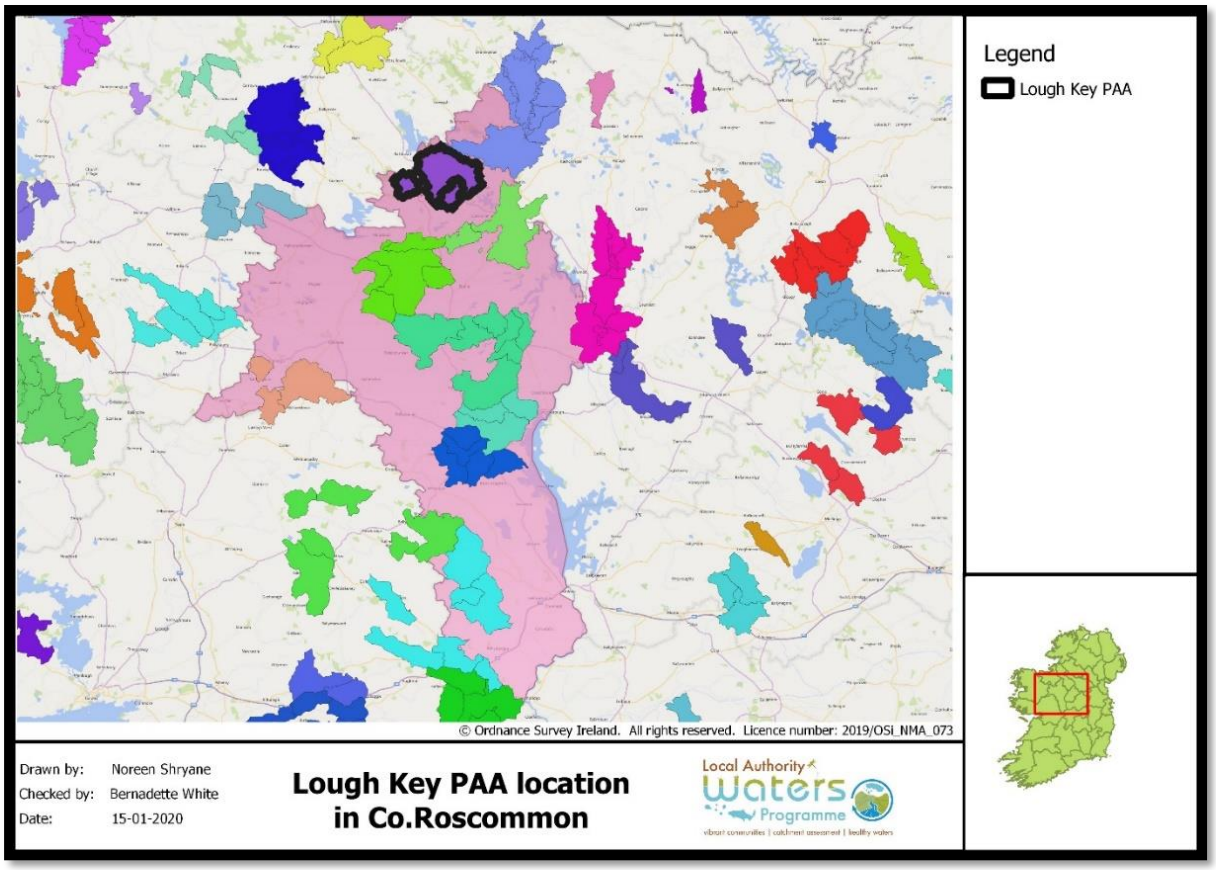


Figure 1 Lough Key PAA Location

A catchment assessment workshop was held in Castlebar on 26th to 28th April 2017. It was attended by representatives of local authorities (Mayo, Galway, Roscommon, Leitrim, Sligo), LAWCO, Irish Water, IFI, Forest Service, Coillte, NPWS, Teagasc, GSI, DAFM, Marine Institute and EPA. Based on the draft River Basin Management Plan priorities, a set of agreed principles and the local priorities of the workshop attendees, 34 areas were recommended for action in the Western Region, of which Lough Key PAA was one. Lough Key PAA was selected, for the following reason:

• Important for tourism.

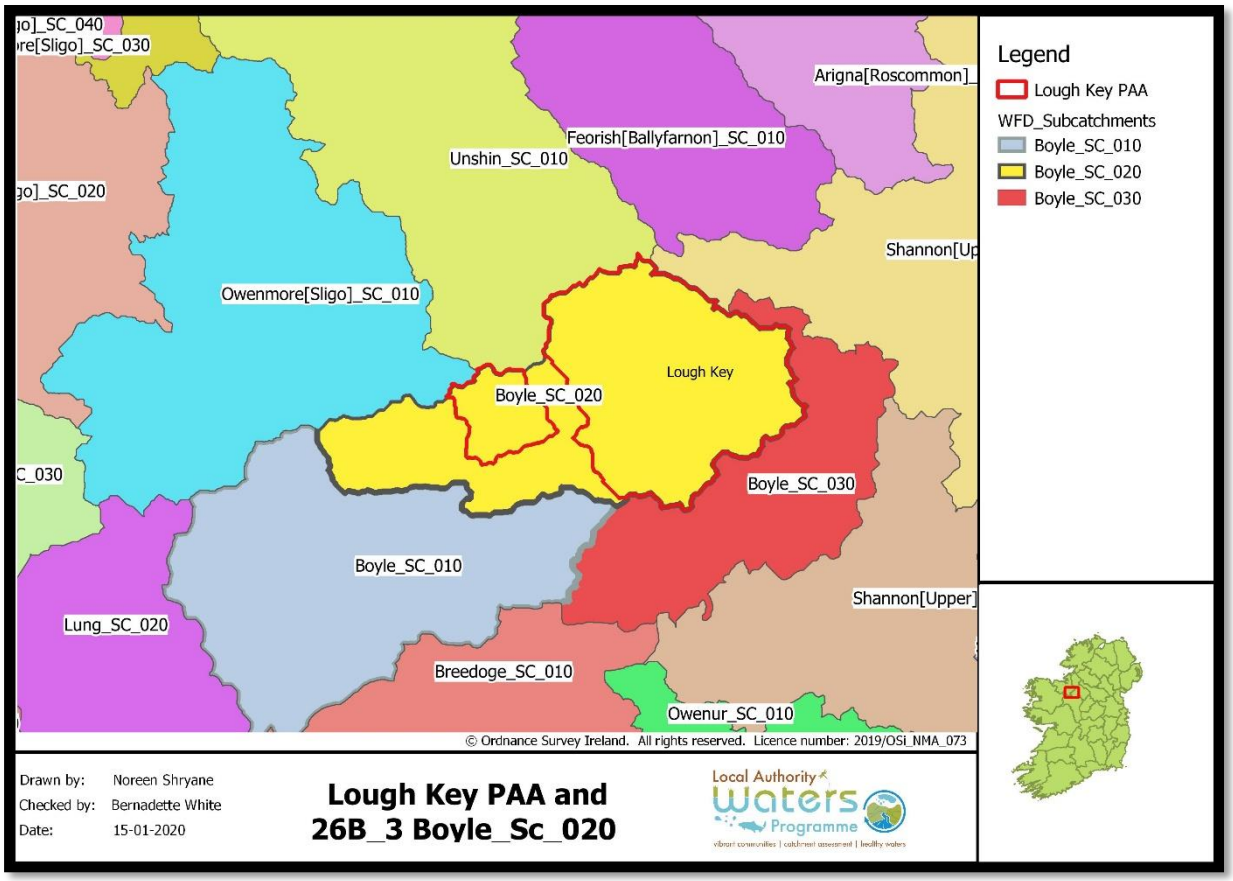


Figure 2 Lough Key PAA within the 26B_3 Boyle_Sc_020 sub-catchment

1.2 PAA Summary

Table 1 summaries the risk classification, environmental objectives, ecological status, significant pressures (and sub-category) for each water body within the PAA. **Figure 3** and **Figure 4** illustrate the ecological status classification and risk classification for the Lough Key PAA waterbodies. For the Lough Key Lake water body, two significant pressure types have been identified; Anthropogenic pressures (boating and Lough Key Forest Park have been identified as potential pressures) and invasive species (zebra mussels).Anthropogenic pressures have also been determined to be significant for the Boyle_040 river water body, which is assessed at Cootehall Bridge which is downstream of Oakport lake.

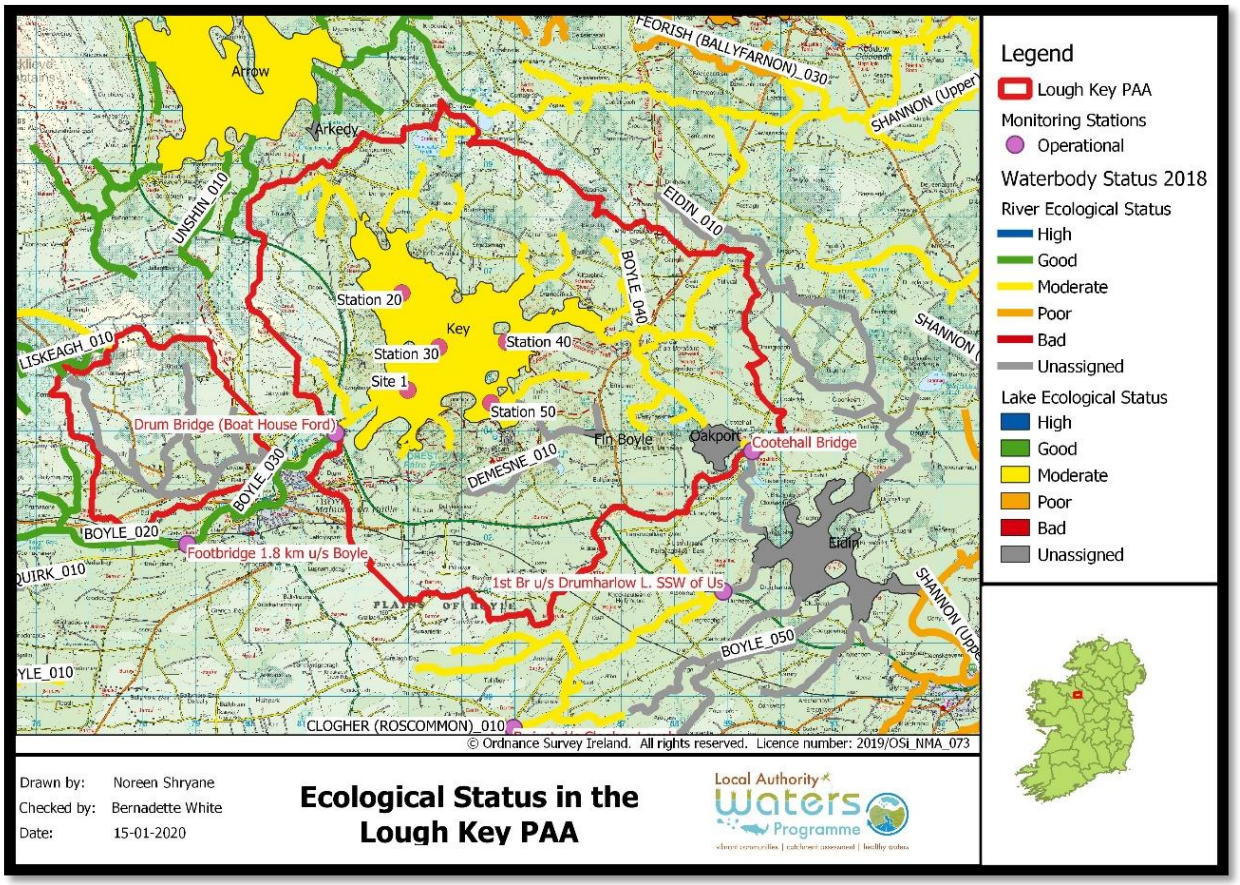


Figure 3 Lough Key Ecological Status

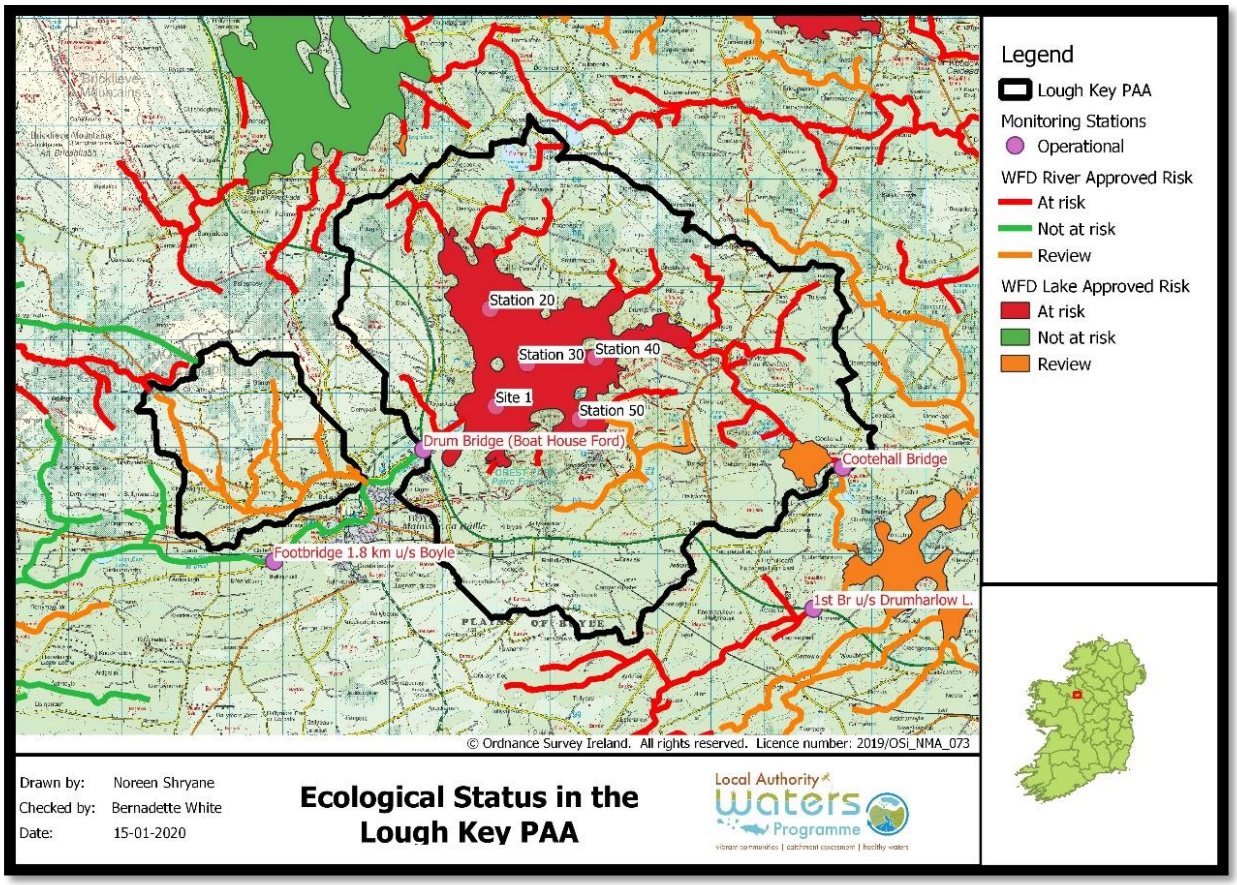


Figure 4 Lough Key Risk Map

1.3 Information Sources Consulted

Several information sources were consulted during the preparation of the desk study for the Lough Key PAA including:

- WFD web application – EPA characterisation data
- Satellite Imagery for analysing land use- https://www.planet.com
- Google earth for time lapse aerial imagery.
- LAWPRO/ Roscommon County Council (MCC) workshop on 18th October 2019 in Roscommon.
- Pers. Comms from Roscommon County Council

Table 1 Summary of Risk, Ecological Status, Pressures, Significance for the Lough Key PAA

					Ecological Status									
WB Name	**WB Code**	**Water Body Type**	**3rd Cycle Risk**	**High Status obj.**	**2007-2009**	**2010-2012**	**2010-2015**	**2013-2018**	**2020 Q values**	**Pressure Category**	**Pressure Subcategory**	**Significant Pressure**	**Investigative Assessment**	**Date to meet Env. Objective**
Boyle_020	IE_SH_26B 080200	River	*Not at Risk*	No	G	G	G	G	Q3-4	N/A	N/A	N/A	N/A	N/A
Boyle _030	IE_SH_26B 080400	River	*Not at Risk*	No	G	G	G	G	Q4	N/A	N/A	N/A	N/A	N/A
Mocmoyne _010	IE_SH_26M 910890	River	*Review*	No	U[1]	U	U	U	N/A	Forestry Agriculture	Forestry Pasture	No No	IA3	2027
Boyle _040	IE_SH_26B 080600	River	*At Risk*	No	G	G	M	M	Q3	Agriculture Forestry Anthropogenic Pressures	Pasture Forestry Unknown	No No Yes	IA1 IA7	2021
Demesne_010	IE_SH_26D 090760	River	*Review*	No	U	U	U	U	N/A	Forestry Agriculture	Forestry Pasture	No No	IA3	2027
Key	IE_SH_26_724	Lake	*At Risk*	No	G	G	M[2]	M	N/A	Agriculture Forestry Invasive Species Anthropogenic Pressures	Pasture Forestry Invasive Species Unknown	No No Yes Yes	IA1 IA9	2021
Fin Boyle	IE_SH_26_576	Lake	*Review*	No	U	U	U	U	N/A	Extractive Industry	Quarries	No	IA1 IA3	2027
Oakport	IE_SH_26_721	Lake	*Review*	No	U	U	U	U	N/A	Agriculture	Pasture	No	IA1 IA3	2027

[1] U= Unassigned, G=Good, M=Moderate

[2] In the 2013-2015 monitoring cycle ecological status deteriorated from Good to Moderate in Lough Key. The metric that failed to reach Good status was Macrophytes (WFD Cycle 2 Boyle Subcatchment Assessment Document)

Table 2 Summary of Monitoring stations and ecological status for Lough Key

Waterbody		**Key (IE_SH_26_724)**	
Risk Category		***At Risk***	
Environmental Objective		**Good**	
Environmental Objective Date		2021	
Monitoring Type		Operational, Biological and Supporting Chemistry	
Monitoring stations (Figure 1)		Phytoplankton	Station 30
		Macrophytes	M_1, M_2, M3, M_4, M_5 and M_6
		General Chemistry	Key Station 20, Key Station 30, Key Station 40, Key Station 50, Site 1
Lake type		Type 12: Low altitude, high alkalinity, deep and large lakes	
Biological Status			
Phytoplankton	*2007-2009*	Good	
	2010-2012	High	
	2010-2015	Good	
	2013-2018	High	
Other Aquatic Flora			
Macrophytes	*2007-2009*	Good	
	2010-2012	Good	
	2010-2015	Moderate	
	2013-2018	Moderate	
Phytobenthos	*2007-2009*	Not applicable	
	2010-2012	Not applicable	
	2010-2015	Not applicable	
	2013-2018	Not applicable	
Invertebrate Status			
Monitored but no standard has been developed and/ or the quality element is not used for status assessment.			
Fish Status			
	2007-2009	Not applicable	
	2010-2012	Not applicable	
	2010-2015	Not applicable	
	2013-2018	Not applicable	
Hydromorphological Conditions			
Hydromorphology	*2007-2009*	Not applicable	
	2010-2012	Not applicable	
	2010-2015	Not applicable	
	2013-2018	Good	
Evidence of drainage		No	
Comments		Macrophytes are driving the overall ecological status of this lake. Invasive species, specifically Zebra mussels have been identified as a significant pressure on Lough Key.	
Conceptual model required (Y/N)		Y	
Ecological Status			

Waterbody	Key (IE_SH_26_724)
Risk Category	***At Risk***
Environmental Objective	**Good**
Environmental Objective Date	2021
Monitoring Type	Operational, Biological and Supporting Chemistry
2013-2018	Moderate
Observations from Macrophyte Report	Lough Key has seen a decline in its charophyte population when 2017 results are compared with a baseline survey from 2008. There has been a decrease in the maximum depth of colonisation also between these dates. The total records of plants have decreased from 118 in 2008 to 85 in 2017. The condition of the supporting element, total phosphorus, shows no overall improvement or deterioration. Levels are within the high/good boundary for the majority of years of survey (2007 to 2017) and chlorophyll status is good. In summary, the lake plant community is characterised by the dominance of tolerant and elodeid taxa and declining Chara species. The plant community in Lough Key is somewhat typical of that seen in a lake where nutrients are higher than optimal for a natural system and where there are zebra mussels. Usually in an enriched lake there will be a reduction in the maximum depth of colonisation and the average depth of presence mainly due to high chlorophyll levels from increased phytoplankton growth. Both depth metrics have scored highly over the four surveys in this lake but with a reduction in the last survey. It is possible the zebra mussels are filtering enough phytoplankton to allow the water to remain relatively clear. There is a reduction in *Chara* spp. and this will typically occur in eutrophic lakes where elodeid species can outcompete and shade *Chara* species when nutrient levels are high. While the total phosphorus levels are not overly high, the baseline measurement in 2008 and a historical measurement from 2001 suggest it has been much higher. Where TP levels are high for many years' phosphorus will build up in the sediment where it can be utilized by rooted macrophytes. Thus, many tolerant species can have a competitive advantage for many years although TP levels in the water column may be falling. For Lough Key it may be required that total phosphorus levels are reduced to below the high/good boundary for many years before the lake is returned to one with an optimal macrophyte community dominated by *Chara* spp.
Significant issue: monitoring points	Total phosphorus and zebra mussels.
Significant issue: Waterbody	Total phosphorus and Zebra mussels. Potentially sediment.

2 Receptor information and assessment

2.1 Context and Setting

The Lough Key PAA is one of 14 PAAs wholly or partially within Co. Roscommon (**Figure 1**). The PAA extends from the townlands of Kiltycreaghtan in the West to Clegna in the East and Aghacarra in the North and to Rusheen in the South.

Land use is predominantly agriculture, with areas of pasture in the south and agricultural land with natural vegetation in the north/ north-west. There is one urban area, which is Boyle town. There are also areas of extractive sites, which include road and other aggregate quarries in the south-east. Throughout the north-west and east of the sub-catchment, there are smaller areas of coniferous forest, peat bogs, and woodland scrub. Designated drinking water groundwater bodies underlying the sub-catchment are Curlew Mountains, Gorteen and Carrick on Shannon. There is a GSI source protection area for Rockingham Spring which overlaps between the Boyle_SC_010 and Boyle_SC_020 subcatchments.

There are no SACs or SPAs which intersect the PAA or the subcatchment in which the PAA sits. Proposed Natural Heritage Areas – Corrigeenroe March (site code 000596) is in the north of the sub-catchment. Fin Lough (site code 001636) is in the south-east of the sub-catchment. Hog's Island (Lough Key) (site code 001638), Drumman's Island (Lough Key) (site code 001633), Drum Bridge (Lough Key) (site code 001631) and Tawnytaskin Wood (Lough Key) (site code 001651) are in the mid-east of the sub-catchment (**Figure 5**).There are Walking/ Cycling Trails – Miner's Way and Historical Trail across the sub-catchment, from north-east to north-west. Lough Key Forest Park walks are in the centre to the east of the sub-catchment.

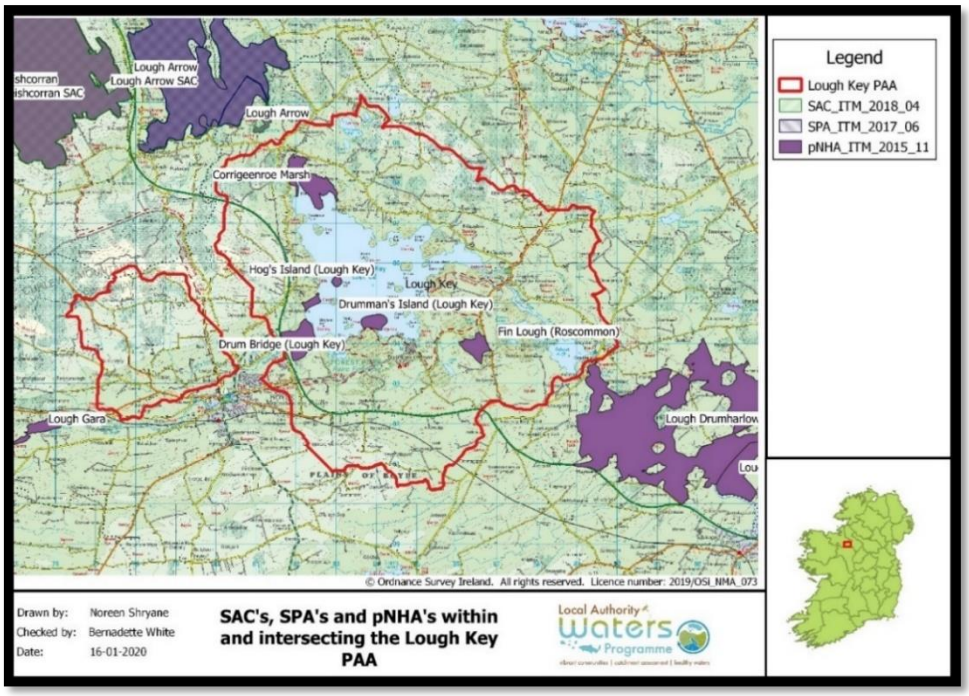


Figure 5 Lough Key PAA interaction with pNHA's

2.2 Receptor Information tables

2.2.1 Boyle_SC_010

In order to understand the issues impacting the water quality in the PAA, it is necessary to evaluate the chemistry available for the subcatchment upstream of the PAA which is the Boyle_SC_10. There are three waterbodies within this subcatchment: Boyle_010, Lough Gara and Derrymaquirke_010.

The **Boyle_010** river waterbody is in the Boyle_SC_10 which is located upstream of the Lough Key PAA. This waterbody is *At Risk* and is at Moderate Status (2013-2018). There are two EPA Monitoring Stations on the Boyle_010; **Cuppanagh Bridge** (Operational) which has Q Values (**Figure 6**) and **Culwoe Bridge** (Investigative) which has no Q Value Data. There is Hydrochemistry data available for Cuppanagh Bridge only which is pre-2007. The annual average EQS was breached for total phosphorus, ammonia and nitrate historically for this site. (**Table 3**). The annual average EQS for BOD was breached in 1997 (1.64mg/l), 2006 (1.925mg/l) and 2007 (2.72mg/l).

	1980	1983	1987	1992	1996	1999	2002	2005	2008	2011	2014	2017
Result	5	4	4.5	4	4	4	4	4	4	4	4	3.5
Classification	High	Good	High	Good	Good	Good	Good	Good	Good	Good	Good	Moderate
Q-Value	5	4	4-5	4	4	4	4	4	4	4	4	3-4

Figure 6 Q Values available for ***Cuppanagh Bridge*** – Invertebrates driving Status

Table 3 Outline of parameters influencing water quality in the Boyle_010

Waterbody		**Boyle_010**
Risk Category		***At Risk***
Environmental Objective		**Good**
Monitoring station		**Cuppanagh Bridge RS26B080100**
Monitoring station type		Operational
Biological Status		
Q values	*1996*	Q4
	1999	Q4
	2002	Q4
	2005	Q4
	2008	Q4
	2011	Q4
	2014	Q4
	2017	Q3-4
	2020	Q3-4
Water chemistry		
Monitoring station		**Cuppanagh Bridge RS26B080100**
PO_4+ Ecological Threshold <0.025 (high status) <0.035 (good status) as an annual mean mg P/L	*1995*	0.029
	1996	0.024
	1997	0.025
	1998	0.030
	2005	0.005
	2006	0.009
	2007	0.012
Baseline PO_4+		**0.019**
NH_3+ Ecological Threshold <0.040 (high status) <0.065 (good status) as an annual mean mg N/L	*1995*	0.140
	1996	0.144
	1997	0.145
	1998	0.140
	2005	0.028
	2006	0.029
	2007	0.043
Baseline NH_3+		**0.096**
NO_3- Indicative Ecological Threshold 3.5 for good status as an annual mean (none for high status at this point) mg N/L	*1995*	6.153
	1996	3.784
	1997	3.077
	1998	3.31
Baseline NO_3-		**4.081**
RHAT Score		No RHAT score available
Evidence of Drainage (OPW scheme, drainage district or other)		Boyle Arterial Drainage Scheme under OPW.

Waterbody	Boyle_010
	Commenced in July 1982 Completed in December 1995[3]
Comments	The total phosphorus, ammonia and nitrate breached the annual average EQS historically.
Ecological Status 2010– 2015	Good
2013-2018	Moderate
EPA Biologist comments **(Q value assessments, 2017 2020)**	A decline in quality to unsatisfactory was noted at Cuppanagh Bridge (0100) at the outflow of Lough Gara (June 2017). *Conditions improved to an extent at Cuppanagh Bridge with a low density of the Ephemera danica but large carpets of the zebra mussel (Dreissena) were in a decaying state as water levels in the nutrient enriched L. Gara were receding in early summer (June 2020).*
Protected Areas	Lough Gara SPA Lough Gara pNHA
WFD Objective	Good
Significant issue: monitoring points	Sediment Ammonia, total phosphorus and nitrate (Historic) Invasive species
Significant issue: waterbody	Sediment Ammonia, total phosphorus and nitrate (Historic) Invasive species

The Boyle_010 has many tributaries which flow into Lough Gara which is *At Risk* and at Moderate Status (2013-2018).

Lough Gara Lake Chemistry Analysis

Lough Gara is a low altitude, high alkalinity, shallow and large lake (Type 10). The mean EQS for total phosphorus was exceeded at Site 1, Site 2, Site 3 and Site 4 in 2020. There has been no exceedance since 2007 at Site 5. Chlorophyll levels have been below the good/moderate boundary for all sites except Site 4 in 2007. Zebra mussels are present in the lake. It should be noted that Phytoplankton biomass (chlorophyll) should be used with caution for assessing lake ecological and trophic status when zebra mussels are present (S.I No. 77 of 2019 Surface Water Regulations Amendment). The Lough Gara North Roscommon Regional Supply Scheme was non-compliant for pesticides in 2015. The key issues in this source were MCPA and Glyphosate. However, there has been no evidence of ongoing issues with pesticides based on recent updates from the National Pesticides in Drinking Water Action Group.

[3] Arterial Drainage of the Boyle and Bonet Rivers Dec 1996

Table 4 Outline of parameters influencing water quality Lough Gara

Waterbody		Gara IE_SH_26_728				
Risk Category		*At Risk*				
Environmental Objective		Good				
Monitoring Station		Site 1	Site 2	Site 3	Site 4	Site 5
Water chemistry						
Total phosphorus (mg P/l) High status ≤ 0.010 (mean) Good status ≤ 0.025 (mean) (Total phosphorus mg/l)	*2007*	0.007	0.005	-	0.006	0.013
	2008	0.034	0.024	0.036	0.040	0.020
	2009	0.023	0.018	0.020	0.025	0.013
	2010	0.020	0.020	0.025	0.030	0.015
	2011	0.020	0.018	0.028	0.023	0.015
	2012	-	-	-	-	-
	2013	0.028	0.020	0.020	0.025	0.020
	2014	0.013	0.013	0.014	0.032	0.014
	2015	0.021	0.018	0.020	0.025	0.015
	2016	0.015	0.018	0.018	0.027	0.013
	2017	0.020	0.022	0.025	0.031	0.020
	2018	0.019	0.019	0.021	0.033	0.019
	2019	0.021	0.022	0.026	0.033	0.018
	2020	0.030	0.029	0.030	0.045	0.024
Baseline TP (2017-2020)		**0.023**	**0023**	**0.026**	**0.036**	**0.020**
Total ammonia (mg N/l) High status ≤ 0.040 (mean) and ≤ 0.090 (95%ile) Good status ≤ 0.065 (mean) and ≤ 0.140 (95%ile)	2007	0.018	0.018	0.021	0.011	0.024
	2008	0.021	0.021	0.028	0.035	0.015
	2009	0.019	0.021	0.021	0.029	0.015
	2010	0.033	0.021	0.024	0.049	0.019
	2011	0.021	0.021	0.021	0.019	0.019
	2012	-	-	-	-	-
	2013	0.015	0.016	0.017	0.022	0.008
	2014	0.024	0.028	0.032	0.034	0.024
	2015	0.016	0.017	0.016	0.011	0.029
	2016	0.013	0.013	0.026	0.013	0.010
	2017	0.014	0.010	0.018	0.023	0.014
	2018	0.014	0.015	0.010	0.017	0.010
	2019	0.016	0.018	0.021	0.010	0.010
	2020	0.031	0.022	0.024	0.018	0.018
Baseline NH_3 (2017-2020)		**0.019**	**0.016**	**0.018**	**0.017**	**0.013**
Chlorophyll a (µg/l) Lake type 10 HG: 5.8	2007	3.50	8.56	4.09	20.43	5.45
	2008	5.68	5.05	5.55	6.20	2.0
	2009	4.15	4.38	6.08	6.25	2.6
	2010	4.75	5.6	6.78	5.78	3.68
	2011	4.58	3.65	6.08	6.20	2.75
	2012	-	-	-	-	-
	2013	3.40	3.95	3.85	5.68	2.65
	2014	2.75	2.28	2.43	3.65	2.73

Waterbody		Gara IE_SH_26_728				
Risk Category		*At Risk*				
Environmental Objective		Good				
Monitoring Station		Site 1	Site 2	Site 3	Site 4	Site 5
GM: 10[4]	*2015*	3.27	3.43	4	4.87	3.77
	2016	4.03	4.63	4.50	4.60	4.3
	2017	3.10	3.65	3.93	5.03	2.98
	2018	1.85	1.9	1.83	1.78	2.35
	2019	2.08	2.15	2.38	3.68	4.03
	2020	1.60	1.9	2.33	4.50	3.63
Baseline chlorophyll a (2017-2020)		**2.16**	**2.40**	**2.62**	**3.75**	**3.25**
Significant issue: monitoring points		Total phosphorus (Historically -2009 and previous years) Invasive Species and Sediment				
Significant issue: waterbody		Total phosphorus (Historically -2009 and previous years) Invasive Species and Sediment				
Comments		The total phosphorus levels across all five sites from 2013 to 2018 are showing an upward trend. In 2008 and potentially prior to this year, total phosphorus levels exceeded the mean EQS for good status across Sites 1- 4 on this lake. Therefore, there is potentially phosphorus within the lakebed sediments which is a constant supply to lake macrophytes. There is a downwards trend in Lough Gara for total ammonia (as N) and chlorophyll (**Appendix A 9.1).** The invasive Dreissena is now rampant near the lake outflows (EPA Biologist 2020).				

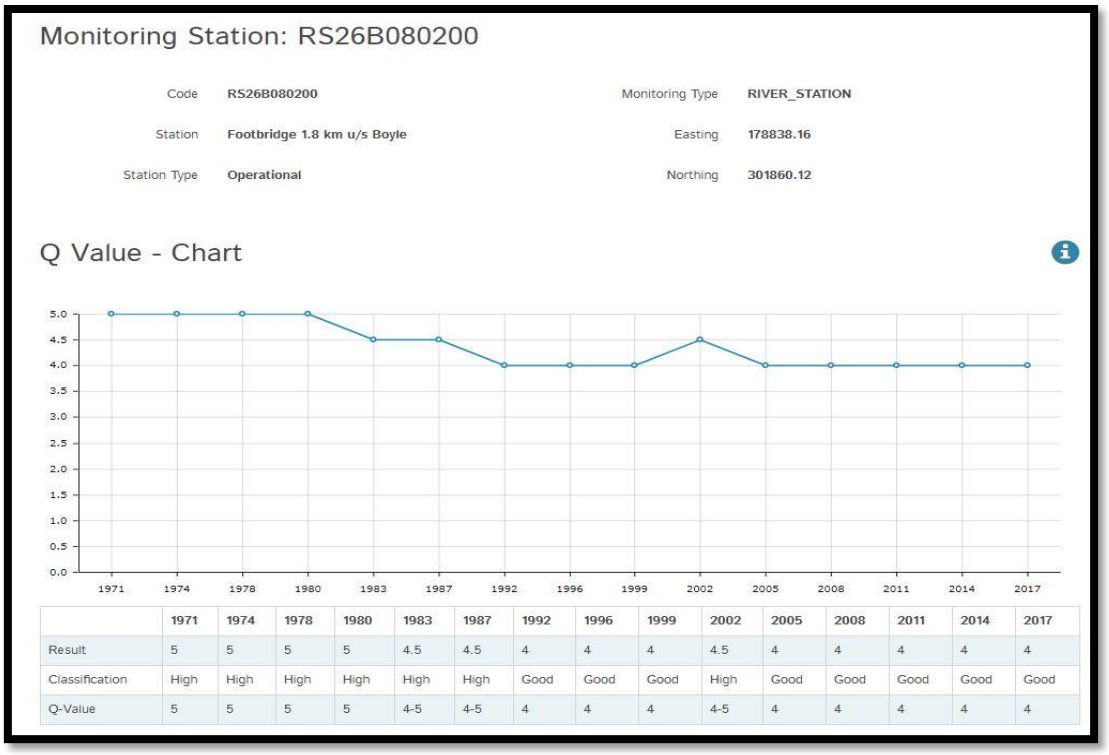
The **Derrymaquirke_010** river waterbody is *at Review* and is unassigned with no hydrochemistry data or Q Values available. It flows into Lough Gara near the outfall of the Boyle_010 river.

2.2.2 Boyle_SC_020

The 2nd cycle Lough Key PAA does not include the Boyle_020 and Boyle_030 river waterbodies but in order to understand the issues in the Lough Key PAA it is necessary to evaluate the chemistry available for these waterbodies.

The **Boyle_020** waterbody is *Not at Risk* and is at Good Status. It has one EPA operational monitoring station (**Footbridge 1.8km u/s Boyle).** The Q Values for this station can be seen in **Figure 7** below. The hydrochemistry data is detailed in **Table 5.**The hydrochemistry data for 2007 onwards does not indicate an issue with ortho-phosphate, nitrate, ammonia. In the late 90's/early 00's however, a spike in ortho-phosphate was noted (2002), and ammonium and nitrate exceedances. In addition, the annual average EQS for BOD was breached in 1998 (1.630mg/l), 2003 (1.597mg/l) and in 2005 (1.674mg/l).

[4] The phytoplankton boundary conditions for lake types 7,8,11 and 12 shall apply on an interim basis for classifying lake types not currently listed. EQR boundary conditions are yet to be developed for shallow calcareous lakes i.e., lake type 10 e.g., Lough Gara. The chlorophyll a boundary conditions for lake types 7, 8, 11 and 12 is 5.8 µg/l for High/ Good and 10 µg/l for Good/ Moderate.



	1971	1974	1978	1980	1983	1987	1992	1996	1999	2002	2005	2008	2011	2014	2017
Result	5	5	5	5	4.5	4.5	4	4	4	4.5	4	4	4	4	4
Classification	High	High	High	High	High	High	Good	Good	Good	High	Good	Good	Good	Good	Good
Q-Value	5	5	5	5	4-5	4-5	4	4	4	4-5	4	4	4	4	4

Figure 7 Q Values for ***Footbridge 1.8km u/s Boyle***

The **Boyle_030** is also *Not at Risk* and is at Good Status. It has one EPA operational monitoring station (**Drum Bridge (Boat House Ford).** The Q Values for this station can be seen in **Figure 8** below. The hydrochemistry data is detailed in **Table 5.** The hydrochemistry data for 2007 onwards does not indicate an issue with the nutrient's ortho-phosphate, nitrate or ammonia, however it is noted that in the late 90's, ortho-phosphate, ammonium and nitrate levels were much higher than they are today indicating nutrient pollution issues at that time. In addition, there were breaches in the annual mean EQS for BOD in 1996 (1.563mg/l), 1998 (1.558mg/l), 2004 (1.933mg/l), 2006 (1.555mg/l), 2007 (1.6mg/l) , 2008 (1.65mg/l) and 2014 (1.56mg/l).

Monitoring Station: RS26B080400

Code	RS26B080400	Monitoring Type	RIVER_STATION
Station	Drum Bridge (Boat House Ford)	Easting	181627.00
Station Type	Operational	Northing	303947.00

Q Value - Chart

	1971	1978	1980	1983	1987	1992	1996	1999	2000	2002	2005	2009	2011	2014	2017
Result	5	3.5	3.5	4	4	4	4	4	4	4	4.5	4	4	4	4
Classification	High	Moderate	Moderate	Good	Good	Good	Good	Good	Good	Good	High	Good	Good	Good	Good
Q-Value	5	3-4	3-4	4	4	4	4	4	4	4	4-5	4	4	4	4

Figure 8 Q Values for **Drum Bridge (Boat House Ford)**

The **Boyle_040** is *At Risk* and is at Moderate Status. It has one EPA operational monitoring station **(Cootehall Bridge).** The Q Values for this station can be seen in **Figure 9** below. The hydrochemistry data available from 2007 onwards does not indicate an issue with the nutrient's ortho-phosphate, nitrate or ammonia (**Table 5**). There has been no breach in either EQS for ammonia or ortho-phosphate since 2007. In the late 90's, a spike in ortho-phosphate was noted in 1997, while ammonium and nitrate levels were also significantly higher than they are today. In addition, there were exceedances in the annual Mean EQS for BOD in 2006 (2.034mg/l) and 2014 (1.59mg/l). It should be noted that the monitoring point however is downstream of Lough Key, and downstream of Oakport Lake, given its location at Cootehall Bridge, and therefore is not reflecting inputs to Lough Key.

	1971	1974	1980	1983	1992	1996	1999	2002	2005	2009	2011	2014	2017
Result	5	5	5	4.5	4	4	4	4	4	4	4	3.5	3.5
Classification	High	High	High	High	Good	Good	Good	Good	Good	Good	Good	Moderate	Moderate
Q-Value	5	5	5	4-5	4	4	4	4	4	4	4	3-4	3-4

Figure 9 Q Values for **Cootehall Bridge**

Having reviewed the aerial imagery from Google Earth, it does appear that there was thinning of the Coillte forestry in February 2013 immediately upstream of Oakport lake which may have contributed to the decline in the status in the 2010-2015 period.

Table 5 Outline of parameters influencing water quality in the Boyle_020, Boyle_030, Boyle _040

Waterbody		Boyle_020	Boyle_030	Boyle_040
Risk Category		*Not at Risk*	*Not at Risk*	*At Risk*
Environmental Objective		Good	Good	Good
Monitoring station		Footbridge 1.8 km u/s Boyle (RS26B080200)	Drum Bridge (Boat House Ford) RS26B080400	Cootehall Bridge (RS26B080600)
Monitoring station type		Operational	Operational	Operational
Biological Status				
Q values	*1996*	Q4	Q4	Q4
	1999	Q4	Q4	Q4
	2002	Q4-5	Q4	Q4
	2005	Q4	Q4-5	Q4
	2008	Q4	-	-
	2009	-	Q4	Q4
	2011	Q4	Q4	Q4
	2014	Q4	Q4	Q3-4
	2017	Q4	Q4	Q3-4
	2020	Q3-4	Q4	Q3
Water chemistry				
Monitoring station		Footbridge 1.8 km u/s Boyle (RS26B080200)	Drum Bridge (Boat House Ford) RS26B080400	Cootehall Bridge (RS26B080600)
PO_4+ Ecological Threshold <0.025 (high status) <0.035 (good status) as an annual mean mg P/L	*1995*	0.029	0.042	0.014
	1996	0.025	0.049	0.021
	1997	0.024	0.036	0.062
	1998	0.030	0.025	0.025
	2000	-	0.014	-
	2001	-	0.014	-
	2002	0.057	0.016	-
	2003	0.009	0.013	-
	2004	0.019	0.015	-
	2005	0.016	0.013	0.015
	2006	0.017	0.017	0.012
	2007	0.012	0.022	0.010
	2008	-	0.018	0.013
	2009	-	0.019	0.011
	2010	-	0.016	0.009
	2011	-	0.011	0.009
	2012	0.011	0.017	0.013
	2013	0.009	0.013	0.009
	2014	-	0.014	0.007
	2015	0.019	0.015	0.008
	2016	0.008	0.008	0.007
	2017	0.010	0.008	0.007
	2018	0.009	0.009	0.008

Waterbody		Boyle_020	Boyle_030	Boyle_040
	2019	0.010	0.009	0.015
	2020	0.021	0.012	0.009
Baseline PO_4+ (2017-2020)		**0.013**	**0.010**	**0.010**
NH_3+ Ecological Threshold <0.040 (high status) <0.065 (good status) as an annual mean mg N/L	*1995*	0.140	0.143	0.140
	1996	0.144	0.139	0.142
	1997	0.140	0.140	0.140
	1998	0.140	0.140	0.140
	2000	-	0.018	-
	2001	-	0.028	-
	2002	0.102	0.045	-
	2003	0.069	0.034	-
	2004	0.041	0.040	-
	2005	0.041	0.028	0.031
	2006	0.036	0.027	0.019
	2007	0.051	0.030	0.022
	2008	-	0.038	0.034
	2009	-	0.059	0.027
	2010	-	0.051	0.022
	2011	-	0.021	0.022
	2012	0.024	0.030	0.021
	2013	0.050	0.033	0.020
	2014	-	0.045	0.027
	2015	0.024	0.036	0.041
	2016	0.026	0.032	0.026
	2017	0.036	0.022	0.026
	2018	0.068	0.046	0.017
	2019	0.034	0.026	0.027
	2020	0.036	0.040	0.019
Baseline NH_3+ (2017-2020)		**0.044**	**0.034**	**0.022**
NO_3- [5] Indicative Ecological Threshold 3.5 for good status as an annual mean (none for high status at this point) mg N/L	*1995*	5.176	6.452	6.1
	1996	4.175	4.101	3.895
	1997	3.415	3.658	2.912
	1998	3.450	4.180	4.1
	2002	1.609	0.280	-
	2003	0.221	0.283	-
	2004	0.830	0.837	-
	2005	0.377	0.393	0.334
	2006	0.568	0.563	0.460
	2007	0.509	0.446	0.471
	2008	-	0.371	0.373

[5] For the Boyle_020 nitrate is not included in the sampling, therefore total n was used

Waterbody		Boyle_020	Boyle_030	Boyle_040
	2009	-	0.295	0.265
	2010	-	0.301	0.246
	2011	-	0.374	0.334
	2012	1.008	0.298	0.271
	2013	0.885	0.315	0.223
	2014	-	0.307	0.283
	2015	1.103	0.257	0.259
	2016	0.411	0.126	0.196
	2017	0.655	0.350	0.264
	2018	1.575	0.190	0.184
	2019	0.940	0.366	0.420
	2020	1.435	0.325	0.213
Baseline NO_3 (2017-2020)		**1.151**	**0.308**	**0.270**
Hydromorphology				
RHAT Score		No RHAT score available	No RHAT score available	No RHAT score available
Evidence of Drainage (OPW scheme, drainage district or other)		Boyle Arterial Drainage Scheme under OPW. Commenced in July 1982 Completed in December 1995[6] The OPW carried out maintenance works on channel C0 (Boyle_020, Boyle_030 and the Boyle_040 inflowing into Lough Key from Boyle Town) between October 2018 and June 2019.The works commenced at Drum Bridge (Wooden Bridge) near N4 and concluded just downstream of C1/15 (Outfall of Lough Gara). The works primarily consisted of pruning of branches with some tree cutting and the removal of some fallen trees from bed of the river. OPW do not intend to carry out maintenance on this channel again for a number of years.		
Comments		There is an upward trend for ammonia (as N) and total Oxidised Nitrogen (TON) since 2013 and a downward trend for ortho-phosphate.	There is an upward trend for TON and a downwards trend for ammonia (as N) and ortho-phosphate since 2013.	There is a downward trend in ammonia (as N), ortho-phosphate and TON since 2013.
Conceptual model required (Y/N)		Y	Y	Y
Ecological Status 2010– 2015 2013-2018		Good	Good	Moderate
EPA Biologist comments (Q value assessments, 2017 2020)		The EPA operational station witnessed a decline to unsatisfactory condition. Increased tolerant taxa were a consequence of the excessive algae (Cladophora glomerata) and high levels of interstitial siltation. The sensitive invertebrate indicators had much reduced densities relative to what would be expected in such favourable cobble habitat (June 2020).	Quality at Drum Bridge was satisfactory, although only marginally better than the upstream station. Siltation and eutrophication was still in evidence there in this borderline reach. An exceptionally high density of roach fry was observed in the vicinity of Drum Bridge (June 2020).	Ecological status deteriorated from Good to Moderate in 2013-2015. An increase in siltation with calcareous features were noted by the EPA biologist. The station at Cootehall Bridge (0600) saw a further decline with an absence of the mayfly, Ephemera Danica noted here again. (June 2017) Quality declined further at Cootehall Bridge. A thorough search failed to produce E. danica and zebra mussel and the water louse Asellus had an increased density. The invasive Dreissena is now rampant near the lake outflows (June 2020).

[6] Arterial Drainage of the Boyle and Bonet Rivers Dec 1996

Waterbody	Boyle_020	Boyle_030	Boyle_040
Protected Areas	Rockingham Spring is in a GSI Special Protection Area.	Rockingham Spring is in a GSI Special Protection Area.	Proposed Natural Heritage Areas – Corrigeenroe March, Fin Lough, Hog's Island (Lough Key), Drumman's Island (Lough Key), Drum Bridge (Lough Key), Tawnytaskin Wood (Lough Key). Rockingham Spring is in a GSI Special Protection Area.
WFD Objective	Good	Good	Good
Significant issue: monitoring points	Historically nutrients. Recent upwards trend again. Sediment	Historically nutrients. Recent upwards trend again. Sediment	Historically nutrients. Invasive Species Sediment
Significant issue: waterbody	Historically nutrients. Recent upwards trend again. Sediment	Historically nutrients. Recent upwards trend again. Sediment	Historically nutrients. Sediment

Lough Key Lake Chemistry Analysis

The mean EQS for total phosphorus was exceeded in 2008 across all monitored sites and in 2009 at station 30. Since then, the nutrient levels in Lough Key have remained at or below the good/moderate boundary. The EPA macrophyte report for Lough Key states that the baseline measurement in 2008 and a historical measurement from 2001 suggests that total phosphorus was much higher than it has been more recently. Analysis of the hydrochemistry data from the Boyle_020 and Boyle_030 would tend to confirm this, given the higher ortho-phosphorus concentrations recorded in the late 90's (1995 – 1998). Where total phosphorus levels are high for many years, phosphorus will build up in the sediment and can be used by rooted macrophytes. Many tolerant species can have a competitive advantage for many years although total phosphorus levels in the water column may be falling.

Chlorophyll levels have also been below the good to moderate boundary for the majority of years between 2008 and 2020 except for Station 30 in 2009 and 2018 and Station 40 in 2020. It should be noted that phytoplankton biomass (chlorophyll) should be used with caution for assessing lake ecological and trophic status when zebra mussels are present (S.I No. 77 of 2019 Surface Water Regulations Amendment).

The 2017 plant status of Lough Key is moderate and has been since the 2014 survey when it deteriorated from good status. The 2016-2018 Macrophyte report for Lough Key states: *"The lake plant community is characterised by the dominance of tolerant and elodeid taxa and low and declining Chara species. The plant community in Lough Key is somewhat typical of that seen in a lake where nutrients are higher than optimal for a natural system and where there are zebra mussels.*

Usually in an enriched lake there will be a reduction in the maximum depth of colonisation and the average depth of presence mainly due to high chlorophyll levels from increased phytoplankton growth. Both depth metrics have scored highly over the four surveys in this lake but with a reduction in the last survey. It is possible the zebra mussels are filtering enough phytoplankton to allow the water to remain relatively clear. There is a reduction in Chara spp. and this will typically occur in eutrophic lakes where elodeid species can outcompete and shade Chara species when nutrient levels are high".

Table 6 Outline of parameters influencing water quality in Lough Key

Waterbody		Key (IE_SH_26_724)				
Risk Category		*At Risk*				
Environmental Objective		Good				
Monitoring Station		Site 1	Key Station 20	Key Station 30	Key Station 40	Key Station 50
Water chemistry						
Total phosphorus (mg P/l) High status ≤ 0.010 (mean) Good status ≤ 0.025 (mean) (Total phosphorus mg/l)	*2007*	-	-	-	-	-
	2008	**0.032**	**0.026**	**0.027**	**0.026**	**0.025**
	2009	0.016	0.015	**0.030**	0.014	0.015
	2010	0.018	0.017	0.015	0.019	0.019
	2011	0.018	0.013	0.014	0.013	0.014
	2012	0.019	0.022	0.018	0.018	0.014
	2013	0.020	0.020	0.022	0.019	0.020
	2014	0.020	0.020	0.020	0.017	0.016
	2015	0.021	0.020	0.022	0.019	0.019
	2016	0.018	0.018	0.017	0.017	0.019
	2017	0.020	0.020	0.020	0.018	0.019
	2018	0.020	0.018	0.021	0.018	0.018
	2019	0.020	0.019	0.018	0.018	0.020
	2020	0.019	0.021	0.018	0.032	0.018
Baseline TP (2017-2020)		**0.020**	**0.020**	**0.019**	**0.022**	**0.019**
Total ammonia (mg N/l) High status ≤ 0.040 (mean) and ≤ 0.090 (95%ile) Good status ≤ 0.065 (mean) and ≤ 0.140 (95%ile)	2007	0.010	0.010	0.010	0.020	0.015
	2008	0.007	0.022	0.032	0.007	**0.075**
	2009	0.017	0.016	0.035	0.017	0.021
	2010	0.030	0.025	0.030	0.022	0.025
	2011	0.013	0.013	0.016	0.023	0.020
	2012	0.006	0.006	0.005	0.006	0.007
	2013	0.017	0.015	0.020	0.015	0.015
	2014	0.010	0.010	0.010	0.010	0.010
	2015	0.017	0.017	0.016	0.016	0.015
	2016	0.010	0.012	0.010	0.010	0.010
	2017	0.020	0.019	0.023	0.020	0.018
	2018	0.010	0.012	0.010	0.010	0.015
	2019	0.020	0.020	0.021	0.023	0.021
	2020	0.010	0.018	0.010	0.015	0.02
Baseline NH_3 (2017-2020)		**0.015**	**0.017**	**0.016**	**0.017**	**0.019**
Chlorophyll a (µg/l) Lake type 12 HG: 5.8 GM: 10 MP: 20 PB: 40	2007	2.050	1.600	2.267	2.100	2.067
	2008	4.175	4.900	3.975	5.275	4.575
	2009	5.500	5.925	26.550	5.375	6.275
	2010	3.900	4.500	3.975	4.925	5.050
	2011	4.467	3.566	5.700	4.633	5.466
	2012	2.550	2.300	2.500	2.125	2.400
	2013	5.125	6.225	5.050	6.375	6.100
	2014	6.475	7.725	5.475	6.825	6.050
	2015	5.350	5.900	6.300	6.400	8.050

Waterbody		Key (IE_SH_26_724)				
Risk Category		*At Risk*				
Environmental Objective		Good				
Monitoring Station		Site 1	Key Station 20	Key Station 30	Key Station 40	Key Station 50
	2016	7.750	6.925	7.450	7.475	9.900
	2017	3.150	4.275	3.850	3.600	4.625
	2018	2.825	5.000	27.875	6.500	5.525
	2019	4.975	4.800	3.950	4.450	5.775
	2020	4.000	7.067	8.200	23.33	6.267
Baseline chlorophyll a (2017-2020)		**3.738**	**5.286**	**10.969**	**9.470**	**5.548**
Significant issue: monitoring points		Total phosphorus (historically – 2008 & potentially in previous years) and Invasive Species. Possibly sediment.				
Significant issue: waterbody		Total phosphorus (historically – 2008 & previous years) and Invasive Species. Possibly sediment.				
Comments		The total phosphorus levels in Lough Key across the 5 operational monitoring sites from 2013 to 2019 are showing a downward trend. In 2008 (and potentially prior to this year although we have no data to confirm this), total phosphorus levels exceeded the mean EQS for good status across all monitored sites on the lake. Therefore, there is potentially phosphorus within the lakebed sediments which is a constant supply to lake macrophytes. Total ammonia (as N) and chlorophyll are showing an upward trend (**Appendix A 9.2).**				

3 Significant Pressures

3.1 Agriculture

Agriculture has not been identified as a significant pressure on any water body within the Lough Key PAA based on EPA characterisation (2015). However, given that the potential significant issues are total phosphorus (at least historically) and potentially sediment, agriculture will not be ruled out as a potential significant pressure at this stage in the process.

The Lough Key PAA is dominated by a mix of both peat and poorly draining soils, primarily to the north and north west of Lough Key, and well drained soils to the south and south west of Lough Key. Phosphate PIP tends to be higher ranked along the smaller tributaries entering the Boyle River such as the Mocmoyne_010, and along sections of the Boyle_020 waterbody, and to the north of Lough Key (townlands of e.g., Doon, Derryvunny, Annagh/Rumaila). Upstream of the PAA, is Lough Gara and the Boyle_010 and PIP for phosphate is significantly higher in this subcatchment (Boyle_SC_010). PIP for surface water nitrate is generally low in the PAA water bodies, bar some rank 1 -3 PIP areas to the south of Lough Key (e.g., Demense_010). Upstream of the PAA in the Boyle SC_010 sub catchment there is only one small pocket of higher ranked PIP for nitrate (1-3) in the Ballymore West and East area.

Agriculture is identified through EPA characterisation (2nd cycle) as a significant pressure on Lough Gara[7]. The associated activities potentially leading to this pressure were identified as use of MCPA for rush control however recent updates from the National Pesticides in Drinking Water Action Group show that Lough Gara is no longer appearing on exceedance updates. The pollution impact potential for phosphate map shows significant areas of relative risk for phosphate loss from agriculture to surface water as shown in **Figure 10**.

The majority of the Boyle_SC_010 and Boyle_SC_020 is farming below 170kgs of nitrogen per hectare. There are two herdowners farming between the 170-210kgs of nitrogen per hectare. There are 30% well drained soils, 35% Poorly drained soils and 23% peat soils in the Boyle subcatchments

Figure 11). Agriculture in the Boyle_SC_010 and Boyle_SC_020 is extensive and the main farming enterprises are beef/suckler. The average farm size is 43kgs N/Ha. This information is based on the 2014 LPIS data.

[7] Upper Shannon (Boyle) Catchment Assessment 2010-2015 (HA26B)- December 2018

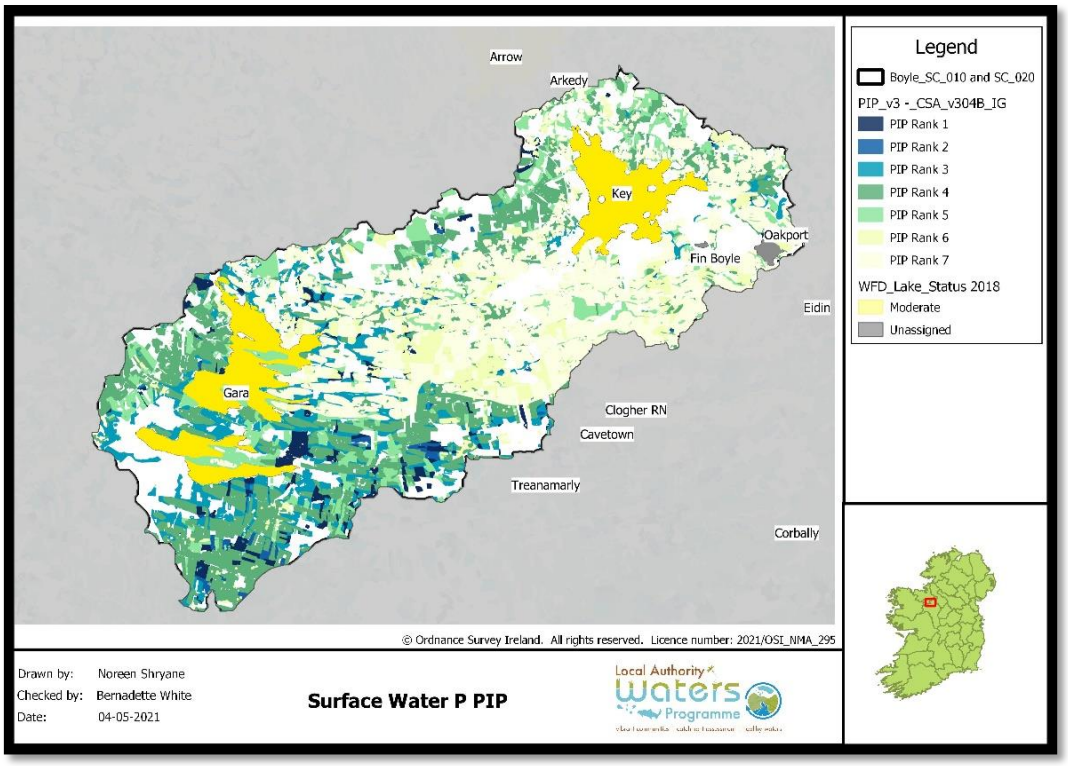


Figure 10 Surface Water P PIP

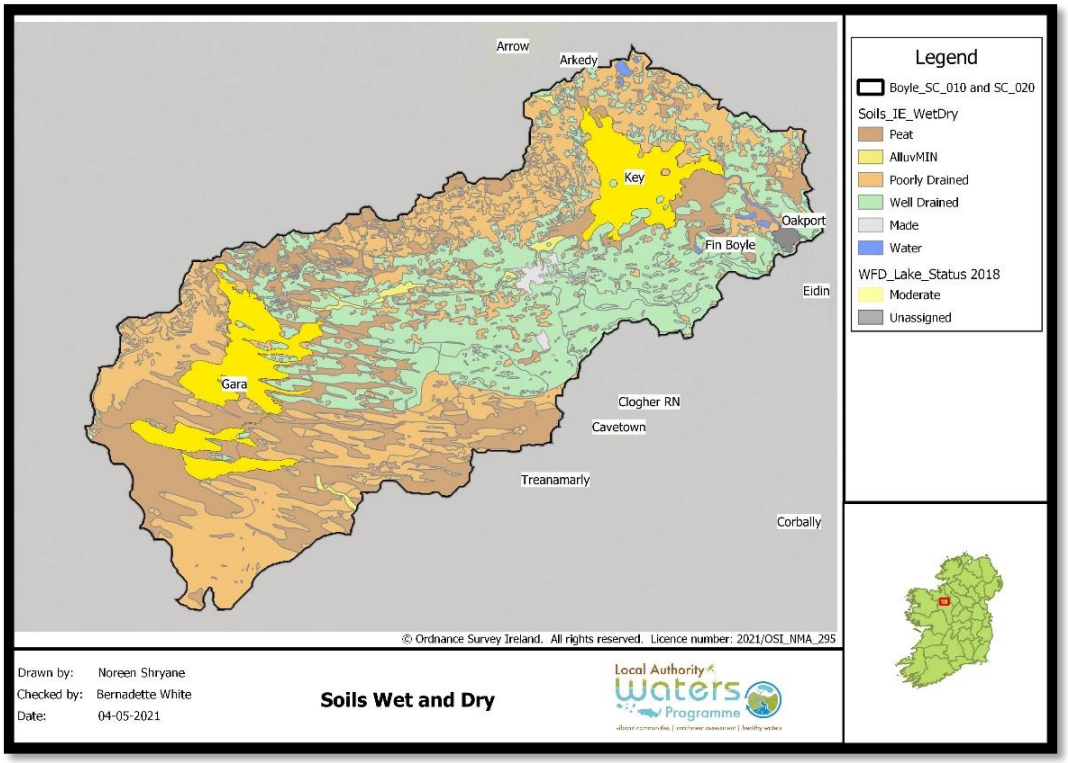


Figure 11 Soils Wet and Dry

3.2 Urban Waste Water (Boyle Agglomeration and Combined Sewer Overflows)

The town of Boyle is served by a large mostly combined sewerage system with dedicated storm sewers which drain to the river (Agglomeration PE of 2,001 to 10,000). All foul flows from the various areas are collected at a main pumping station located at the treatment plant (**Figure 12**). The town has a number of light industries which discharge only domestic grade effluent to the collection system.

All effluent from the Boyle WWTP discharges to the Boyle_040 river through a single discharge point (SW1). The wastewater treatment plant has a capacity PE of 6,000. The treatment process includes the following: - Preliminary Treatment (Screening and Grit Removal), Secondary Treatment (Fine Bubble Diffused Aeration), Nutrient Removal (Chemical Dosing for phosphorous removal).

The history of exceedances in the ELVs (2012, 2014, 2015 and 2016) lead to a number of improvement works which were undertaken in 2017:

- The preparation of a Drainage Area Plan and Wastewater Source Control Study has been undertaken in Boyle to accurately estimate the condition of the existing networks and the flow and load arriving to the Wastewater Treatment works.
- The manhole and sewer CCTV survey are complete for the Town and the Flow and Rainfall Survey in Boyle are also complete.
- The Model build for the network in the Town is ongoing.
- The above works are completed and at Present there are no plans for further capital investment in the Boyle Wastewater Treatment Plant (November 2019).

In 2018, the final effluent from the Primary Discharge Point was non-compliant with the Emission Limit Values (ELV) for ortho phosphate (mg/l) and ammonia NH_3 (mg/l). There were 5 incidents at the plant which were reported to the EPA. In 2019, the final effluent from the Primary Discharge Point was non-compliant with the ELV for ammonia NH_3 (mg/l). There were 2 incidents at the plant which were reported to the EPA. The 2019 AER for Boyle states that "*Based on ambient monitoring results a deterioration in BOD, concentrations downstream of the effluent discharge is noted. A deterioration in water quality has been identified, however it is not known if it or is not caused by the WWTP. Other causes of deterioration in water quality in the area are unknown".*

LAWPRO have completed an assimilative capacity assessment for the WWTP using data from 2018 and 2019. The calculations do not demonstrate an assimilative capacity issue relating to the primary discharge, or an available headroom capacity issue. The hydrochemistry data available for the Boyle_030 (Drum Bridge (Boat House Ford) monitoring point, downstream of the primary discharge and SWOs) does not indicate an issue with the nutrient's ortho-phosphate, nitrate or ammonia. However, it may be possible that nutrients are being transported to the downstream Lough Key and are accumulating in the lake. There were breaches in the annual mean EQS for BOD in 2007 (1.6mg/l), 2008 (1.65mg/l) and 2014 (1.56mg/l). There has been numerous individual exceedances in the mean EQS for ammonia and BOD from 2016 to 2020.

The availability of the phytoplankton for the zebra mussels depends on seasonal factors and on the available phosphorus in Lough Key. It is known that the main source of this nutrient is through the loadings from Boyle WWTP, as agriculture is marginal in the catchment (Lucy 2005). The WWTP phosphorus removal system in 2002 was intended to significantly reduce loadings. From 2001 to 2003, TP loadings to the lake dropped from mesotrophic to oligotrophic levels and it was anticipated that this would continue indefinitely. It was hoped that this perhaps would result in a reduction in the zebra mussel population due to a subsequent reduction in available food (phytoplankton). However,

according to the data in the subsequent decade, WWTP phosphorus loadings were mostly mesotrophic (except 2007, 2010, 2013) as were the lake water TP levels, which reflect an input from the WWTP (Lucy 2015). [8]

LAWPRO were made aware of potential intermittent discharges from the Wooden Bridge pumping station into the Boyle River at the community information meeting held on 24th of October 2019. These incidents were of particular concern to the locals given the nature of municipal wastewater materials they observed close to the discharge location of the pumping station. Also, it had been noted that these potential discharges were occurring at times other than storm weather events or periods of prolonged wet weather. SWO facilities such as Wooden Bridge pumping station should not be operating during dry weather. This issue will be assessed during the LCA to gather further evidence. If a problem is found, LAWPRO will liaise with Irish Water.

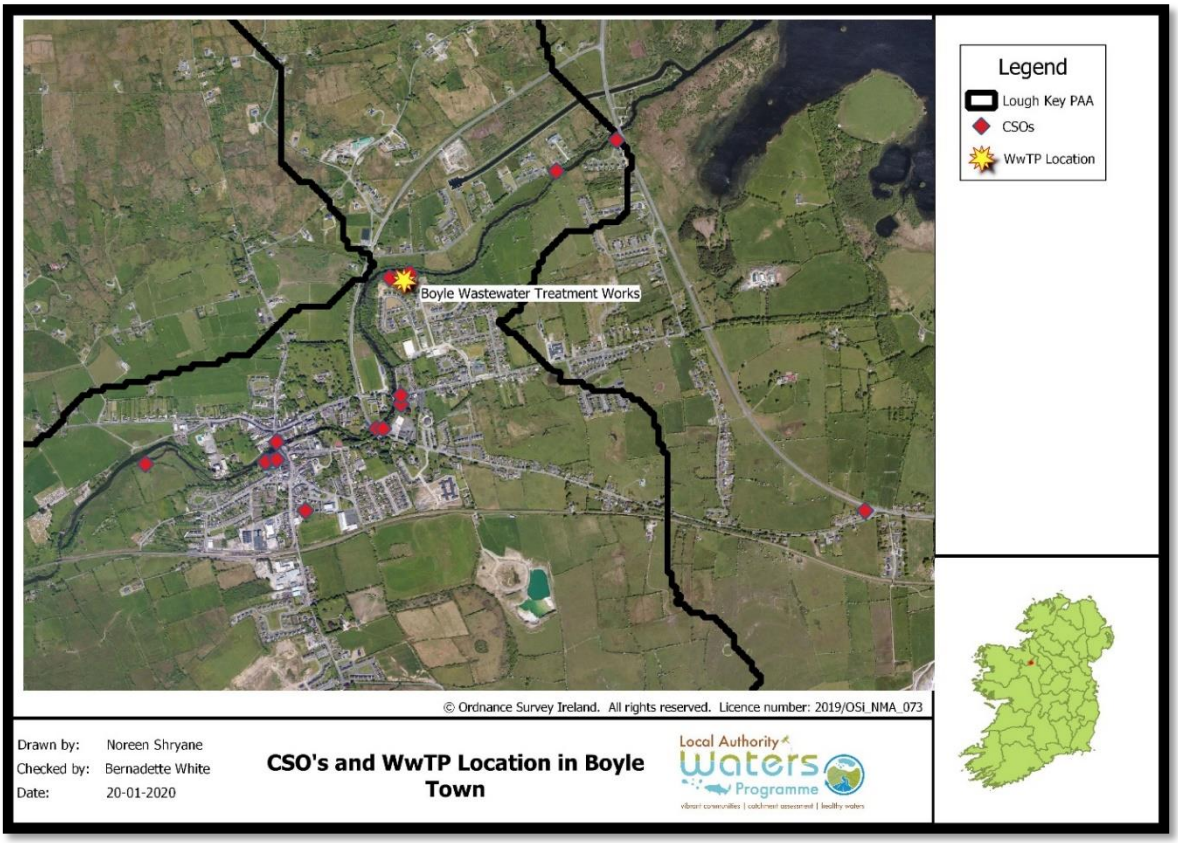


Figure 12 Combined Sewer Overflows and WWTP Location

[8] 2015-W-SS-18 - Zebra Mussel Survey of Lough Key 2015

3.3 Anthropogenic Pressures

Recreational pressures e.g., boating and Lough Key Forest Park are potential sources of anthropogenic pressures on the Boyle_040 and Lough Key based on EPA characterisation (2015). There are two private marinas in the PAA: The Moorings and Tara Marina. There are eight moorings located on the Boyle River and Lough Key; seven of these are operated by Waterways Ireland and one is a private mooring (Lough Key old Harbour).There are two Waterways Ireland pump out facilities (one at the Boyle canal and the other at Lough Key Forest Park at the Marina).

The following are possible impacts from recreational activities:

1. The release of hydrocarbons into the environment by the engines of recreational boats.
2. Oily and bilge water: unburnt or incompletely burnt fuel, particulates and traces of oil are released and they can accumulate locally, especially when boats are stationary, which results in an oil film on the surrounding water.
3. Sewage and grey water: grey water (washing waters) from recreational craft contains a wide range of chemicals and fats and can often be released into waterbodies.
4. Antifouling paints which are used to prevent marine organisms developing on the surface of the hull. The biocide agents they contain might be toxic, but their use is regulated.[9]

3.4 Invasive Species

The zebra mussel (Dreissena polymorpha) is an aquatic invasive species, which spread to Lough Key from the lower Shannon in the late 1990s. Zebra mussels are effective filter feeders, with high individual clearance rates of phytoplankton, cyanobacteria and other particles. Successful colonisation of a lake results in increased transparency and decreased chlorophyll levels and often a consequent decrease in total phosphorus in the water column. [10] The total phosphorus levels in Lough Key across the 5 operational monitoring sites from 2013 to 2019 are showing a downward trend. While the total ammonia (as N) and chlorophyll concentrations are showing an upward trend. One possible effect is that while the zebra mussels are stripping the lake of phytoplankton, they are depositing nutrients at the bottom of the lake which will makes more plants grow. They are also causing more light to get to the bottom of the lake which would also help these plants to grow. Water transparency could also change fish behaviour. Anglers have also pointed out that by covering the bottom of lake they could also affect the hatches of certain types of insects, which provide vital food for trout and salmon.[11]

[9] https://ec.europa.eu/environment/integration/research/newsalert/pdf/87na2_en.pdf
[10] Dr. Frances Lucey, 2005, Nutrient Levels and the Zebra Mussel population in Lough Key
[11] https://www.irishtimes.com/news/charting-billions-of-colonising-mussels-1.332867

4 Other issues and pressures in the PAA

4.1 Forestry

Forestry has not been identified as a significant pressure on any water body within the Lough Key PAA based on initial characterisation. However, given that the potential significant issues are total phosphorus (at least historically) and potentially sediment, forestry will not be ruled out as a potential significant pressure at this stage in the process. There is an extensive area of both private and Coillte forestry in the upper reaches of the sub catchment on old red sandstone where forest mediated acidification could be an issue (**Figure 13**).

Within private plantations, the main species planted within the PAA was Sitka Spruce. The second most common species was broadleaf (other mature). For Sitka Spruce , broadleaf (other mature) and Norway spruce, the majority of planting took place in the 1990's and 2000's and therefore would have been subject to new Forest Service guidelines regarding buffer zone management along watercourses e.g., within the buffer zone, ground preparation and other forest operations curtailed in order to protect water quality. In addition, drainage channels leading from the site must taper out before entering the buffer zone. Within the Coillte plantations, the main species planted was Sitka Spruce. The second most common land use type is comprised of felled, bare plantable and unplantable, burned and water. The third most common species is Norway Spruce. Private planting has been dominated by Sitka Spruce the majority of which was planted in the 1990's and 2000's and therefore would have been subject to new Forest Service guidelines regarding buffers zone management along watercourses.

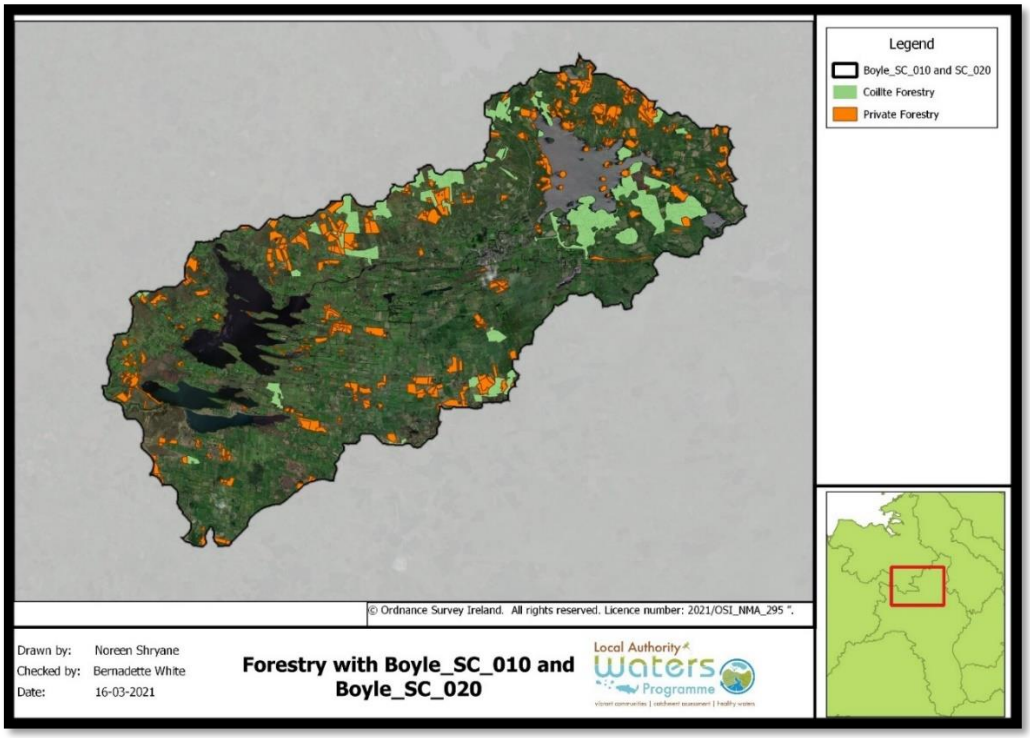


Figure 13 Forestry cover within Boyle_SC_010 and Boyle_SC_020

4.2 Historic Landfill

There is a historic unlicenced landfill site, Boyle landfill, in the upper reaches of the Mocmoyne_010 RWB (**Figure 14**). This landfill is not lined and it was capped with whatever soil was available at the time. This landfill closed in 1998. This landfill was monitored once a year between 2002 and 2015 by the local authority. There is no other monitoring data available. There were three surface water monitoring sites (SW1, SW2 and SW3 and five groundwater monitoring sites (BH1, BH2, BH3, BH4 and BH6). There were numerous exceedances of the mean EQS for ammonia and BOD in all three SW sites. The orthophosphate was below both EQS's at SW1 and SW2. There were multiple exceedances in the mean EQS at SW3. There were multiple exceedances in ammonia and orthophosphate across all borehole sites. There were no remediation works completed on Boyle landfill.

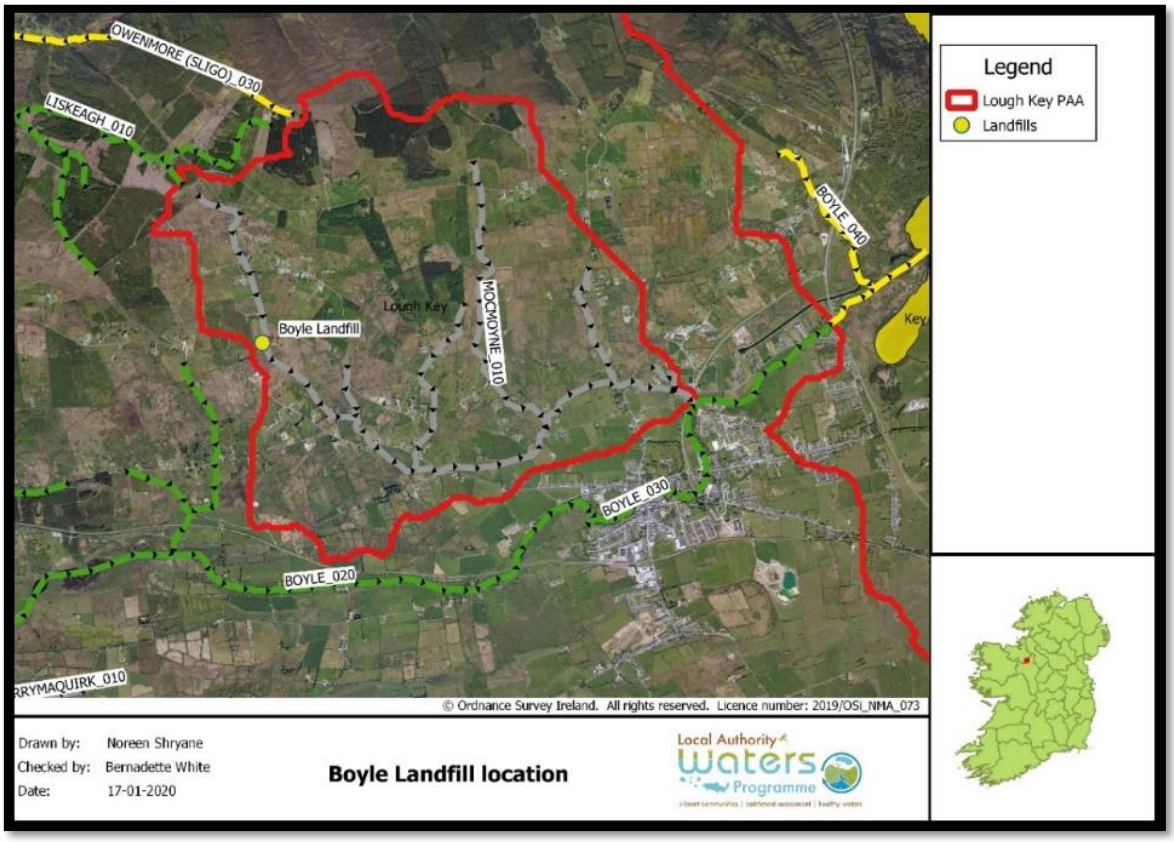


Figure 14 Historic Landfill within the Mocmoyne_010 River waterbody

4.3 Industry (Section 4s)

There are Four Section 4 Licences in the 2nd cycle waterbodies: **Aghacarra Housing Estate** (WP-01-19), **Bramer Doon Limited** (The Moorings Restaurant) (WP-01-18), **Katonah Developments Limited** (Seven domestic dwellings) (WP-04-04) and **Tara Marina** (**Paddy Gilboy**) (WP-02-04A) (**Figure 15**) and one Section 4 in a 3rd cycle waterbody (**Keywater Fisheries Ltd**.)

Aghacarra Housing Estate: This housing estate is located in the North West of the PAA near Corrigeenroe village. The associated wastewater treatment plant was substantially upgraded under a new application in 2019 including that it now discharges to ground water (Curlews Mountain Groundwater body) and not to surface water as was originally the case. The monitoring data will be assessed when it becomes available.

Bramer Doon Ltd: The Section 4 for Bramer Doon Ltd is not mapped in **Figure 15** however it is at the same location as Katonah Developments Ltd. The following information has been provided by Roscommon County Council: The site of Katonah Developments Ltd and Bramer Doon Ltd is not suitable for percolation therefore a discharge licence was granted for the Moorings Restaurant in 2018/2019 which has its own treatment plant with a discharge to Lough Key. The only available monitoring data for The Moorings Restaurant is for 2020 because prior to the granting of the new discharge licence the Moorings discharge was going to the treatment plant for Katonah Developments Ltd. The 2020 discharge monitoring data for Bramer Doon Ltd. indicates an issue with ortho-phosphate with it exceeding the discharge licence limit at every sampling date (seven in total). All other parameters were within the licence limit.

Katonah Developments Ltd: In November 2019 there was only one house of the seven occupied however in February 2021 all houses are occupied. There is a settlement tank for the effluent which is pumped to a peat bed filtration system. This system however is very overgrown and needs to be replaced. There has been issues with the effluent flowing over ground to a field drain which then makes its way to a reed bed on the shores of Lough Key. Sewage fungus has been noted in this drain by Roscommon County Council Staff.

Tara Marina has a treatment plant and a discharge licence. The 2019 discharge monitoring data indicates exceedances in BOD, ortho-phosphate and suspended solids in May 2019. The assimilative capacity calculation for 2019 does not demonstrate an assimilative capacity issue, nor is there an available headroom capacity issue.

It was not possible to complete assimilative capacity calculations for Bramer Doon Ltd or Katonah Developments Ltd as the Hydrometric Gauge (Drumcormick) which is located on the shores of Lough Key across from the Mooring Restaurant is inactive. There are two further gauges downstream on the Boyle_040 river however there is only water level data available for these. As these two Section 4s discharge into Lough Key it is not possible to calculate the flow of the receiving waterbody. The 2019 discharge monitoring data for Katonah Development Ltd indicated one exceedance for suspended solids.

Keywater Fisheries Ltd: This Section 4 is located in the upper reaches of the Boyle_020 waterbody. The license was issued in 2003 and gives an indication of the current emission limit values. This premises was closed for a number of years but has reopened with some small-scale research projects ongoing in collaboration with Bord Iascaigh Mhara. Sligo County Council are in the process of reviewing the license (May 2021). They have no active flow measurement in operation at the present time, which they are trying to address. They have registered the abstraction with the EPA. The average of 6 samples taken over 12 months indicates an exceedance for Suspended Solids.

The monitoring data for all the Section 4's will be assessed on an ongoing basis.

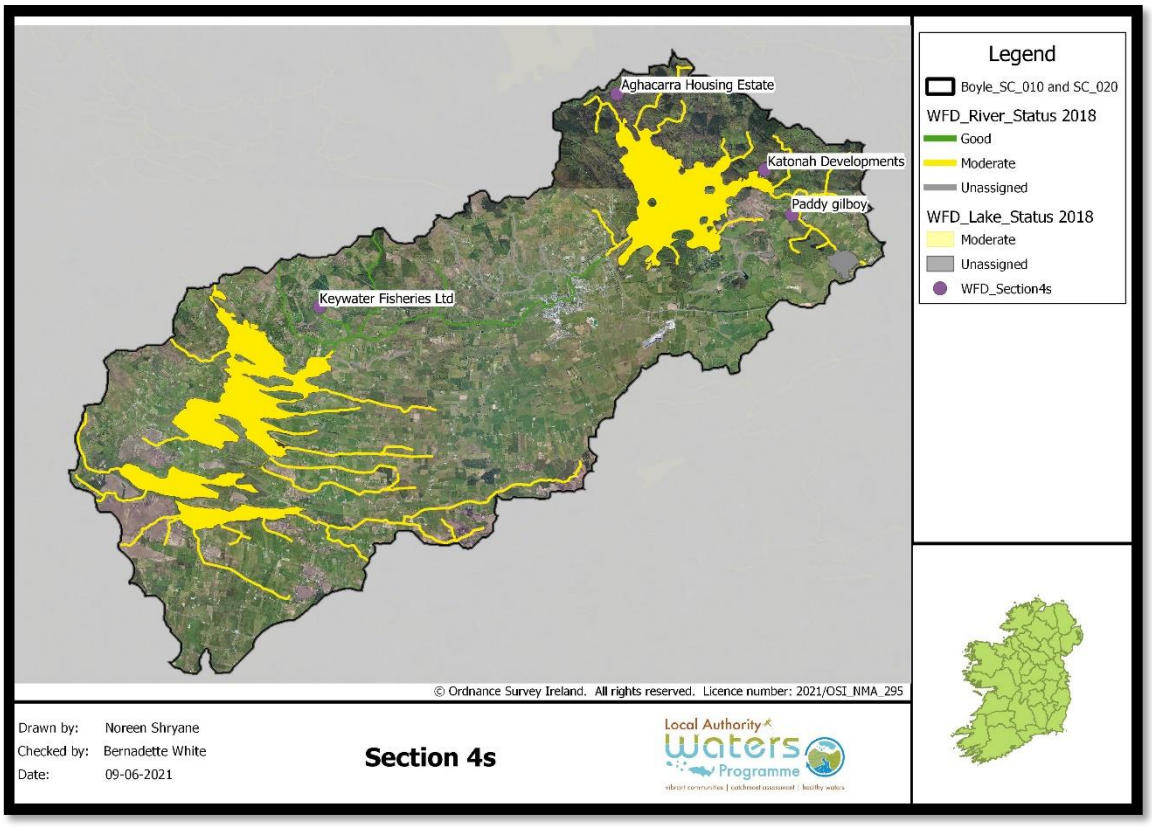


Figure 15 Section 4s within the Boyle_SC_020

4.4 Domestic Waste Water (DWWTS)

The EPA Sanicose model shows a number of high impact potential and very high impact potential systems in the Mocmoyne_010 and Boyle_040 river subbasins. In particular in the Boyle_040, there are some clusters along streams which input to Lough Key. Limited inspections (3 based on the DWWA on EDEN) have been carried out in this PAA to date by the local authority therefore there is no real evidence for significant pressures from DWWTS on water bodies.

5 Pathway Information and analysis/ Conceptual Model

5.1 Overview of Pathways in the PAA

The regional pathway framework is provided by the aquifer in the PAA and sub-compartments are determined by soil drainage and groundwater vulnerability. For this PAA, five compartments (**Table 7** and **Figure 16**) have been identified. The conceptual model has been outlined at subcatchment scale.

The Boyle_SC_010 and Boyle_SC_020 consists of three different aquifer types which are as follows:

- Regionally Important Aquifer – Karstified (Conduit) (RKc)
- Locally Important Aquifer – Bedrock which is moderately productive only in Local Zones (LI)
- Poor Aquifer – Bedrock which is Generally Unproductive except for Local Zones (PI)

- Compartment 1- Regionally Important Aquifer – Well drained soils
- Compartment 2- Regionally Important Aquifer – Poorly drained soils
- Compartment 3- Locally Important Aquifer - Well drained soils
- Compartment 4- Locally Important Aquifer- Poorly drained soils
- Compartment 5- Poor Aquifer- Poorly drained soils

The first and second compartments comprises a Regionally Important Aquifer – Karstified (Conduit) (RKc) and is the dominant aquifer type in the Boyle subcatchments. Compartment 1 is on the well-drained soils while compartment 2 is on the peat and poorly drained soils. The groundwater flow is dominated by conduits, and karst features such as swallow holes and large springs are common. There is a high degree of interconnection between groundwater and surface water in this GWB. Numerous karst features such as turloughs, swallow holes, sinking streams, sparse or intermittent streams, limestone pavements, caves and large springs are evident. Surface streams sink frequently, draining through karst features into the groundwater system, providing rapid recharge to groundwater. Streams re-emerge as springs, after flowing as groundwater for some distance, to form significant surface streams (Carrick on Shannon Groundwater Body description) once again. Any contamination of surface water is rapidly transported into the groundwater system, and vice versa.

The third and fourth compartments comprise of a Locally Important Aquifer – Bedrock which is moderately productive only in Local Zones (LI). Compartment 3 is on the well-drained soils and compartment 4 is on the Poorly drained soils. In general, the effective thickness of the aquifer is likely to be not more than 15 m, comprising a weathered zone of a few metres and a connected fracture zone below this. The groundwater body is composed primarily of low permeability rocks, although localized zones of enhanced permeability do occur in the vicinity of fault zones. Small, isolated areas of higher permeability rocks occur within the groundwater body. The rock units in this body are of low permeability and baseflow to rivers and streams is likely to be relatively low. (Curlew Groundwater Body description).

The fifth compartment comprises of Poor Aquifer – Bedrock which is Generally Unproductive except for Local Zones (PI). The compartment is predominately on the peat and poorly drained soils. Most recharge is likely to occur in the upland areas in the Curlew Mountains where the subsoil is thinnest. A large number of streams run off the upland areas indicating that the bedrock is of relatively low permeability and much of the potential recharge is rejected. Recharge is of a diffuse nature. (Curlew Groundwater Body description).

Subsoils are mostly till derived chiefly from Devonian sandstones and Cut peat. The majority of the two Boyle sub-catchments subsoil permeability is low, however there is a band along both the northern and southern boundary (compartment, 1, 2 and 5) where it is <3m to bedrock. Groundwater vulnerability is high to extreme where the subsoils are <3m to bedrock as there is little if any attenuation. The peat and poorly drained areas have low to moderate vulnerability. Susceptibility for transporting nitrate along the sub surface and near surface water pathway is predominantly low with the exception of the well-drained soils which are highly susceptible to transporting nitrate (**Figure 17**). High risk areas for phosphate loss to surface water coincide with the peat, poorly drained and mineral alluvium areas. Phosphate is more likely to flow overland to surface waters rather than being retained in the soil and subsoil.PIP maps for nitrate in surface water and groundwater indicate predominately moderate to low-risk areas throughout the subcatchments. There are a few small patches of high-risk areas in both surface and ground water where the depth to bedrock is <3m. PIP maps for phosphate in surface water indicates moderate to high-risk areas (Rank 1-3) throughout the Boyle_SC_010 subcatchment with some smaller patches scattered through the Boyle_SC_020 subcatchment (**Figure 18**). There are numerous mapped karst features by GSI within the PAA, including 3 turloughs, 2 tracer lines, approximately 13 springs, 19 swallow holes and numerous sinking streams.

In summary, the soils in the Boyle sub catchments are predominately wet with overland flow/drains as the main pathways for contaminants. The soils in the well-drained areas of the sub catchments have a high rank (1-3) for near surface and sub surface nitrate loss.

5.2 Pathways Conceptual Model

Table 7 Main pathways identified within each compartment in the Lough Key PAA and associated subcatchments

		Compartment 1 (Regionally Important Aquifer)	Compartment 2 (Regionally Important Aquifer)	Compartment 3 (Locally Important Aquifer)	Compartment 4 (Locally Important Aquifer)	Compartment 5 (Poor Aquifer)
		Well Drained	Poorly Drained	Well Drained	Poorly Drained	Poorly Drained
Pathway Info	Aquifer	Regionally Important Karsified Conduit	Regionally Important Karsified Conduit	Locally Important Aquifer	Locally Important Aquifer	Poor Aquifer
	Topography	Undulating to Hill Flat to undulating	Undulating to Hill Flat to undulating	Undulating to Hill Flat to undulating	Undulating to Hill Flat to undulating	Undulating to Hill
	Soil	TLs TDSs	TDSs Cut	TDSs	TDSs Cut	BkPt TDSs
	Soils Wet/Dry	Well drained soils	Peat and Poorly drained Soils	Well drained soils	Peat and Poorly drained Soils	Peat and Poorly drained Soils
	Subsoil	Till derived chiefly from Devonian Sandstones Till derived chiefly from limestones Bedrock and outcrop and sub crop	Cut Peat Till derived chiefly from Devonian Sandstones	Till derived chiefly from Devonian Sandstones	Cut Peat Till derived chiefly from Devonian Sandstones Bedrock and outcrop and sub crop	Cut Peat Till derived chiefly from Devonian Sandstones
	Subsoil Permeability	Low to Not applicable , DTB<3m	Low to Not applicable , DTB<3m	Low to Not applicable , DTB<3m	Low to Not applicable , DTB<3m	Low to Not applicable , DTB<3m
	Rock Unit	Dinantian Pure Bedded Limestones	Dinantian Pure Bedded Limestones	Dinantian lower impure limestone Dinantian Mixed Sandstones, Shales and Limestones	Dinantian lower impure limestone Dinantian Mixed Sandstones, Shales and Limestones Basalt and Other Volcanic Rocks	Devonian Old Red Sandstone
	Groundwater vulnerability	Extreme (E) to X	X to Low	Extreme (E) to X	X to Low	X to Low
	Karst Features	Turlough, Sinking streams, Boreholes, Swallow holes, enclosed depressions	Turlough, Sinking streams, Boreholes, Swallow holes, enclosed depressions	1 x Borehole	None	None
	Hydrology	Low	High	Low	High	High

		Compartment 1 (Regionally Important Aquifer)	Compartment 2 (Regionally Important Aquifer)	Compartment 3 (Locally Important Aquifer)	Compartment 4 (Locally Important Aquifer)	Compartment 5 (Poor Aquifer)
		Well Drained	Poorly Drained	Well Drained	Poorly Drained	Poorly Drained
	Drainage density					
	PO4 Susceptibility to Surface Water	Rank 4-7	Rank 1-6	Rank 4-7	Rank 1-4	Rank 1-4
	NO3 susceptibility to Surface Water	Rank 1-3	Rank 4-5	Rank 1-3	Rank 4-5	Rank 4-5
	PO4 PIP	Rank 4-7	Rank 1-3	Rank 4-7	Rank 1-3	Rank 1-3
	NO3 PIP	Rank 1-3	Rank 4-7	Rank 1-3	Rank 4-7	Rank 4-7
	Flowpaths	Subsurface pathways	Overland Flow	Subsurface pathways	Overland Flow	Overland Flow
	Likely CSAs	Rank 1-3 N PIP	Rank 1-3 P PIP	Rank 1-3 N PIP	Rank 1-3 P PIP	Rank 1-3 P PIP
	Direct (e.g., pipe)	Section 4	-	-	Section 4	-
Location of Monitoring station		Boyle_040 monitoring station (Cootehall Bridge) is within this compartment but is at the lower end of the catchment and is therefore influenced by all compartments.	-	-	Boyle_010 (Cuppanagh Bridge) Boyle_020 (Footbridge 1.8km U/S Boyle) Boyle_030 (Drum Bridge)	-
Significant Issues		nitrate	sediment phosphate	nitrate	sediment phosphate	sediment phosphate

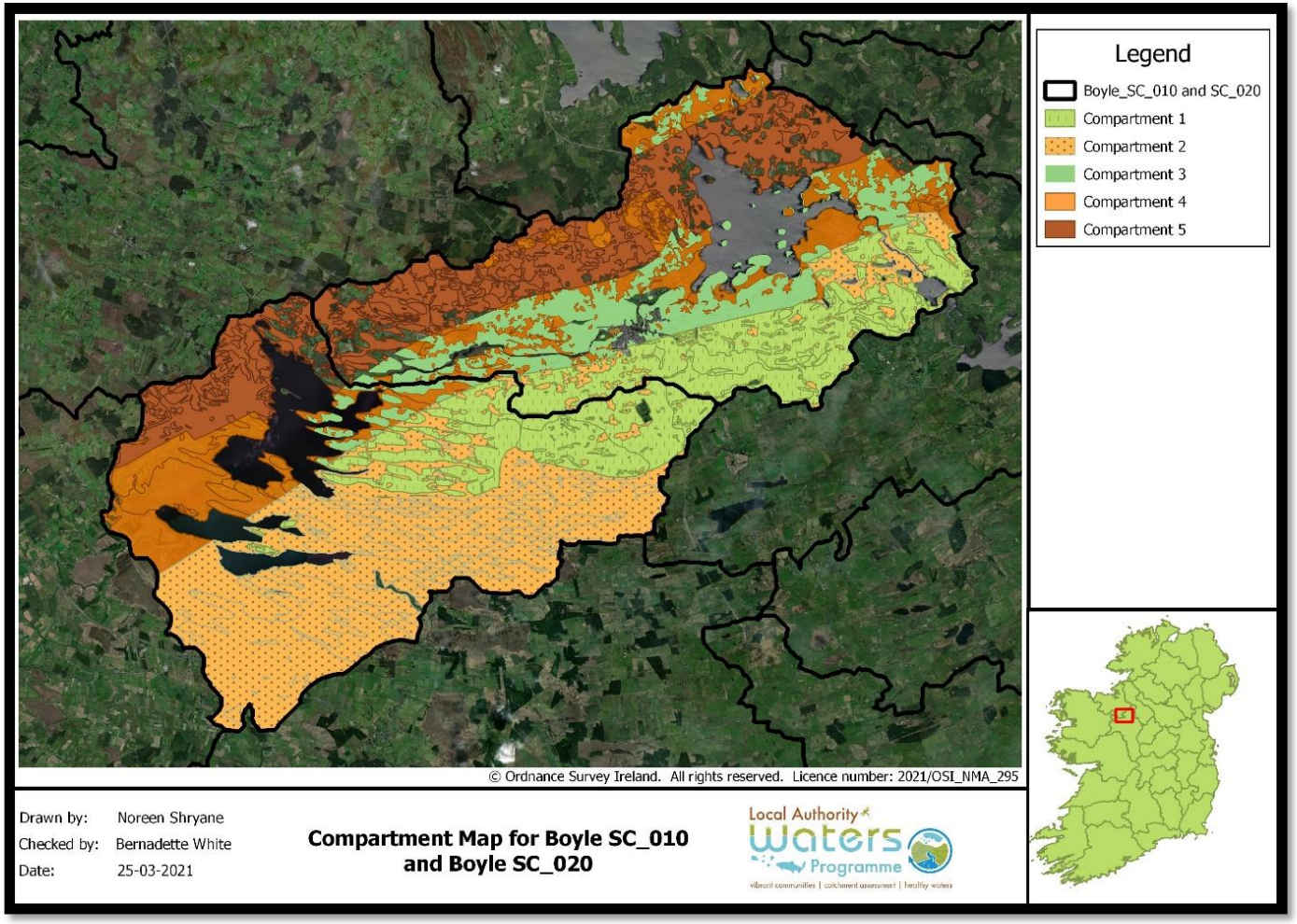


Figure 16 Compartments in the conceptual model

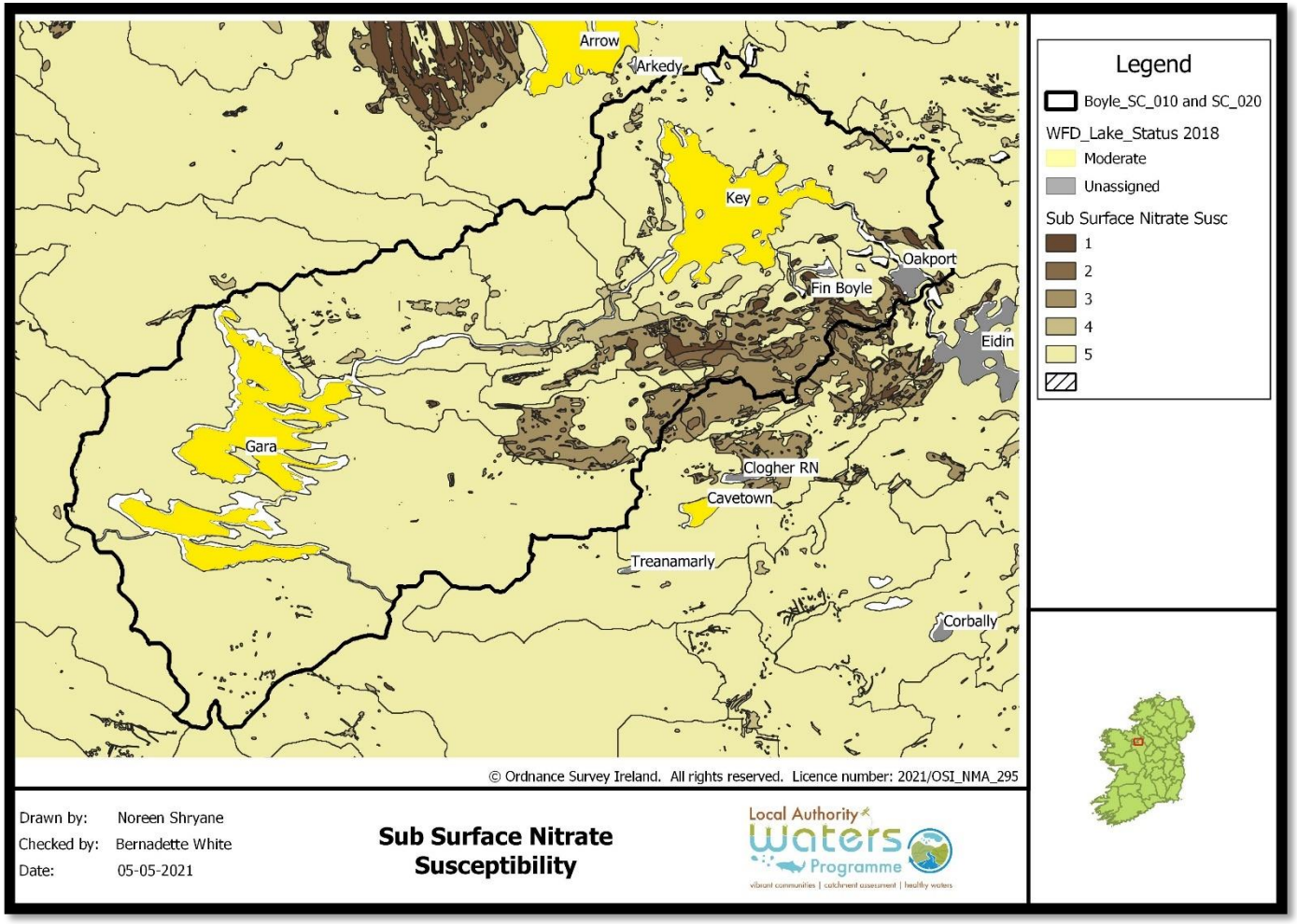


Figure 17 Sub surface nitrate susceptibility in the Boyle subcatchments

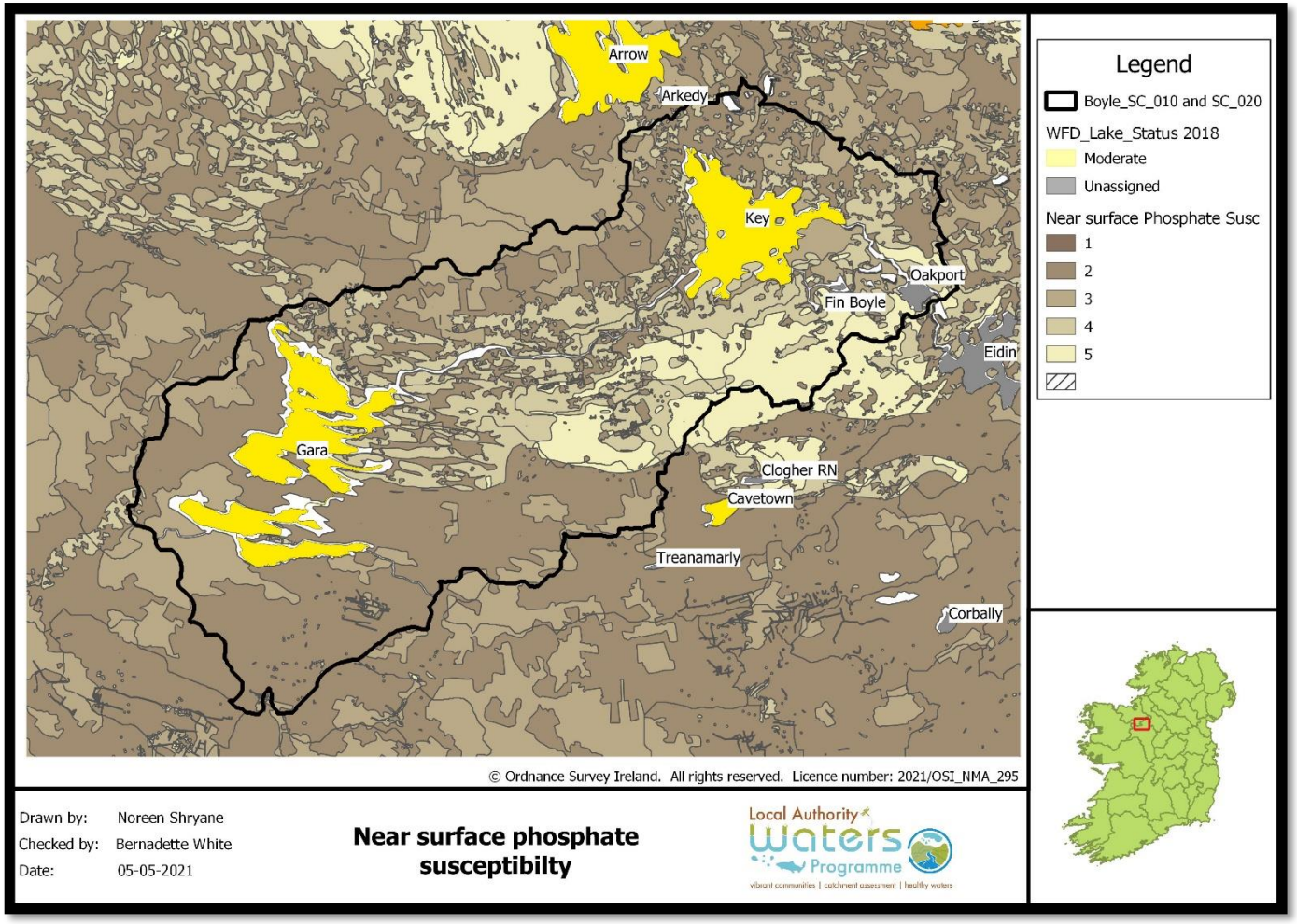


Figure 18 Near surface phosphate susceptibility in the Boyle subcatchments

6 Interim Story of the PAA

The Lough Key PAA includes the river waterbodies; Boyle_040, Demesne_010 and Mocmoyne_010 and the lake waterbodies; Fin Boyle, Oakport and Key. The Boyle_040 and Lough Key are *At Risk* of not achieving their WFD Objectives and the Fin Boyle, Oakport, Demesne_010 and Mocmoyne_010 are at *Review*. The Boyle_020 and Boyle_030 river waterbodies are proposed to be added to the PAA in the 3rd cycle implementation of the River Basin Management Plan. The addition of these water bodies allow for better characterisation of the water bodies at subcatchment scale. Both of these waterbodies are *Not at Risk* of achieving their WFD objective.

6.1 Boyle_020 and Boyle_030

The **Boyle_020** and **Boyle_030** waterbodies were classed as *Not at Risk* and were at Good Status for the 2013 to 2018 monitoring period. However, a Q value assessment in 2020 at the monitoring stations in the Boyle_020 showed a drop from Q4 to Q3-4 which indicates a drop to moderate status for this biological element. The data collected by the EPA and LAs for WFD and Irish Water AERs for Boyle WwTP will be assessed during the 3rd cycle when the PAA is expanded.

6.2 Mocmoyne_010

The Mocmoyne_010 river waterbody is at *Review* and is currently unassigned. The conceptual model suggest phosphate is the most likely significant issue, if in excess. The areas in the mid-section and north of the subbasin in the vicinity of the forestry plantations and on the peat and poorly drained areas to the north of the catchment are the most likely areas where impact, if any, might originate. There are some clusters of DWWTS with high to very high-risk potential for P risk, however none are clustered near the outlet of the Mocmoyne to the Boyle River, therefore it is unlikely they are a significant pressure. There is a historic landfill (Boyle landfill) adjacent to a tributary of this river. The compliance monitoring available for the Boyle landfill between 2002 and 2015 has shown exceedances in ammonia, BOD and orthophosphate. There were no remediation works completed for this landfill. A local catchment assessment will be undertaken upstream of the confluence of the Mocmoyne with the Boyle River, to assess if the river water body is impacted or not. Should the river be classified as being *At Risk ,* further assessment of the landfill will be required to determine if it is a significant pressure.

6.3 Boyle _040

The Boyle_040 river waterbody is *At Risk* of failing to meet its WFD objective and is currently at Moderate ecological status. Anthropogenic pressures were identified as the significant pressure during EPA characterisation (2nd cycle, 2015). The significant issue cannot be determined with confidence at this stage without local catchment assessment, however the conceptual model indicates phosphate and sediment may be issues if in excess. Receptor information compiled has indicated that historically, nutrients were an issue in this water body (**Table *5***). The Boyle_040 drains a predominately poorly drained catchment. The pollution impact potential for phosphate loss to surface waters is high in the north of the PAA on the poorly drained soils. An increase in sediment was noted at the monitoring station by the EPA biologist during surveys in 2017 while there was an increased density of zebra mussel noted in the 2020 surveys . There have been numerous exceedances in the ELVs set

for the WwTP in Boyle Town in the last few years however the assimilative capacity calculations do not indicate a capacity or headroom issue. Nevertheless, the WWTP will be a focus during the LCA. In addition, attendees at the community information meeting also identified issues with the SWO's at Wooden Bridge in Boyle and provided evidence of raw effluent and toilet paper regularly being observed in the river where the Boyle_030 river flows into the Boyle_040.

6.4 Demesne_010

The Demesne_010 river waterbody is at *Review* and is currently unassigned. The conceptual model suggests nitrate is the most likely significant issue, should the water body be identified as impacted. Landuse in the subbasin is dominated by agriculture. The focus of the LCA will be to establish the water quality and determine if it is impacted or not. Should the river be classified as being *At Risk*, further assessment will be required to determine sources of pressures.

6.5 Lough Key

Lough Key Lake waterbody is *At Risk* of failing to meet its WFD objective and is currently at Moderate ecological status with macrophytes determining the status class. Invasive species (zebra mussel) and Anthropogenic pressures were identified as significant pressures during the EPA 2nd cycle characterisation (2015). The significant issue with regard to the invasive species is altered habitat due to morphological changes and other significant impacts. The significant issue for the anthropogenic pressure cannot be determined with confidence at this stage without local catchment assessment however, recreational activities (boating) on Lough Key, Lough Key Forest Park and Section 4's along the lake shore associated with housing and businesses could be potential pressures. The Boyle SC_010 upstream of Lough Key predominately sits in compartments 2, 4 and 5 which are poorly drained. The significant pressures are sediment, historic ammonia, total phosphorus and nitrate in the Boyle_010 with total phosphorus, sediment and invasive species in Lough Gara. Lough Key sits within compartment 3, 4 and 5. Overland flows are likely pathways in areas along the northern parts of the sub-catchment (compartment 4 and 5), where soils are poorly drained; underlying sub-soils have low permeability or depth to bedrock less than 3m with a poor aquifer. Susceptibility of phosphates by near surface pathways and pollution impact potential of phosphates to surface water are high in these poorly draining areas.

6.6 Fin Boyle

The Fin Boyle Lake waterbody is at *Review* and is currently unassigned. The Fin Boyle sits within compartment 2 which is poorly drained. Overland flows are the likely pathway in this compartment with phosphate and sediment the likely significant issue. The focus of the LCA will be to establish the water quality of the lake and determine if it is impacted or not. Should the lake be classified as being *At Risk*, further assessment will be required to determine sources of pressures acting on the lake.

6.7 Oakport

The Oakport lake waterbody is at *Review* and is currently unassigned. Oakport lake sits with compartment 1 (well drained) and compartment 2 (poorly drained). The inputting Boyle_040 tributary passes through a poorly drained area (compartment 2) with an extensive forestry planation

just upstream of the lake however to the west and east of the lake is well drained (compartment 1). The land use, pathways and PIP information available suggest ortho-phosphate could potentially be a significant issue. The focus of the LCA will be to establish the water quality of the lake and determine if it is impacted or not. Should the lake be classified as being *At Risk*, further assessment will be required to determine sources of pressures acting on the lake.

7 Work Plan

Initially in this PAA, LCA will need to focus on confirmation of the significant issues i.e., phosphate, nitrate, sediment etc acting on the PAA water bodies, given the receptor information has not clearly indicated what the issues are. One potential theory is that historically high nutrients have led to the decline in ecological status in Lough Key as reflected in the lake macrophyte status. Once the issues have been confirmed, the sources of the pressures impacting on each of the water bodies can be investigated. LCA will require SSIS/RA and targeted chemistry sampling as well as catchment walks initially. Once the significant issues are confirmed, detailed catchments walks can be undertaken where required. Unmapped karst features will be recorded where encountered, particularly swallow holes which may be transferring nutrients and sediment via groundwater pathways such as sinking streams.

Rivers

Mocmoyne_010

The LCA will focus on confirmation of whether this water body is impacted or not. If impacted, a proposal will be made for a suitable monitoring station to the EPA, and the water body will be retained for the 3rd cycle of the WFD in order to characterisation the pressures at the local scale.

Table 8 LCA plan for Mocmoyne_010

LCA Station	Station Name	SSIS/ RA	Chemistry	Reason
Site 1	Bridge on N61	Yes	Yes	▪ In order to establish the whether the water body is impacted or not, a site upstream of the confluence with the Boyle River will be assessed using SSIS/RA and Chemistry (ortho-phosphate, total p, ammonia, BOD and nitrate).[12] Three seasons of assessment will be undertaken. ▪ If the site is impacted, no further sites upstream will be assessed in the 2nd cycle, and recommendations will be put forward for further assessment of pressures in the 3rd cycle of the RBMP.

[12] Based on the IA3 Nutrient Monitoring Survey Decision Tree

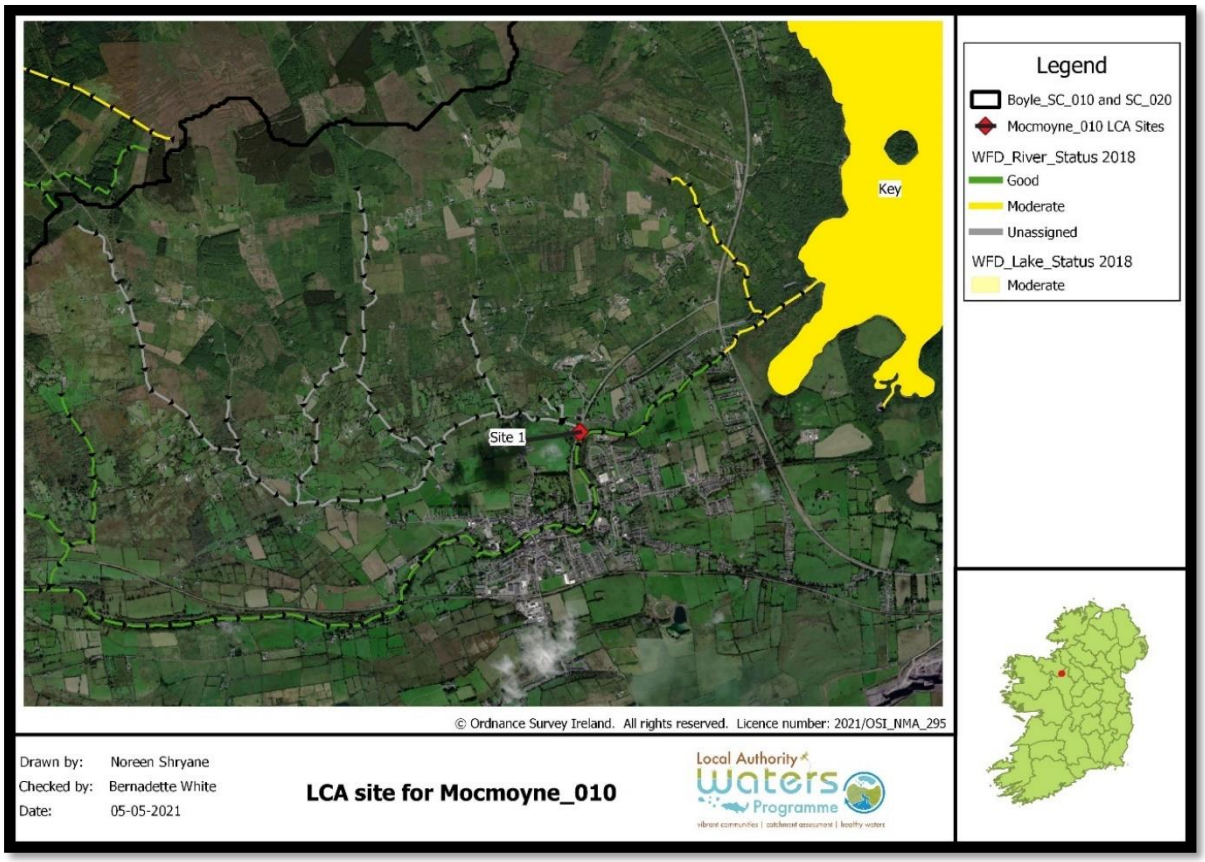


Figure 19 LCA site for Mocmoyne_010

Demesne_010

The Demesne_010 river waterbody is at *Review* and is currently unassigned. The LCA will focus on confirmation of whether this water body is impacted or not. If impacted, a proposal will be made for a suitable monitoring station to the EPA, and the water body will be retained for the 3rd cycle of the WFD in order to characterisation the pressures at the local scale. The LCA plan for this waterbody is outlined in **Table 9** and **Figure 20**.

Table 9 LCA plan for Demesne_010

LCA Station	Station Name	SSIS/ RA	Chemistry	Reason
Site 3.2	Demesne_26-Interstitial, Br d/s from Erironagh R Conf. (Investigative)	Yes	Yes	▪ In order to establish the risk class of the water body conditions will be verified at this site using SSIS/RA and Chemistry (ortho-phosphate, total p, ammonia, BOD and nitrate).[13] ▪ If the site is impacted, no further sites upstream will be assessed, and recommendations will be put forward for further analysis in the 3rd cycle of the RBMP.

[13] Based on the IA3 Nutrient Monitoring Survey Decision Tree

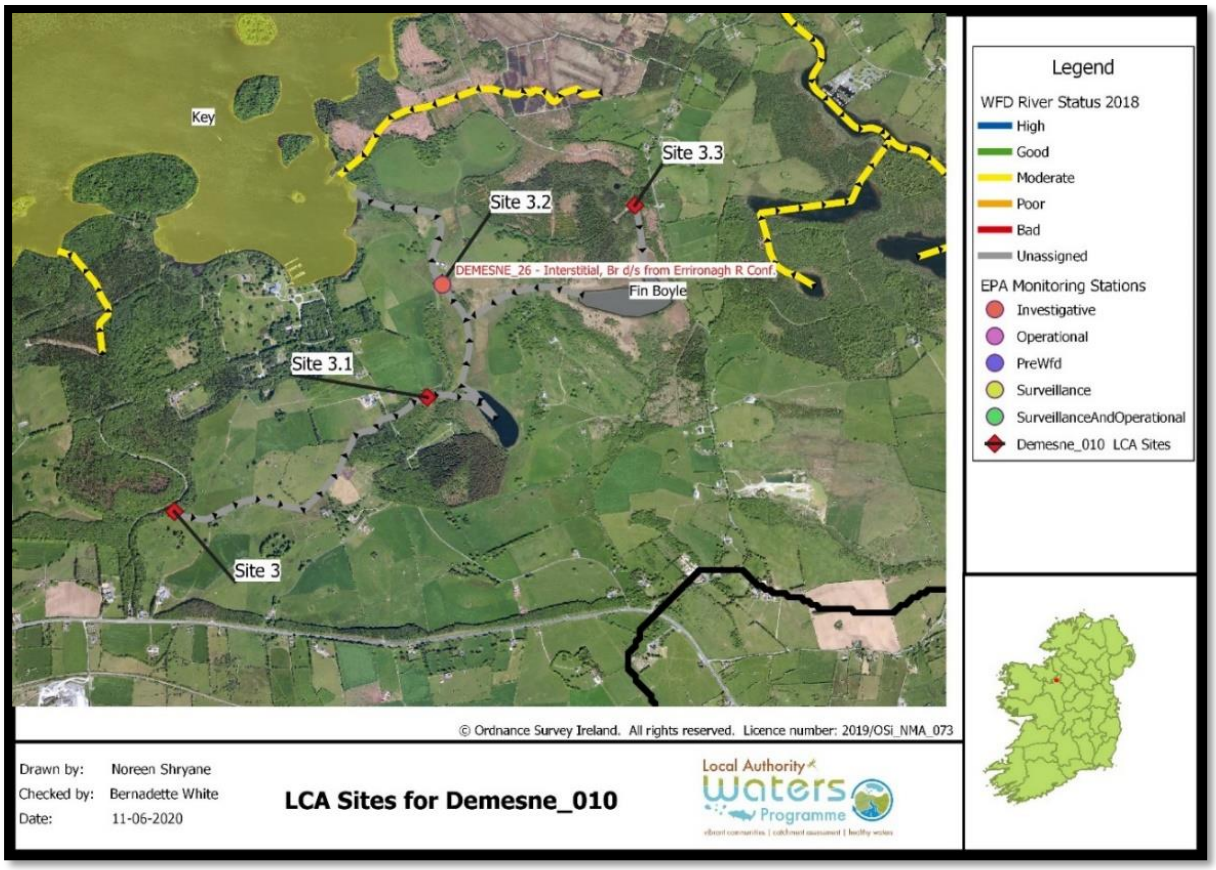


Figure 20 LCA sites for Demesne_010

Boyle_020 and Boyle_030

These waterbodies are hydrologically linked to the PAA i.e., are upstream of the Boyle_040. These waterbodies have been at Good Status in the last four monitoring periods and are *Not At Risk* of meeting their WFD objective. The upstream ambient monitoring location for the Boyle WwTP is located on the Boyle_020 and the downstream ambient monitoring location is located on the Boyle_030. The data collected by the EPA and LAs for WFD and Irish Water AERs for Boyle WwTP will be assessed as it become available. LAWPRO will continue to collate observations at the following locations: the confluence of the Mocmoyne_010 with the Boyle_030; the confluence of the Demense_010 with Lough Key, and also along the Boyle River channel in the town, particularly at Drum Bridge.

Table 10 LCA plan for Boyle_020 and Boyle_030

LCA Station	Station Name	SSIS/ RA	Chemistry	Reason
BL020_04 (Ambient Upstream Monitoring site for WwTP)	Footbridge 1.8km U/S Boyle (Boyle_020) Operational	Yes	Yes	▪ A SSIS/RA and Chemistry sample will be taken here as this site will be a reference site (no impacts from the WwTP). ▪ Obtain ortho-phosphate, total p, ammonia, BOD, nitrate and suspended solids.
BL030_01	Boyle- Bridge at Boyle Abbey (Boyle_030) Pre-WFD	No	No	▪ This is an easily accessible site in the town of Boyle for observations.
BL030_02 (Ambient Downstream Monitoring site for WwTP)	Drum Bridge (Boat House Ford) (Boyle_030) Operational	Yes	Yes	▪ A SSIS/RA and Chemistry sample will be taken here. This site will be ideal to show potential impact from the WwTP. ▪ Obtain ortho-phosphate, total p, ammonia, BOD, nitrate and suspended solids.

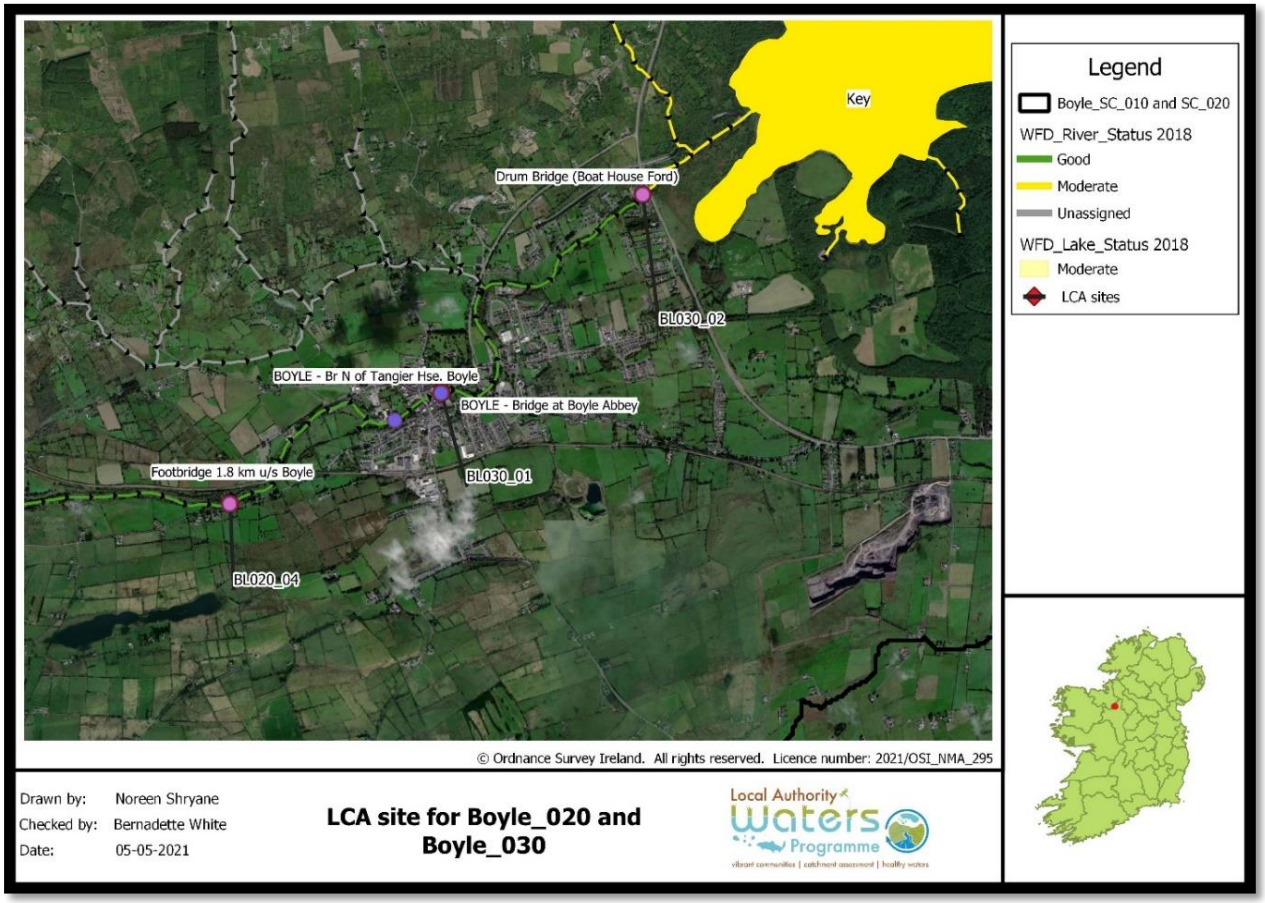


Figure 21 LCA sites for Boyle_020 and Boyle_030

Boyle_040

The Boyle_040 river waterbody is *At Risk* of failing to meet its WFD objective and is currently at Moderate ecological status. Anthropogenic pressures were identified as the significant pressure during the EPA characterisation (2nd cycle). Recreational pressures e.g., boating and Lough Key Forest Park are potential sources of anthropogenic pressures, along with Section 4's around the shores of Lough Key. The EPA monitoring station for the Boyle_040 station is to the south of Lough Key on the outflowing section of the Boyle River. An IA7 which is an assessment focusing on multiple sources in multiple areas was recommended by the EPA and the deskstudy would agree with that proposal. Therefore, the LCA initial assessments proposed are outlined in **(Table 11** and **Figure 22)** below**.**

Table 11 LCA Plan for Boyle_040

LCA Station	Station Name	SSIS/ RA	Chemistry	Reason
Site 2	Downstream of overpass on N4	Yes	Yes	▪ This site is approximately 90m downstream of the Wooden Bridge Pumping Station and SWO. This site will be used to identify any potential impacts of discharges from the SWO.
Site 2.2	Br 360m s/w Corrigennroe school (Investigative)	Yes	Yes	▪ Establish if there are potential impacts on this tributary from the surrounding catchment. ▪ The location of one of the Section 4's (Aghacarra Housing Estate) discharges to groundwater upstream of this site. It is not possible to assess potential impact at Site 2.2.
Site 2.3	Bridge at farmyard entrance	Yes	Yes	▪ Establish if there are potential impacts on this tributary from the surrounding catchment.
Site 2.4	Downstream river crossing with L1012	Yes	Yes	▪ Establish if there are potential impacts on this tributary from the surrounding catchment.
Site 2.5	Farm road off the L1012	Yes	Yes	▪ Establish if there are potential impacts on this tributary from the surrounding catchment.
Site 2.6	River crossing at bend in front of two bungalows	Yes	Yes	▪ Establish if there are potential impacts on this tributary from the surrounding catchment.
WP -04-04 Site 1 **Katonah Site 1**	Drain to the left of the Housing Estate along laneway	No	Yes	▪ There are issues with this Section 4 discharge (Katonah Developments Ltd. ▪ Observations will be undertaken to establish if there is runoff from the treatment plant on site into the drain.
Bramer Doon Site 1		No	Yes	▪ Bramer Doon Section 4 discharges into Lough Key to the left of the Marina. Access to this private marina may be an issue to obtain visual observations of the discharge pipe.
Site 2.7	Trib beside Riverhaven log cabins	Yes	Yes	▪ Establish if there are potential impacts on this tributary from the surrounding catchment.

LCA Station	Station Name	SSIS/ RA	Chemistry	Reason
Site 2.8	Upstream site on trib that confluences U/S of Knockvicar	Yes	Yes	▪ Establish if there are potential impacts on this tributary from the surrounding catchment.
Site 2.9	Downstream site on trib that confluences U/S of Knockvicar	Yes	Yes	▪ Establish if there are potential impacts on this tributary from the surrounding catchment.
Site 2.10	BOYLE - Knockvicar Bridge (Pre WFD)	Yes	Yes	▪ This site is 200m downstream of the confluence of two tributaries one of which is an outfall from Lough Key. This site is also upstream of a Section 4 – Tara Marina
Site 2.10.1	Tara Marina	No	Yes	▪ Observations will be made at the discharge point on the Marina boundary.
Site 2.11	Cootehall Bridge (Operational)	Yes	Yes	▪ This is the EPA Operational Monitoring Station for the Boyle_040.
Site 2.12	Trib outlet from peatland on eastern shoreline of Lough Key	Yes	Yes	▪ Establish if there are potential impacts on this tributary from the surrounding catchment.
Site 2.13	Fairy bridge in Lough Key Forest Park	Yes	Yes	▪ Establish if there are potential impacts on this tributary from the surrounding catchment.

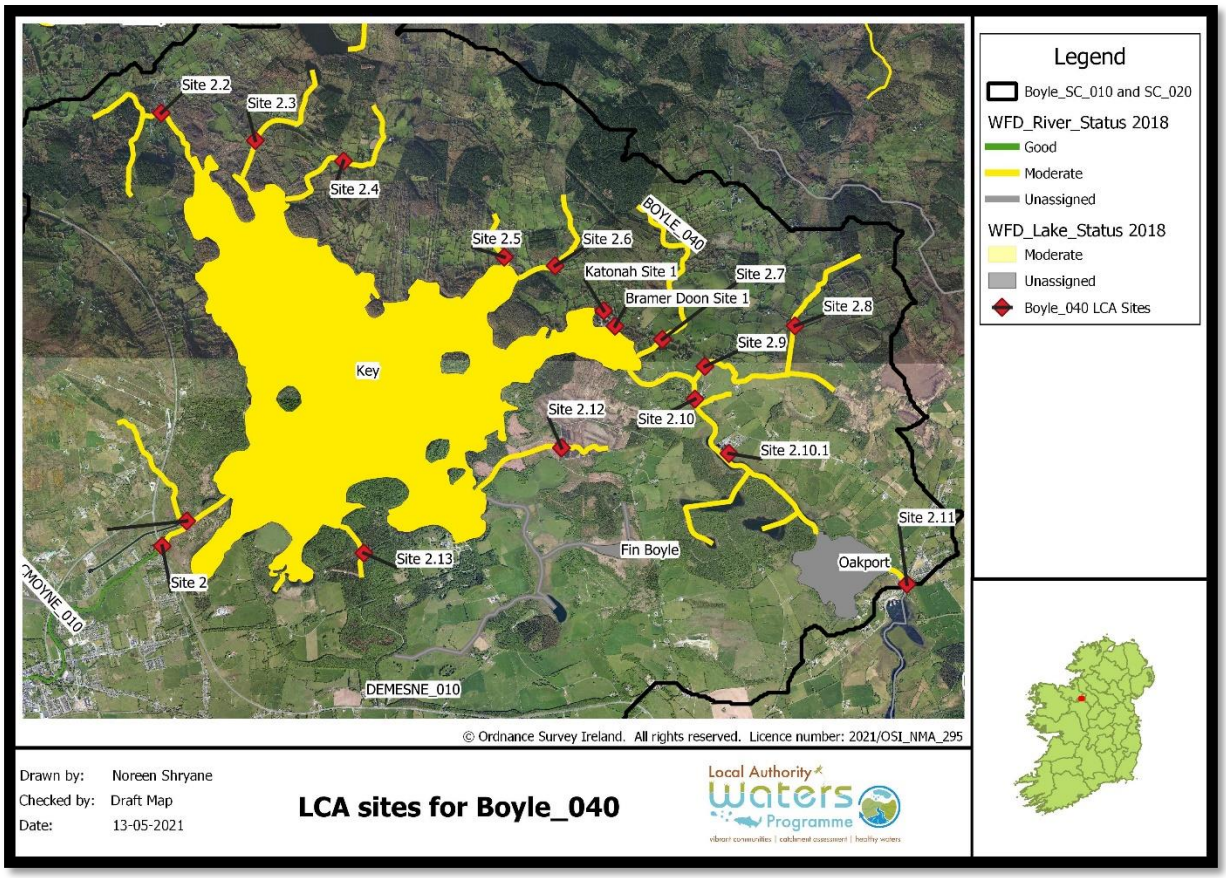


Figure 22 LCA Sites for Boyle_040

Lakes

Fin Boyle and Oakport

The minimum requirements for estimating the risk of a lake not meeting its WFD objectives, are the collection and analysis of two water samples – one collected in Spring (April or May) and a second in Summer (July or August) (Section 4.2.7, Volume 1, LCA Guidance). Analysis undertaken on lake samples shall include the following parameters as a minimum requirement: total phosphorus, chlorophyll *a*, alkalinity, total ammonia (mg/l N), pH, dissolved oxygen and conductivity. The following observations should be included: weather, wind direction, presence of algal blooms, macrophytes, sediment and modifications of channel outlet (Unassigned Lakes Sample Protocol(LAWPRO)).One site has been chosen for assessment at the lake shore for Fin Boyle Lake. Two sites have been chosen for lake sampling for the Oakport Lough (**Figure 23**).

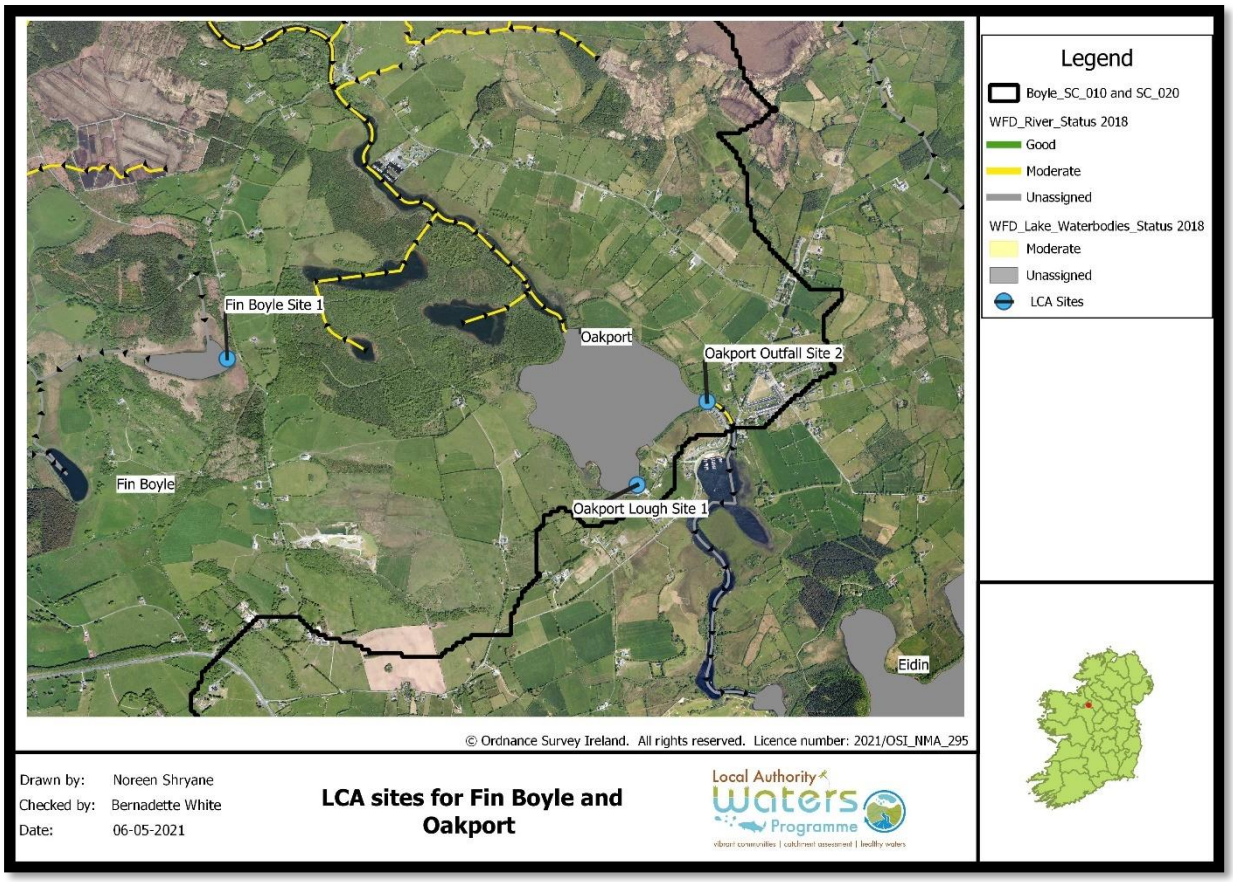


Figure 23 LCA sites for Fin Boyle and Oakport

8 Communications

8.1 Submissions on Draft RBMP

Submissions, observations and comments made by interested parties on the draft River Basin Management Plan (RBMP) for Ireland 2018-2021 were reviewed to identify any significant concerns raised about the waterbodies within the PAA or the surrounding area during the consultation process. No submissions specific to the rivers or lakes were made.

8.2 Community Information Meeting

Community groups are active in the area such as Boyle Tidy Towns Committee. The PAA community information meeting was held in Lough Key Forest and Activity Park visitor centre on the 24th of October 2019. The meeting involved presentations from the Community Water Officer and the lead Catchment Scientist for the PAA followed by a question-and-answer session with the attendees. Comments raised during the meeting are outlined in **Table 12**.

Table 12 Community Information Meeting comments

Comments
Issues were raised on the night about the efficiency of the Wooden Bridge Pumping Station on the outskirts of Boyle Town with visual evidence of tissue paper and raw sewage entering the Boyle River. This information has informed the LCA plan for the Boyle_040 and analysis will be undertaken in the vicinity of all pumping stations in the catchment, with additional discussions with Irish Water required. This section of river is often used by locals for swimming and there is a walkway adjacent to the river.
Unmapped karst features were also identified, which may be important factors in terms of pathways for contaminants via groundwater pathways. A local offered to identify these along with the LAWPRO team.
A local boat operator offered to bring LAWPRO staff out on the lake to assist with any surveys required.

8.3 Farmers Meeting

ASSAP held a farmers meeting in the Lough Key Forest and Activity Park visitor centre on the 27th of February 2020. The meeting was supported by LAWPRO. It was attended by farmers located in the PAA. The meeting involved presentations from the ASSAP advisor, LAWPRO Catchment Scientist and a Teagasc Forestry Advisor which were followed by a question-and-answer session with the attendees. Questions raised during the meeting are outlined in

Date of Completion: 16th March 2021

Table *13*.

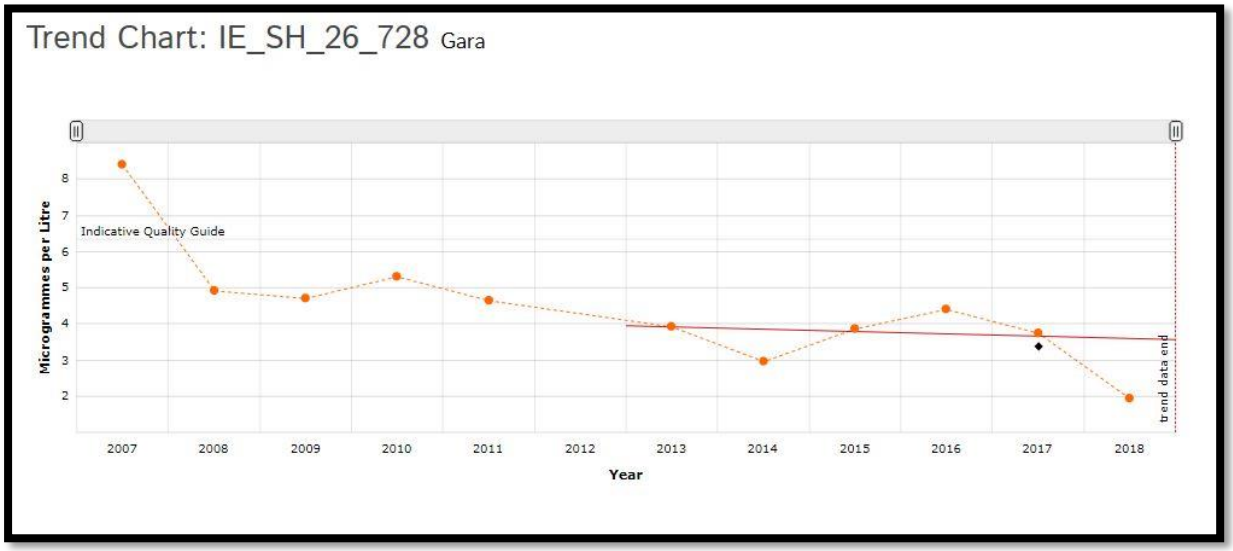
Date of Completion: 16th March 2021

Table 13 Farmers Meeting questions and comments

Question
The local authority are viewed as a threat to farmers livelihoods especially sheep and beef farmers who rely on premiums. How can you change people's attitude to the local authority's environmental enforcement activities? perceptions?
Where are you going in the catchment and how many sites are you visiting?
What implications have the karst features on the catchment if there is activity outside the PAA Boundary impacting water quality within the PAA? Will the landowners outside the PAA boundary be offered ASSAP's services? Will LAWPRO be assessing these areas?
How can we follow up on LAWPRO'S progress in the catchment?
What are you doing about the WwTP in Boyle Town? With the best will in the world from the farming community, until the WwTP is fixed no improvements will be seen.

9 Appendix A

9.1 Chlorophyll Trend Chart for Lough Gara



9.2 Chlorophyll Trend Chart for Lough Key